Bulletin 1981-82

Massachusetts Institute of Technology

Courses and Degree Programs Issue
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The Institute has adopted an affirmative action plan expressing its continuing commitment to the principle of equal opportunity in education.

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An MIT Education for Our Times

Earlier in this century people looked to science and technology to light the path of progress. This is no longer the case. That early, and somewhat naive, optimism has been replaced by a skepticism and by an alarming decline in scientific literacy in this country. This decline reflects, in part, the difficulty of keeping up with fields which grow and change with astonishing speed. But there is also, among the public, an ignorance, wariness, and discomfort about most things scientific and technological . . .

It is clear, however, that the future development not only of this nation, but of the world, is inexorably tied to continued scientific progress and to the humane and thoughtful applications of science. What is needed is not a retreat from science and technology, but a more complete science and technology.

We must strive to develop among ourselves, among our students, and in the public at large, an understanding of the fact that engineering and science are, by their very nature, humanistic enterprises.

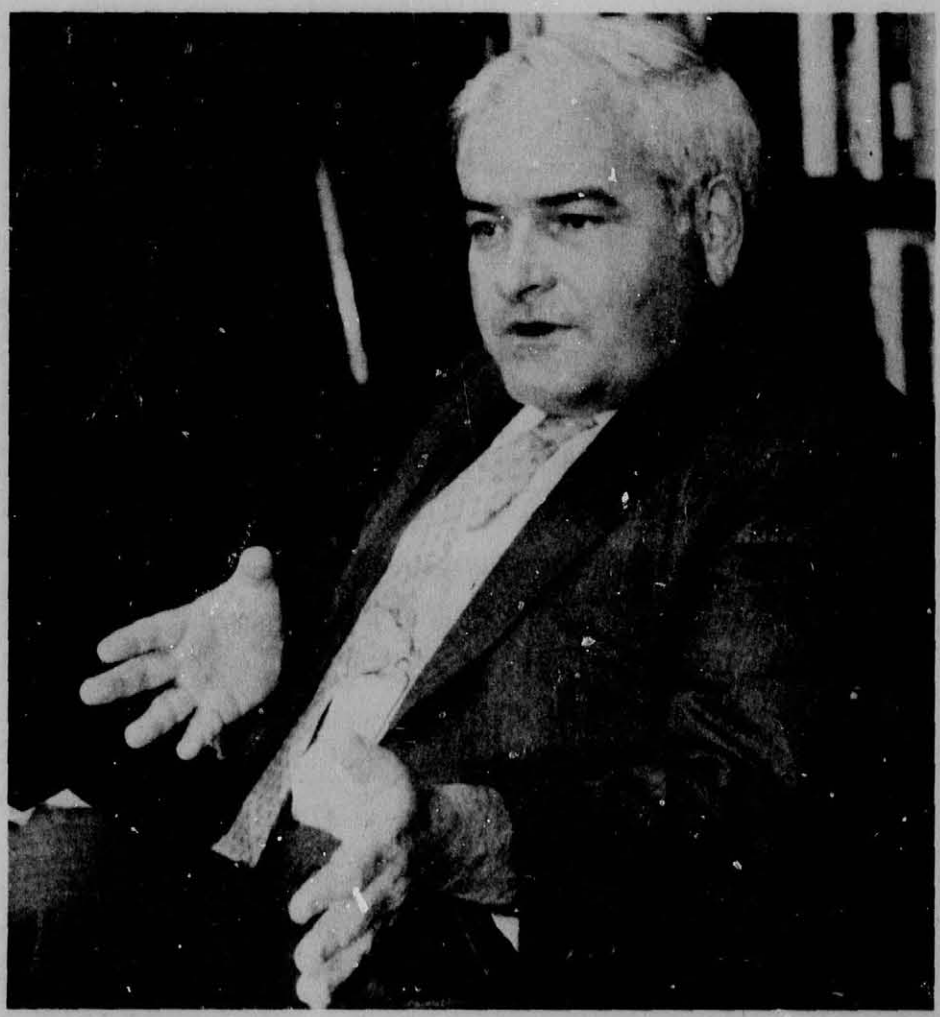
Scientific inquiry is, at once, a most natural and highly refined expression of the human mind and spirit. It is derived from native curiosity about the nature of our world and about the universe, and it results in speculations and concepts which help to give meaning and order to that world. Engineering and technology are both natural and socially derived enterprises. They offer suggestions of agenda — on goals and priorities — for scientific inquiry . . . Ultimately, I believe, this inquiry and these enterprises must [illegible]t where they begin, with concern for the human condition.

The attention to the humanistic elements and the human consequences of all that we do must be broadly shared. For, not only do we need a more complete science and technology, but we need to understand — and to engage — the larger social, cultural, and historical domains of which they are a part. We must continue to be a sanctuary for the constructive criticism of the technological enterprise and of the larger society. These principles must be built into the academic programs of our students — both undergraduate and graduate — and they must be reflected in the lives and activities of all who choose to be a part of this institution . . .

For over a century, MIT has been a place where exceptional people from all walks of life come together to work and to study. As such, MIT has a responsibility to itself and to the nation to be open — and to reach out — to the most talented and promising people, regardless of race or sex . . . For the sake of MIT, and for the world we help to build, we would do well to share the vision of Margaret Mead, articulated nearly 50 years ago, but no less relevant today:

If we are to achieve a richer culture, rich in contrasting values, we must recognize the whole gamut of human potentialities, and so weave a less arbitrary social fabric, one in which each diverse human gift will find a fitting place.

From the Inaugural Address of
Paul E. Gray
President

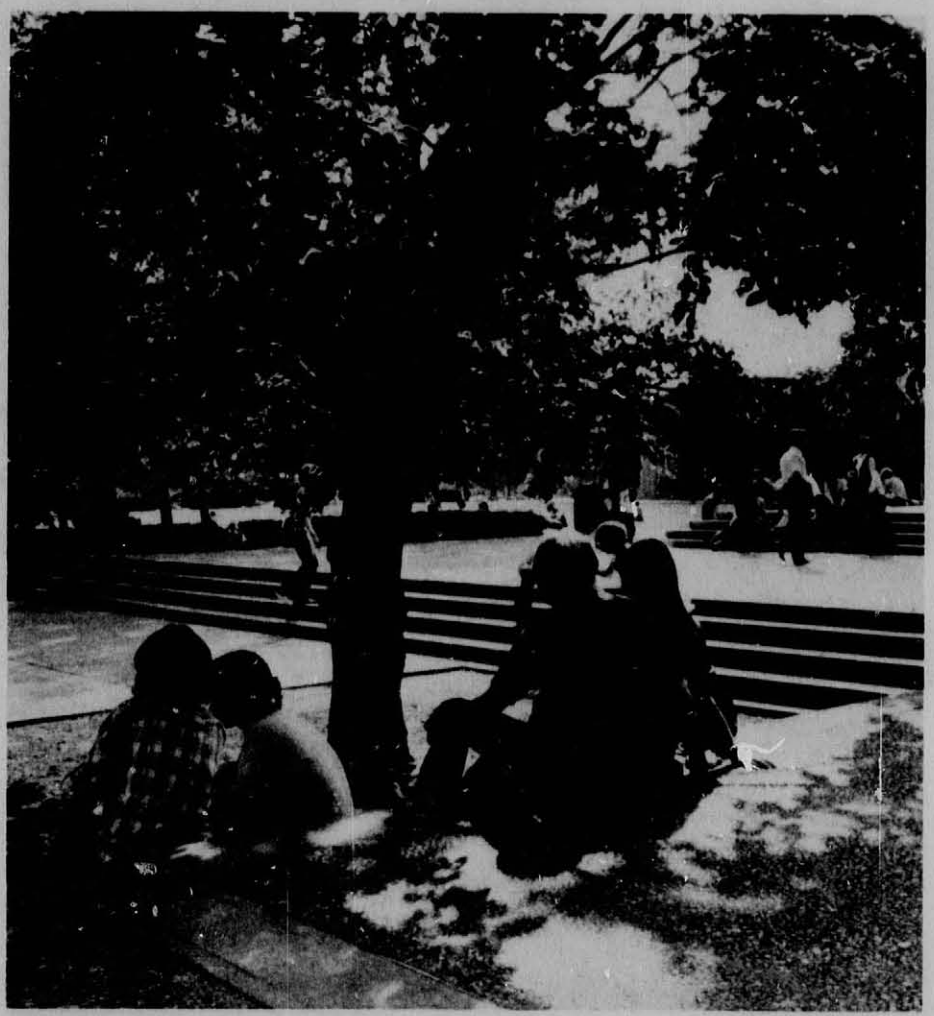



NATURAL

This is MIT







This is MIT

History and Purpose

On February 20, 1865, four years after approval of its founding charter, the Massachusetts Institute of Technology opened its doors to admit the first class of 15 students. The event marked the culmination of an effort by William Barton Rogers, MIT's founder and first president, to create a new kind of educational institution relevant to the times and to the nation's need, where students would be educated in the application as well as the acquisition of knowledge. A distinguished natural scientist, Rogers stressed, too, the importance of basic research, and believed that professional competence was best fostered by a coupling of teaching and research and attention to real-world problems.

Today, education and related research continue to be MIT's central purpose, with relevance to the practical world as a guiding principle. The Institute is an independent, coeducational, privately endowed university. It is broadly organized into five academic Schools — Architecture and Planning, Engineering, Humanities and Social Science, Management, and Science. Within these Schools there are 23 academic departments, as well as many interdepartmental laboratories, centers, and divisions which extend beyond the traditional departmental boundaries.

MIT's total enrollment is approximately 9,350, almost evenly divided between undergraduate and graduate students. In 1980-81, MIT students came from all 50 states and the District of Columbia, Puerto Rico, the Virgin Islands, and 95 foreign countries. The proportion of international students at the Institute, about 17 percent, is one of the highest in an American university.

The MIT faculty numbers approximately 1,000, with a total teaching staff of 1,860. Most faculty appointments are in one or more of the academic departments, but the faculty also work in the many interdepartmental laboratories, centers, and



The Academic Program

divisions. Most faculty members at MIT teach both graduate and undergraduate students. Undergraduates often register for graduate classes; many undergraduates and all graduate students participate, often together, in advanced research.

This intermixing of ages, disciplines, and nationalities, which is characteristic of MIT, deeply influences the life and experience of every member of the academic community, bringing together students and teachers, biologists and architects, humanists and engineers, young and old. The result is an academic environment unusual for its singleness of method and purpose, and notable for its diversity of interest.

The central purpose of the academic program at MIT is to give students a sound command of basic principles; a versatility of insight and perspective concerning natural and social phenomena; the habit of continued learning; and the power that comes from a thorough and systematic approach to learning. From these attributes comes the best assurance for continued professional and personal growth, especially in today's rapidly changing world.

The two essential parts of all MIT educational programs are teaching and research. Both of these activities carried on together have greater power than either performed alone. While advancing human knowledge and understanding, research makes special contributions to the Institute's educational program. It provides experience in both theory and experiment for students and faculty, and assures that classroom teaching is up to date. Teaching, at the same time, provides a setting in which the relevance, accomplishments, and vitality of research are continually clarified and assessed.

Each of the 23 academic departments offers one or more degree programs or Courses[1] of study. By and large, students pursue a degree in one of the departments. Degrees are awarded on the basis of satisfactory completion of requirements in each program. Descriptions of departmental programs for graduate and undergraduate students are given in Chapter VI of this catalogue. More detailed information may be obtained by consulting the individual departments.

The academic programs of both undergraduate and graduate students are based upon a core of general Institute and departmental requirements. There is enough flexibility, however, to allow each student, in collaboration with a faculty advisor, to develop an individual program in response to his or her own interests and preparation. For example, there is a growing number of students who concentrate their studies in areas that cross departmental lines. Among these are programs in fields such as planetary and space science, communications, environmental studies, health sciences and technology, visual arts, transportation, urban studies, and energy.

MIT is accredited by the New England Association of Schools and Colleges. Information about accreditation by specific professional organizations is listed within Chapter VI of this catalogue.

In addition to departmental and interdepartmental academic programs, instruction in Aerospace Studies, Military Science, and Naval Science is offered to all eligible students. These programs, which do not lead to degrees at the Institute, are described at the end of Chapter VI.

Undergraduate Courses at MIT lead to the degree of Bachelor of Science (S.B.). Graduate degrees awarded include Master of Architecture (M.Arch.), Master of Science (S.M.), Master in City Planning (M.C.P.), Engineer (each degree designates the field in which it is awarded),[2] Doctor of Philosophy (Ph.D.), and Doctor of Science (Sc.D.).

The chart at the end of this chapter shows Schools, departments, undergraduate and graduate Courses of study and degrees, and Course numbers. For most undergraduates, degree-granting programs, including those which provide periods of on-the-job experience off-campus, require four years of full-time study for the Bachelor of Science.

1
At the Institute the capitalized word **Course** refers to an organized curriculum leading to a specified degree. The lowercased word **course** or **subject**, on the other hand, refers to the individual classes. Each Course is designated by a Roman numeral; individual subjects are given Arabic numerals to correspond with the Course numbers. For example, Civil Engineering is Course I; the number 1.05 indicates a subject given in the Course in Civil Engineering.

2
Engineer degrees include Chemical Engineer (Chem.E.), Civil Engineer (C.E.), Electrical Engineer (E.E.), Engineer in Aeronautics and Astronautics (E.A.A.), Environmental Engineer (Env.E.), Materials Engineer (Mat.E.), Mechanical Engineer (Mech.E.), Metallurgical Engineer (Met.E.), Nuclear Engineer (Nucl.E.), Ocean Engineer (Ocean E.).

Academic Calendar

The academic calendar provides a framework for educational programs and cultural events, and generally influences the patterns of campus life. At MIT the fall term starts the second week of September and ends before Christmas, and the spring term starts the first week in February and ends in late May.

The January Independent Activities Period (IAP), provides a new dimension to educational activities. The time during IAP may be devoted to research, study in a field of the student's interest, travel, relaxation, or investigation of new fields. During this time more than 500 special activities, including films, field trips, seminars and lectures, individual projects, intensive subjects and workshops, are offered on the campus. There are also numerous off-campus activities, including field trips and academic projects abroad.

During the regular Summer Session, MIT offers a selection of the subjects available during the academic year, as well as a few subjects designed for special interests and needs.

1981

August 5
Financial Registration Form due in Student Accounts Office, E19-215

August 5
Payment for first term due

August 10
Last day to petition for September Advanced Standing Exam and to return application card for Postponed Finals

August 26
Transfer Student Orientation begins

August 28
Freshman Orientation Week begins

September 1
Graduate Orientation Week begins

September 1-3
International Open House

September 3, 4
Advanced Standing Exams and Postponed Finals

September 7
Labor Day *(Holiday)*

September 9
Registration Day

September 10
First day of classes

September 16
Last day to petition for October Advanced Standing Exam

October 2
Application for advanced degrees in February due in Registrar's Office, E19-335

October 3
Advanced Standing Exams

October 12, 13
Columbus Day Vacation

October 16
Add Date. Last day to add subjects to registration. $20 processing charge for any add allowed after this date. Last day for juniors and seniors to change an elective to or from P/F grading.

October 19
Automatic withdrawal date for students not having completed four steps of registration

October 23
Last day to turn in Final Exam Conflict Report

October 23
Deadline for students to turn in Freshman Evaluation Forms

October 28
Deadline for instructors to turn in Freshman Evaluation Forms

November 11
Veterans Day *(Holiday)*

November 20
Last day to petition for December Advanced Standing Exam

November 20
Drop Date. Last day to cancel subjects from registration. Undergraduates must petition to Committee on Academic Performance; graduates must petition to Committee on Graduate School Policy for a cancellation after this date. $20 processing charge for any drop allowed after this date.

November 26, 27
Thanksgiving Vacation

November 30-December 1
Second term registration material available in Building 10 Lobby

December 4
Last day for changing thesis title. $20 fee after this date.

December 11
Last day of classes

December 11
Deadline for students to turn in Freshman Evaluation Forms

December 15-18
Final exam period

December 18
Registration material for second term due in Registrar's Office, E19-335. $10 fine for registration received after this date.

December 19-January 3
Christmas Vacation

December 29
First term grade reports mailed

1982

January 4
Deadline for instructors to turn in Freshman Evaluation Forms

January 4
Financial Registration Form due in Student Accounts Office, E19-215

January 4
Payment for second term due

January 4
First day of Independent Activities Period

January 8
Doctor's theses due for January

January 14
Theses, other than Doctor's, due for January

January 14
Last day to go off February degree list

January 14
Last day to petition for February Advanced Standing Exam and to return application card for Postponed Finals

January 15
Martin Luther King, Jr.'s Birthday *(Holiday)*

January 27
Last day of Independent Activities Period

January 28-31
Vacation

February 1
Registration Day

February 2
First day of classes

February 4
Grade reports for January period mailed

February 6
Advanced Standing Exams and Postponed Finals

February 8
Financial aid applications for 1982-83 mailed to continuing students. Afterwards, forms available in Student Financial Aid Office, 5-119.

February 15-16
Washington's Birthday Vacation

February 19
Application for advanced degrees in June due in Registrar's Office, E19-335. $20 fee after this date.

March 5
Add Date. Last day to add subjects to registration. $20 processing charge for any add allowed after this date. Last day for juniors and seniors to change an elective to or from P/F grading.

March 8
Automatic withdrawal date for students not having completed four steps of registration

March 19
Deadline for students to turn in Freshman Evaluation Forms

March 22-26
Spring Vacation

March 29
Deadline for instructors to turn in Freshman Evaluation Forms

April 9
Last day for changing thesis title. $20 fee after this date.

April 16
Summer Session registration material available in Registrar's Office, E19-335

April 19, 20
Patriots' Day Vacation

April 23
Financial aid applications due for 1982-83 in Student Financial Aid Office, 5-119

April 23
Drop Date. Last day to cancel subjects from registration. Undergraduates must petition to Committee on Academic Performance; graduates must petition to Committee on Graduate School Policy for a cancellation after this date. $20 processing charge for any drop allowed after this date.

April 23
Last day to petition for May Advanced Standing Exam and to turn in Conflict Report

April 30
Doctor's theses due for second term

April 30
Summer Session registration material due, Registrar's Office, E19-335

May 3, 4
First term registration material available in Building 10 Lobby. Reference copies of new subject descriptions available in departmental headquarters, libraries, and the Information Center.

May 7
Theses, other than Doctor's, due for second term

May 12
Last day of classes for subjects with final exam

May 12
Deadline for students to turn in Freshman Evaluation Forms

May 14
Last day of classes for subjects with no final exam

May 14
Last day to go off degree list

May 17-20
Final exam period

May 20
Registration material for continuing students due in Registrar's Office, E19-335. $10 fine for any registration for continuing students received after this date.

May 21
Deadline for instructors to turn in Freshman Evaluation Forms

May 28
Commencement exercises

May 31
Memorial Day *(Holiday)*

June 1
Second term grade reports mailed to home address

June 7
First day of Summer Session

Educational Resources

A special feature of education at MIT is the opportunity for students and faculty to participate together in research activities. The Institute devotes substantial resources of its own to such undertakings and receives generous grants from both industry and government in support of such work.

For this work MIT has unusual facilities, some of which are unique among educational institutions. There are more than 70 special laboratories on the campus. In general, the Institute's policy is to make these facilities available to students — with the result that nearly all of MIT's laboratories are shared by undergraduates, graduate students, and faculty members working together in close collaboration on ongoing projects.

Many of these research facilities are described in this catalogue by the departments which operate them. In addition to laboratories and facilities organized within departments, there is a large number of interdepartmental laboratories and centers, established to facilitate work in fields which cross the lines of traditional disciplines. Undergraduate and graduate interdepartmental opportunities and major interdepartmental organizations and research facilities are described in Chapter V.

Libraries

Supporting both the teaching and research activities at the Institute are the MIT Libraries, with holdings of more than one and three-quarter million volumes. More than 18,000 current journals and periodicals and extensive back files provide comprehensive resources in all major fields. These are enriched by numerous special collections, including microfiche, slides, and maps. Through MIT's membership in the Boston Library Consortium, graduate students, faculty members, and research staff have access to extensive research collections outside the Institute.

The Library system, with headquarters in the Charles Hayden Memorial Library building, includes the five major libraries with several branches and reading rooms: the Rotch Library of Architecture and Planning (with a separate Skidmore Room for visual collections); the Dewey Library (economics, industrial management, industrial relations, and political science); the Barker Engineering Library (with a separate Aeronautics and Astronautics Library and Von Hippel Reading Room for materials science); the Humanities Library (with a Music Library and a Reserve Book Room); the Science Library (with the Lindgren Library for the earth and planetary sciences and Chemistry Reading Room); the Student Center Library; the Institute Archives and Special Collections; Rare Books; and the MIT Museum and Historical Collections.

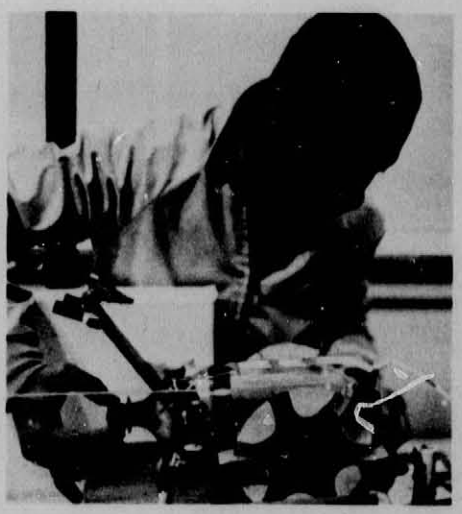
All of the services offered by a fine research library are available: reference and information, interlibrary loans, and microforms, photoprints, and quick copies of works located in MIT or other libraries. The libraries serve primarily Institute students, faculty, staff members, and their families. Others wishing to use the facilities may apply to the Assistant Director for Public Services, Room 14S-216, for a library privilege card.

Information Processing Services

The contributions that the computer can make to the advancement of essentially every field of human endeavor are well recognized. The computer serves as a tool that opens up new ways to process information, and presents an opportunity to formulate and think through problems in wholly different ways. As a result of the application of the computer, new disciplines are emerging and established disciplines are being transformed significantly.

Students, both undergraduate and graduate, are involved in much of this activity. A majority of MIT students begin to use the computer early in their studies and many continue to do so on into graduate work. Opportunities to pursue programs oriented toward computer sciences are available in many departments, where specific research programs are under way in either the development or utilization of the computer.

Information processing facilities at MIT fall into two groups: those provided within the Information Processing Center, which serves as a large, versatile central computing facility; and those provided through the local departmental and laboratory computer facilities, which offer somewhat specialized information processing systems to meet specific needs.



MIT Press

The MIT Press is a principal agency for the execution of the Institute's responsibility to teach not only a residential student body but also the world at large. The Press has worldwide distribution; its books and other educational materials bearing its imprint convey to a broad audience of scholars a sense of the quality of the Institute and its concern with learning. Books published by the Press have won many awards, including the National Book Award and a wide variety of citations for graphic excellence.



The Council for the Arts at MIT

The Council for the Arts at MIT was founded in 1971. A nationally based advice and support body with a membership of 93, the Council is composed of men and women who hold in common the view that relative progress in civilization rests in no small measure on a healthy balance between the arts and sciences. It is the Council's belief that the arts are a particularly significant element of a university based mainly on science and technology. This belief is reinforced at MIT by an undergraduate body that increasingly wants more than specialization and professional competence in an education aimed at broad social and humane ends.

The Council is a grant-making body that uses its own funds to foster the arts at MIT. Its function is to act as a catalyst in a highly participatory, wide-ranging program that is firmly founded on the intellectual tripod of teaching, practice, and research in the arts. Visual and literary arts, dance, music, theatre, cinema, photography, and other art forms receive financial support from the Council. The Council's ultimate goal is to enhance the MIT community as a whole and to help provide students with a collective experience in the arts that will match and complement the depth and insight of their experience in science and technology.



Lowell Institute School

The Lowell Institute School was established at MIT in 1903 to provide evening instruction in technical subjects for residents of the Boston area. Today the School continues this tradition by offering subjects in the areas of modern technology which are not readily available at other evening institutions. The general level of instruction is geared to the practicing technician who has an Associate degree or equivalent experience.

The programs of study range from single subjects designed to broaden an individual's skill level in his or her present employment to comprehensive study of new technological areas which will prepare a technician for employment in a new field. There is a strong emphasis on practical aspects and development of careful experimental technique combined with sufficient theory to provide an adequate foundation of understanding.

Subjects offered by the School do not carry MIT credit, but certificates are awarded to those who complete a satisfactory program. Further information may be obtained by contacting Dr. Bruce D. Wedlock, Director, Lowell Institute School, Room E19-738, MIT, Cambridge, Massachusetts 02139.

The Campus

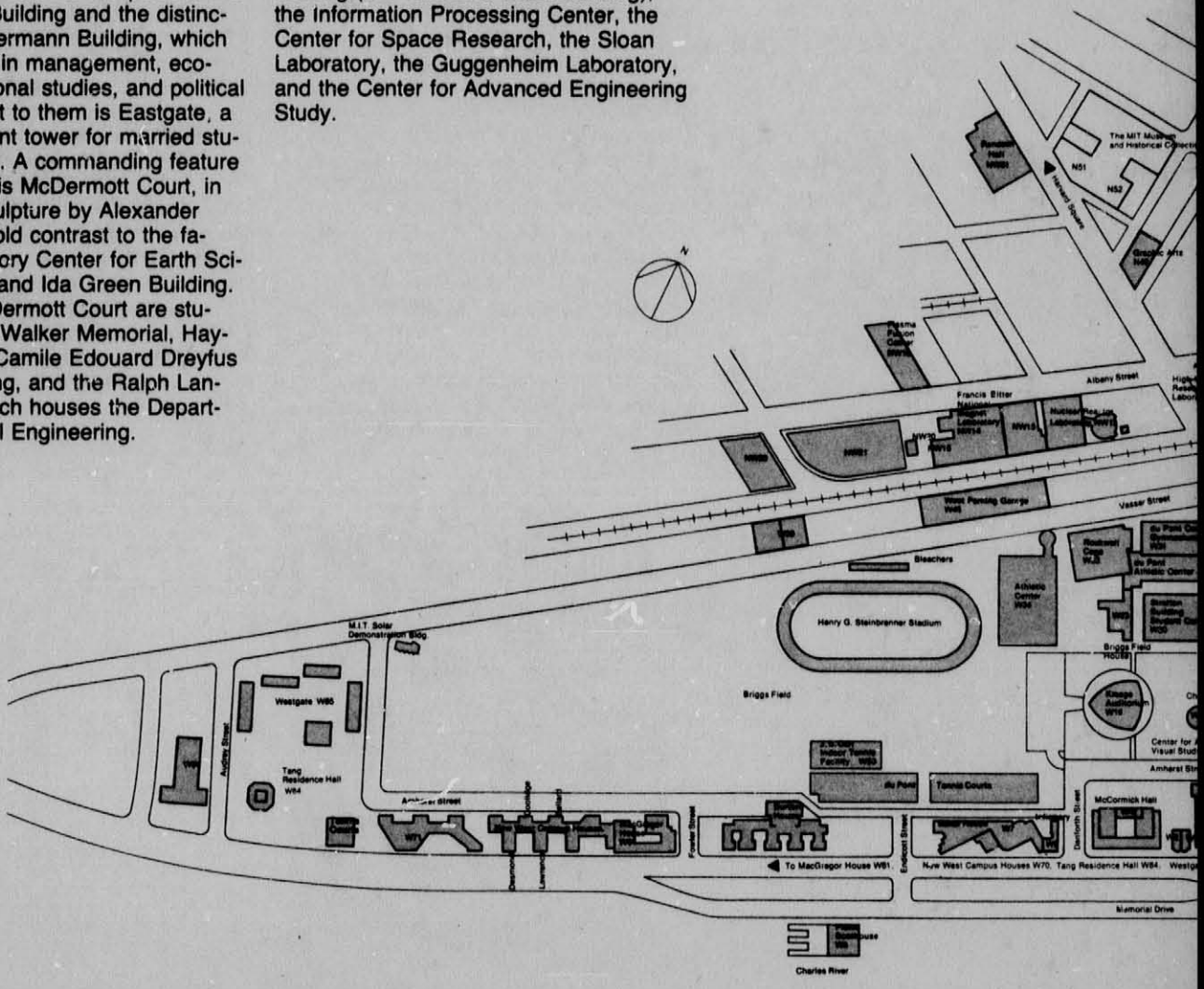
MIT's 135-acre campus extends for more than a mile along the Cambridge side of the broad Charles River Basin facing historic Beacon Hill and the central sections of Boston. Most academic activities are brought together in a group of interconnected buildings designed to permit maximum flexibility and easy communication among the departments and Schools. The extensive athletic plant and playing fields are on the campus, as are the recreational buildings, dormitories, and dining halls. This convenient arrangement contributes greatly to the sense of unity and interdepartmental involvement that characterize the Institute.

At the eastern end of the campus are the Alfred P. Sloan Building and the distinctive Grover M. Hermann Building, which houses activities in management, economics, international studies, and political science. Adjacent to them is Eastgate, a 30-story apartment tower for married students and faculty. A commanding feature of East Campus is McDermott Court, in which a great sculpture by Alexander Calder rises in bold contrast to the facade of the 20-story Center for Earth Sciences, the Cecil and Ida Green Building. Surrounding McDermott Court are student residences, Walker Memorial, Hayden Library, the Camile Edouard Dreyfus Chemistry Building, and the Ralph Landau Building, which houses the Department of Chemical Engineering.

The Institute's main buildings, enclosing the Killian Court, were designed by Welles Bosworth, Class of 1899, and were dedicated in 1916. Banked by magnificent rhododendrons and lined with tall shade trees, the Killian Court opens to a wide view of the Charles River, the low brick buildings of old Boston, and the concrete and glass towers that rise above them.

Interconnected with these central buildings are the Center for Life Sciences (the Dorrance and the Whitaker buildings), the Karl Taylor Compton Laboratories (electronics and nuclear science), the Center for Materials Science and Engineering (the Vannevar Bush Building), the Information Processing Center, the Center for Space Research, the Sloan Laboratory, the Guggenheim Laboratory, and the Center for Advanced Engineering Study.

Across Massachusetts Avenue, on West Campus, is the Student Center (the Julius Adams Stratton building), which contains social rooms, restaurants, offices for student activities, music rooms, a spacious library, and recreational and commercial facilities. The Student Center Plaza is bounded on the west by Kresge Auditorium and on the east by the Chapel. Both buildings were designed by Eero Saarinen. The auditorium contains a large concert hall seating 1,200, a little theatre, offices, and rehearsal rooms.



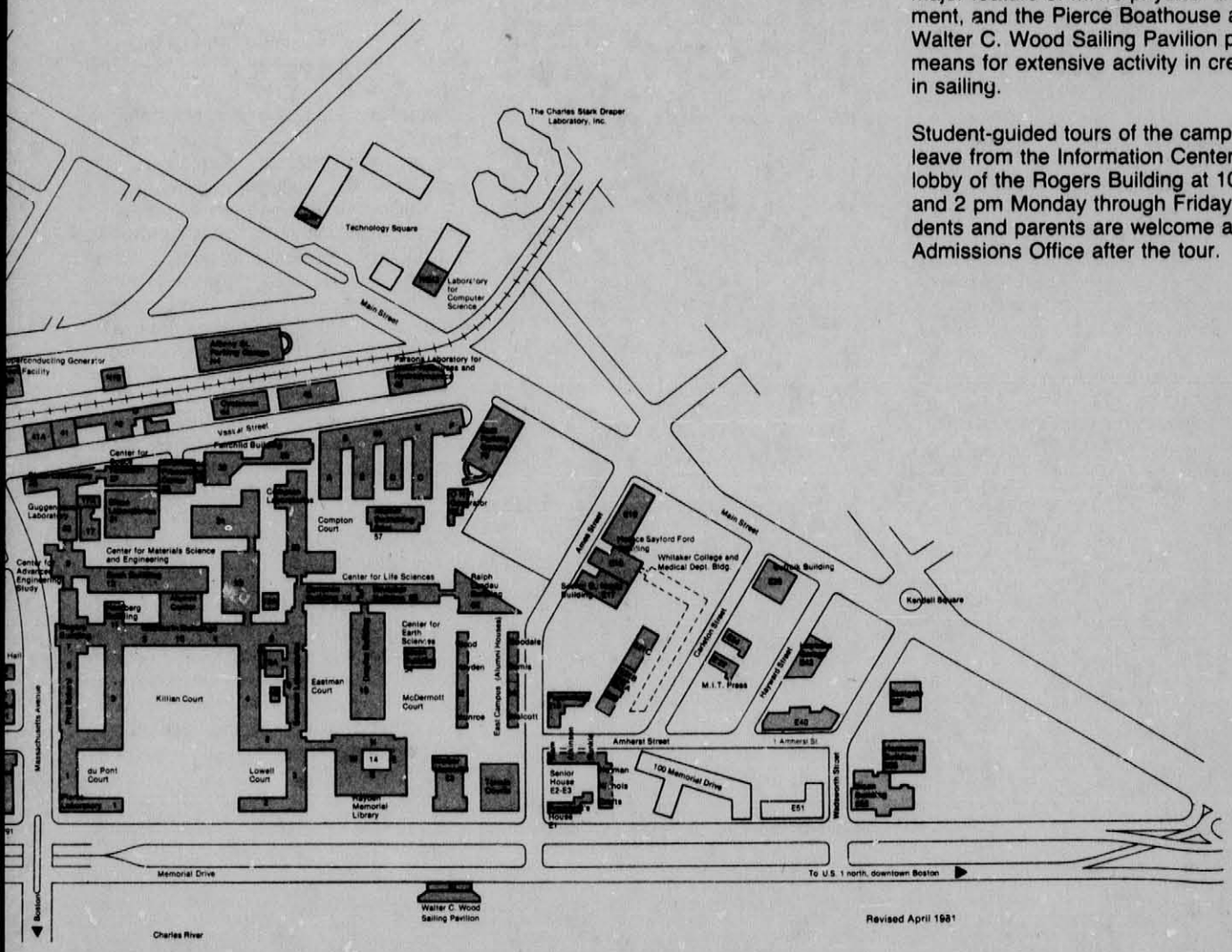
The Chapel is used regularly for religious services by all faiths and is open throughout the day for meditation. The Chapel's unusual design includes an exterior moat that reflects light in changing patterns on the interior walls. Adjacent to the Chapel is the Center for Advanced Visual Studies.

Located throughout the campus is an outstanding collection of contemporary environmental sculpture including works by Henry Moore, Louise Nevelson, Alexander Calder, Pablo Picasso, and Tony Smith. This collection highlights the history, art, and architecture of the Institute.

Along Memorial Drive and facing out on the Charles River are additional student residences, among them the serpentine Baker House, which was designed by the Finnish architect Alvar Aalto. Westgate, an apartment complex for married students, and the Tang residence tower for graduate students are located at the westernmost end of the campus. Also on West Campus are the du Pont Athletic Center and playing fields for soccer, lacrosse, baseball, softball, touch football, rugby, cricket, track, and tennis. The new Indoor Ice Rink-Events Center-Field House was completed in 1980, and Rockwell Cage was renovated to accommodate varsity and intramural basketball, volleyball, and badminton. MIT's Steinbrenner Stadium includes a six-lane, 400-meter, all-weather running track, the first of its kind in North America. The Stadium also includes facilities for the steeplechase and field events, with a game field inside the track oval for intercollegiate soccer, lacrosse, and field hockey games.

The Charles River Basin, which is two miles long and a third of a mile wide, is a major feature of MIT's physical environment, and the Pierce Boathouse and the Walter C. Wood Sailing Pavilion provide means for extensive activity in crew and in sailing.

Student-guided tours of the campus leave from the Information Center in the lobby of the Rogers Building at 10 am and 2 pm Monday through Friday. Students and parents are welcome at the Admissions Office after the tour.



The Boston Environment



MIT is a middle-sized university close to the center of a large metropolitan area. Within a two-mile radius of the Institute are the Museums of Science and Fine Arts, the Gardner Museum, the New England Conservatory of Music, the New England Aquarium, and the Boston Public Library. Students can travel easily to the theatre district where pre-Broadway plays are often previewed and local productions are staged. Among the numerous cultural organizations in the area are the Boston Symphony Orchestra, the Boston Pops, the Boston Ballet Company, the Opera Company of Boston, the Boston Center for the Arts, the Loeb Drama Center, and the Theatre Company of Boston.

MIT is one of more than 50 schools located within the Boston area. Others include Harvard University, Radcliffe College, Boston University, Northeastern University, Boston College, Brandeis University, Tufts University, Simmons College, Wellesley College, and many specialized professional art and music schools. The concentration of academic, cultural, and intellectual activities in the Boston area is one of the largest in the country. As a result, there is an extraordinary variety of young people from all over the country and the world, as well as an impressive range of facilities and activities available to all students.

An hour or two away from MIT by car are the mountains of Vermont and New Hampshire, the ocean beaches of Cape Cod, the lakes and rivers of Maine, the small clusters of fishing towns along the New England coast, and many historical places of interest — Salem, Sturbridge, Lexington, Concord, and Plymouth in Massachusetts alone. The four distinct seasons of New England combined with the varied landscape offer unlimited possibilities for recreation — skiing, mountain climbing, hiking, sailing, swimming, and camping.












LARK
LARK
LARK
3

Organization of the Institute

The governing body of the Institute is a board of trustees known as the Corporation, over which the Chairman presides. Its members include 90 distinguished leaders of science, engineering, industry, and education and (ex officio) the President and the Treasurer of the Corporation. Between quarterly meetings the Corporation functions through its officers and Executive Committee.

The Corporation appoints Visiting Committees for each department and for certain of the other major activities of the Institute. These Committees, whose members are leaders in their respective professions, provide counsel to the departments and in turn make recommendations to the Corporation concerning departmental activities.

The Institute's chief executive officer is the President. In addition, senior administrative officers of the Institute include the Provost, the Associate Provosts, and six Vice Presidents. The academic program is directed by the President, the Provost, the Associate Provosts, and five Deans, each responsible for the undergraduate and graduate programs in one of the five academic Schools. The Institute's 23 academic departments are organized into the five Schools.

The President presides over the faculty of the Institute, which consists of all professors, certain professors emeriti, and a number of administrative officers (ex officiis). Officers of the faculty are the President of the Institute, and the Chairman, the Associate Chairman, and the Secretary of the faculty.

The Academic Council is responsible for the overall administration of the Institute. This group consists of the senior officers, the vice presidents, the deans, the chairman of the faculty, and the director of libraries. Department heads and directors of laboratories and centers join them to form the Faculty Council.

Educational policy for the Institute is determined by the faculty. The MIT faculty meets every month and conducts its business through a number of elected standing committees. The faculty Committee on Educational Policy (CEP), which includes student members, formulates and articulates overall undergraduate educational policy, sponsors educational experiments, and coordinates much of the faculty business. The Chairman of the faculty is ex officio Chairman of the CEP.

The Dean of the Graduate School is concerned with coordinating educational policies of the graduate programs, and the Dean for Student Affairs is directly concerned with all aspects of student life.

The management of research activities, which are financed through contracts with government and industry, is supported by the Office of Sponsored Programs. The Industrial Liaison Program provides industry and other organizations access to research resources at MIT and a means of exchanging information with their MIT counterparts. Through the Program, technological developments made at MIT are transferred to industry for commercial application, and work at the Institute may be coupled to the solution of societal problems.

The MIT Alumni Association has a comprehensive program for keeping some 72,000 men and women, who have studied at MIT, informed of Institute affairs. For example, the Alumni Association publishes *Technology Review*, a nationally circulated journal of contemporary affairs in science, architecture, engineering, humanities, management, and other fields represented among MIT alumni. There are nearly 60 regional MIT clubs throughout the world. The Alumni Fund, through which alumni contribute to the financial mainstream of the Institute, ranks annually among the country's most successful. Alumni activities include conferences, class reunions, and seminars in Cambridge and major cities throughout the United States, as well as a program of communications and directories.

The Association of MIT Alumnae is an organization of former MIT women students with a continuing interest in women currently studying at the Institute. The group maintains and administers its own funds for special financial aid to women students.

Schools, Departments, Courses and Degrees*

See the department's statement for complete information about the specific programs and degrees offered.

Schools and Departments	Undergraduate Courses (and Course Numbers)	Bachelor's Degrees	Graduate Courses (and Course Numbers)	Graduate Degrees
School of Architecture and Planning				
Department of Architecture	Art and Design (IV)	S.B.	Architecture (IV)	M.Arch.
			Architecture Studies	S.M.
			Visual Studies	S.M. Ph.D.
	Architecture (IV-B)	S.B.		
Department of Urban Studies and Planning	Urban Studies (XI)	S.B.	Urban Studies and Planning (XI)	M.C.P. Ph.D.
School of Engineering[1,6]				
Department of Aeronautics and Astronautics	Aeronautics and Astronautics (XVI)	S.B.	Aeronautics and Astronautics (XVI)	S.M., E.A.A., Sc.D., Ph.D.
	Cooperative Course (XVI-B)	S.B.		
Department of Chemical Engineering	Chemical Engineering (X)	S.B.	Chemical Engineering (X)[3]	S.M., Chem.E., Sc.D., Ph.D.
	Chemical Engineering (X-C)	S.B.	Chemical Engineering Practice (X-A)	S.M.
Department of Civil Engineering	Civil Engineering (I)	S.B.	Civil Engineering (I)[3]	S.M., C.E., Sc.D., Ph.D.
			Transportation[5]	S.M.
Department of Electrical Engineering and Computer Science	Electrical Engineering (VI-1[1])	S.B.	Electrical Engineering and Computer Science (VI)[3]	S.M., E.E., Sc.D., Ph.D.
	Computer Science and Engineering (VI-3[3])	S.B.		
	Cooperative Course[2] (VI-A)	S.B.	Electrical Engineering and Computer Science[2] (VI-A)	S.M.

*All footnotes are listed at the end of this chart.

Schools and Departments	Undergraduate Courses (and Course Numbers)	Bachelor's Degrees	Graduate Courses (and Course Numbers)	Graduate Degrees
School of Engineering (continued)				
Department of Materials Science and Engineering	Materials Science and Engineering (III)	S.B.	Materials Science and Engineering (III)[3]	Met.E., Sc.D., Ph.D.
	Materials Science and Engineering (III-A)	S.B.	Ceramics Materials Engineering Materials Science Metallurgy	S.M. S.M. S.M. S.M.
	Cooperative Course (III-B)	S.B.	Polymerics	S.M.
Department of Mechanical Engineering	Mechanical Engineering (II)	S.B.	Mechanical Engineering (II)[3]	S.M., Mech.E., Sc.D., Ph.D.
	Mechanical Engineering (II-A)	S.B.	Textile Technology	S.M.
	Cooperative Course (II-B)	S.B.		
Department of Nuclear Engineering	Nuclear Engineering (XXII)	S.B.	Nuclear Engineering (XXII)	S.M., Nucl.E., Sc.D., Ph.D.
Department of Ocean Engineering	Ocean Engineering (XIII)	S.B.	Ocean Engineering (XIII)	S.M., Ocean E., Sc.D., Ph.D.
	Naval Architecture and Marine Engineering (XIII)	S.B.	Naval Architecture and Marine Engineering (XIII)	S.M.
			Naval Construction and Engineering (XIII-A)	S.M., Ocean E.
	Cooperative Course[2] (XIII-C)	S.B.	Ocean Systems Management (XIII-B)	S.M.
			Ocean Engineering[3] (XIII-W)	Ocean E., Ph.D., Sc.D.

Schools and Departments	Undergraduate Courses (and Course Numbers)	Bachelor's Degrees	Graduate Courses (and Course Numbers)	Graduate Degrees
School of Humanities and Social Science				
Department of Economics	Economics (XIV)	S.B.	Economics (XIV)	S.M., Ph.D.
Department of Humanities	Humanities and Engineering (XXI-A)	S.B.		
	Humanities and Science (XXI-B)	S.B.		
Department of Linguistics and Philosophy			Linguistics (XXIV)	Ph.D.
	Philosophy (XXIV)	S.B.	Philosophy (XXIV)	Ph.D.
Department of Political Science	Political Science (XVII)	S.B.	Political Science (XVII)	S.M., Ph.D.
	Political Science: Public Policy (XVII-A)	S.B.		
Department of Psychology			Psychology (IX)	S.M., Ph.D.
Alfred P. Sloan School of Management[4,6]				
Department of Management	Management (XV)	S.B.	Management (XV)	S.M., Ph.D.
School of Science[4]				
Department of Biology	Life Sciences (VII)	S.B.	Biology (VII)	Ph.D.
	Biology (VII-A)	S.B.		
	Life Sciences (VII-B)	S.B.	Biology[3] (VII-W)	Ph.D.
Department of Chemistry	Chemistry (V)	S.B.	Chemistry (V)	S.M., Ph.D., Sc.D.
Department of Earth and Planetary Sciences	Earth and Planetary Sciences (XII)	S.B.	Earth and Planetary Sciences (XII)	S.M., Ph.D. Sc.D.
			Oceanography	S.M.
			Oceanography[3] (XII-W)	Ph.D., Sc.D.
Department of Mathematics	Mathematics (XVIII)	S.B.	Mathematics (XVIII)	S.M., Ph.D., Sc.D.
	Mathematics (XVIII-A)	S.B.		
	Mathematics (XVIII-B)	S.B.		
Department of Meteorology and Physical Oceanography			Meteorology (XIX)	S.M., Ph.D., Sc.D.
			Oceanography	S.M.
			Oceanography[3] (XIX-W)	Ph.D., Sc.D.

Schools and Departments	Undergraduate Courses (and Course Numbers)	Bachelor's Degrees	Graduate Courses (and Course Numbers)	Graduate Degrees
School of Science (continued)				
Department of Nutrition and Food Science			Nutrition and Food Science (XX)	Ph.D., Sc.D.
			Biochemical Engineering	S.M.
			Food Science and Technology	S.M.
			Neural and Endocrine Regulation	S.M.
			Metabolism and Human Nutrition	S.M.
			Toxicology	S.M.
Department of Physics	Physics (VIII)	S.B.	Physics (VIII)	S.M., Ph.D., Sc.D.
School of Science	Interdisciplinary Science Program (XXV)	S.B.		
Harvard-MIT Division of Health Sciences and Technology			Health Sciences and Technology (HST)	Ph.D., Sc.D.

1
In the departments of the School of Engineering, the S.M. in Technology and Policy is offered under interdepartmental supervision. In the fields of Materials Engineering and Environmental Engineering, programs leading to the degrees of Materials Engineering (Mat.E.) or Environmental Engineer (Env.E.) or Doctor of Science or Doctor of Philosophy are offered under interdepartmental supervision.

2
Five-year Course leading to the S.B. and S.M. awarded simultaneously at the end of the graduate year.

3
See the descriptions of the Joint Programs with the Woods Hole Oceanographic Institution. These descriptions follow the groups of department statements in the School of Engineering and in the School of Science in Chapter VI of this catalogue.

4
Several departments offer the S.M. in Operations Research under interdepartmental supervision.

5
Several departments offer the S.M. in Transportation under interdepartmental supervision.

6
Several departments offer the S.M. in Management of Technology under interdepartmental supervision.







II Campus Life





Campus Activities

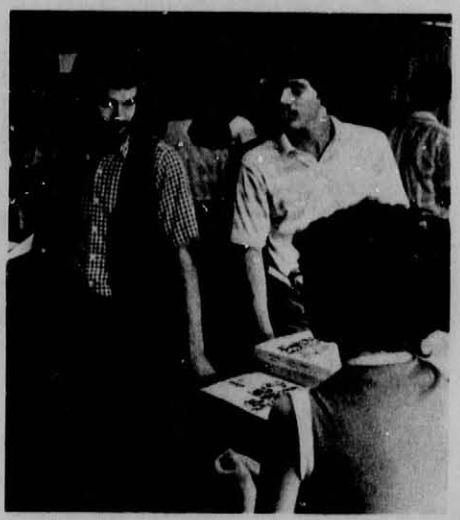
There is more to an MIT education than study and research in classrooms and laboratories. Many activities and services complement strictly academic pursuits, and provide numerous opportunities for students to grow and develop new interests. This chapter describes the range of extracurricular activities on campus; the Institute's housing and dining programs; and the advisory, counseling, and medical services available to students.

Undergraduate Student Government

The MIT Undergraduate Association, to which all undergraduates belong, is the major undergraduate governmental body. A variety of committees is associated with the Undergraduate Association. The Finance Board coordinates budgets and allocates funds to student organizations; its budget hearings are open. The Student Center Committee helps manage the facility and also produces programs, including operation of a 24-hour coffeehouse. The Student Committee on Environment tries to improve classroom and building design and atmosphere and living conditions in the dorms. The Student Committee on Educational Policy proposes educational reforms such as a pass/fail system or an independent study calendar and publishes a course evaluation guide. It also sponsors feedback programs and involves more students in academic departmental decisions. The Student Information Processing Board operates free computer services for student use and advises on computer policy at the Institute. The Association of Student Activities coordinates programs and allocates space. The Nominations Committee recommends student representatives for more than 50 faculty and administrative committees. The Social Committee manages a variety of social and popular music events.

The International Students' Council represents the interests of foreign students at the Institute and sponsors a newsletter, assemblies, and other events.

All living groups, both fraternities and Institute Houses, elect governing councils, responsible for the functioning of their houses. In addition to sponsoring social events, these house councils handle all judicial matters with the respective houses. To deal with the problems of common concern, the fraternities have joined in the Interfraternity Conference (IFC), while the Institute Houses have formed the Dormitory Council. The IFC operates a central food purchasing agency, coordinates and supervises Rush Week, and works to improve relations between fraternities and Boston's Back Bay community by sponsoring an area clean-up and beautification program. The Dormitory Council coordinates common house activities such as freshman orientation, major social events, and handles inter-house judicial problems.



The elected officers of the Nonresident Student Association run a program of tutorial, athletic, and social events for commuting students at the NRSA house on Memorial Drive.

Each class at MIT elects a president and executive committee to handle various class activities.

Graduate Student Government

All graduate students are represented by the Graduate Student Council. The executive body of the Council is elected from representatives of all Courses, Ashdown House, Tang Hall, Eastgate, Westgate, and international students. The Organization encourages social, athletic, cultural, and other extracurricular activities; promotes closer relations between graduate students and faculty outside formal academic exercises; and voices ideas and suggestions of graduate students. The Graduate Student Council sends two representatives to the faculty Committee on Graduate School Policy.



Athletics

The athletic program at the Institute encourages all students to participate in some form of physical recreation. Instruction is offered in a wide variety of activities which may be continued in the years following graduation.

Last year, approximately 900 men and women were active in intercollegiate varsity sports while 4,700 students, seeking more informal activities, joined club and intramural teams. In addition, MIT's sailing program attracts another 1,500 students, faculty, staff, and alumni, and extends sailing privileges to their families.

MIT sponsors varsity sports for men in baseball, basketball, crew (heavyweight and lightweight), cross country, fencing, golf, gymnastics, indoor and outdoor track, lacrosse, pistol, rifle, sailing, skiing, soccer, squash, swimming, tennis, water polo, and wrestling. In addition, there are women's varsity teams in basketball, cross country, crew, fencing, field hockey, gymnastics, sailing, softball, swimming, tennis, and volleyball. Competition includes New England colleges and Ivy League Schools.

The popular intramural program regularly attracts more than two thirds of the undergraduates and a significant number of graduate students. Last year, there were some 1,195 teams with an estimated 11,200 participants, including duplications reflected by those students who competed on more than one team. There are intramural programs in badminton, basketball, bowling, chess, cross country, cycling, fencing, football, frisbee, hockey, pool, rifle, sailing, soccer, softball (fast and slow pitch), squash, swimming, table tennis, track (indoor and outdoor), volleyball, water polo, weightlifting, and wrestling.



Club sports, with intercollegiate competition, but with less formal organization than varsity teams, include football, ice hockey (men and women), rugby (men and women), women's water polo, and white-water kayaking and canoeing. Undergraduate and graduate students participate in both intramural and club programs.

MIT's excellent facilities include the Special Events Center (with an indoor track and ice hockey rink), the du Pont Athletic Center, Alumni Swimming Pool, Walter C. Wood Sailing Pavilion, and Pierce Boathouse. The 20-acre Briggs playing fields include the du Pont outdoor tennis courts. The J. B. Carr Tennis Center includes four indoor courts. Rockwell Cage was renovated last year to accommodate varsity and intramural basketball, volleyball, and badminton. Steinbrenner Stadium features a 400-meter all-weather track, one of the best in the nation.



Lectures, Seminars, and Films

The Lecture Series Committee, an all-student group independently financed by its program of classic and current films, brings outstanding and controversial speakers to the campus. LSC also has cosponsored, with MIT departments or other campus groups, events of cultural, entertainment, or educational significance.

Many nationality groups present movies, as does the Student Center Committee.

Religious Organizations

The long-established programs of the several student religious organizations on the campus are focused about the Chapel and the Student Center. Ministers representing the major faiths devote all or a large part of their time to on-campus activities, counseling with individual students, and advising the student religious organizations.

In accordance with the Chapel's interdenominational status, the Institute has not appointed an Institute Chaplain or Dean of the Chapel. MIT considers that one of its responsibilities is to maintain an atmosphere of religious freedom for all and to provide oppportunity for the exercise of all spiritual interests.

Technology Community Association

Managed by undergraduates, TCA conducts a diversified program of year-round services to the MIT community, including a theatre ticket service, a book exchange, duplicating machines for student use, a print exchange, and annual blood donor and charity drives. TCA also channels volunteers into urban community service projects.

Student Publications

Student publications at MIT include *The Tech*, a student newspaper published twice each week; *The Link* and *Ergo; Technique*, the senior yearbook; *Rune*, an annual literary magazine; *How to Get Around MIT (HoToGAMIT)*, the MIT community guide; and *The Graduate*, a publication of the Graduate Student Council. There are less formal outlets for journalistic talents in the newspapers of the Institute Houses and in departmental newsletters of many kinds.







Music

MIT is a musical community. It has a busy season of musical activities and programs performed by many different musical groups, all of which are open to both undergraduate and graduate students. The Combined Musical Clubs include the Symphony Orchestra, Concert Band, Chamber Players, Festival Jazz Band, Concert Jazz Band, Gospel Choir, Early Music Society, and Chinese Choral Society. There is also a barbershop group, the Logarhythms, and a coed popular music group, the Chorallaries. The Choral Society, which draws its 150 members from the entire MIT community, performs both classical and contemporary choral works.

These organizations give public concerts on the campus, participate in joint concerts on other northeastern college campuses, and take periodic concert tours throughout the East and Midwest.

Chamber music groups, symphonic groups, and concert soloists appear at MIT each year as part of the Humanities Series. Additional chamber music concerts given by faculty and students are regularly scheduled throughout the year. Other professional musical events are sponsored at the Institute by various campus organizations.



Theatre

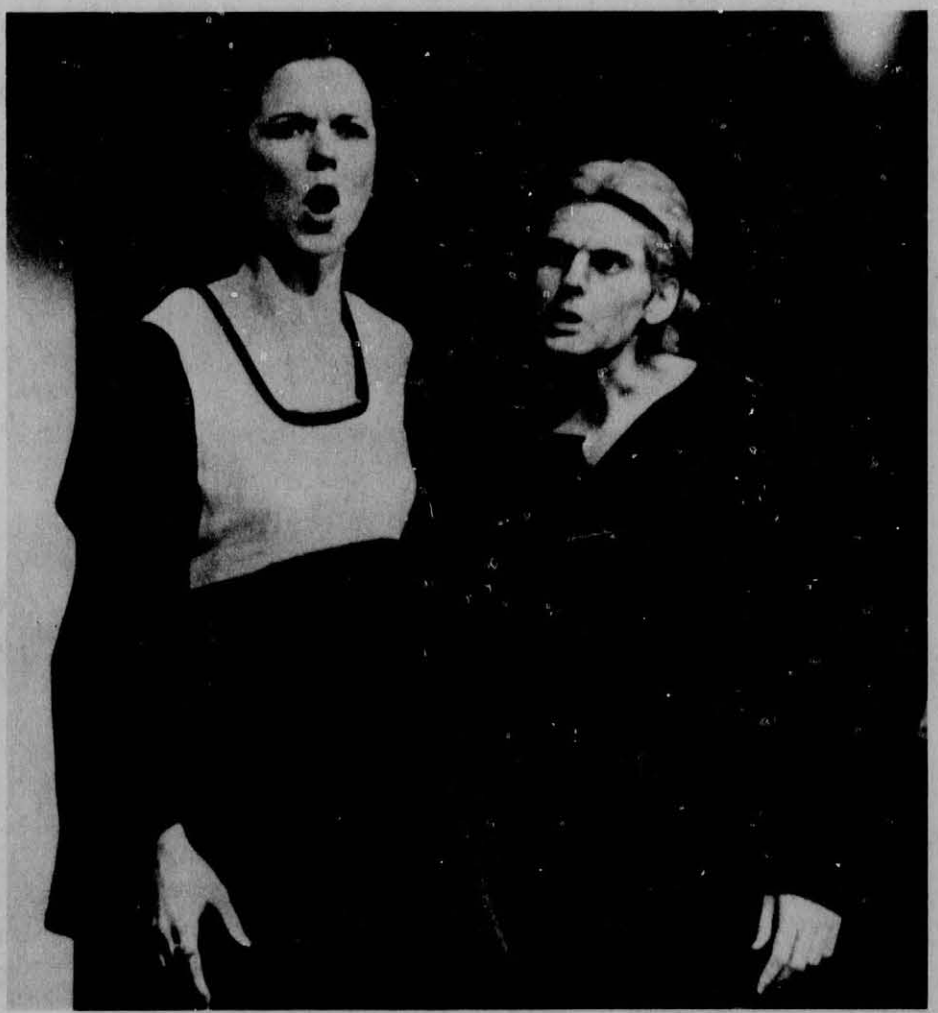
A variety of theatrical performances is presented on the campus by both student organizations and professional groups.

Dramashop, the student drama group, functions under the supervision of the Director of Drama and his assistants, including a set and a costume designer and a technical director. Each year this group presents at least two major productions of full-length plays and several workshop productions of one-act plays directed, designed, and acted by students.

The Musical Theatre Guild produces *Tech Show* (a musical comedy written by students), and a Gilbert and Sullivan operetta or other musical comedy each year.

The MIT Community Players, a group of graduate students and staff and their families, present, under professional direction, a number of plays annually.

The MIT Shakespeare Ensemble produces a spring and fall performance each year.



Special Interest Groups

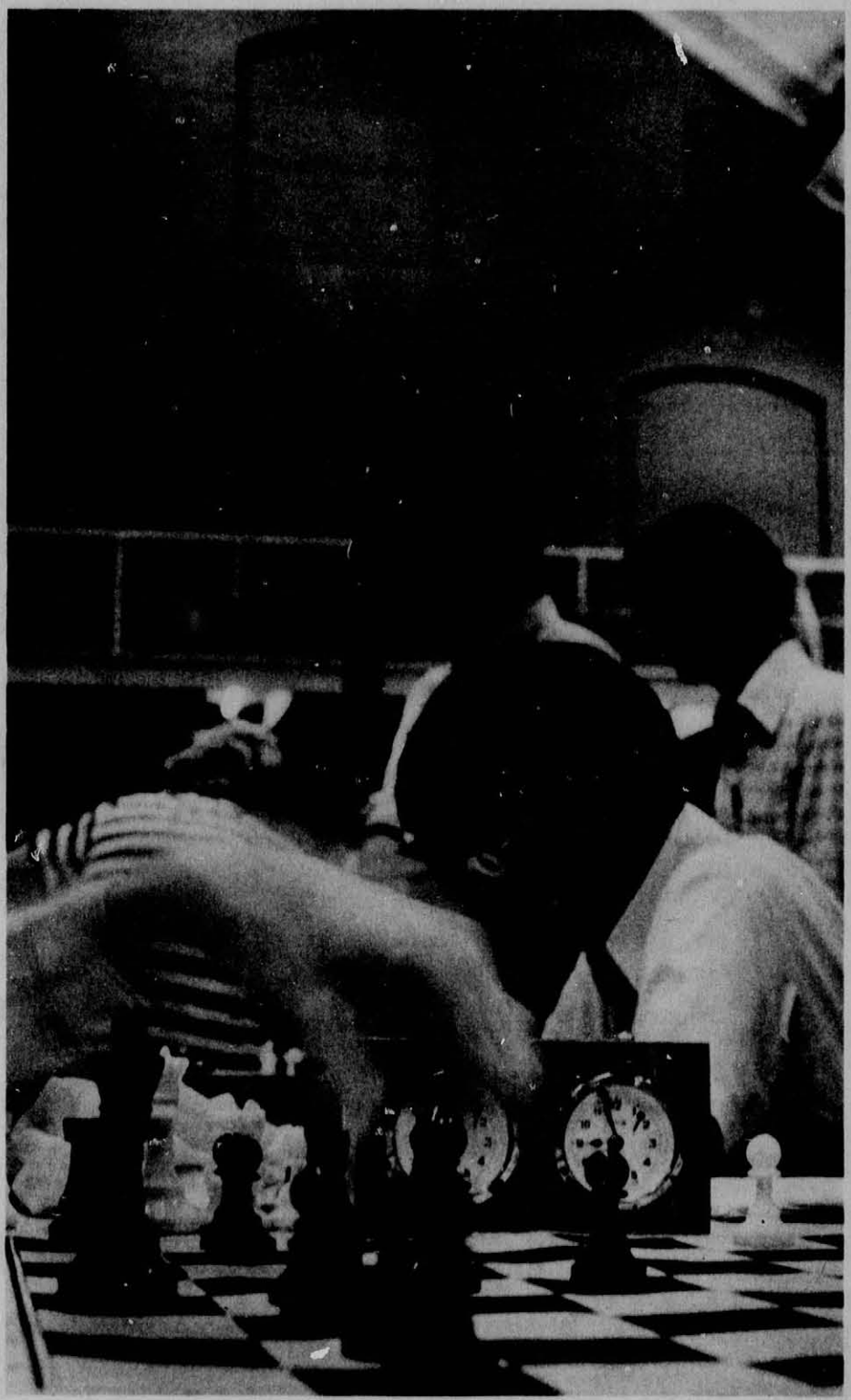
There are more than 80 non-athletic activities and clubs at MIT, many of them open to both faculty and students. Among the most active are the Outing Club, the White Water Club (canoe and kayak), the Hobby Shop, the Debate Society, the "ham" radio station WIMX, WMBR (the FM local broadcasting station), and the Student Art Association.

Many students are actively engaged in social service work in the Greater Boston area. Groups such as the Interfraternity Conference and Alpha Phi Omega, the national service fraternity, sponsor active social service programs.

The MIT Black Student Union (BSU) runs a variety of programs in education, culture, and black students' issues. Numerous nationality clubs sponsor programs for foreign students including discussions and social events. MIT has an active organization of gays, called Gays at MIT (GAMIT). It organizes weekly awareness programs and discussion groups, and sponsors social events throughout the year. The Technology Wives Organization (TWO) is composed of wives of MIT students, both undergraduate and graduate. This social and service organization sponsors a variety of monthly programs.

Dancing of all kinds flourishes at MIT. The Folk Dance Club, the Tech Squares, the Ballroom Dancing Club, and various foreign student groups provide regular opportunities for dancers at all levels of ability. MIT Dance Workshop presents formal programs and supervised instruction as well as sponsoring periodic special courses by professional dancers from the Boston area.

Smaller interest groups include bridge, chess, model rocket, railroad clubs, and strategic games.



Visual Arts Activities

The Committee on the Visual Arts administers the Hayden Galleries, the MIT Permanent Collection, the Catherine N. Stratton and List Student Loan collections, and related non-curricular educational activities. The Hayden Galleries show 12 exhibitions each year focusing on contemporary art and architecture. The Student Loan collections provide prints on loan to students for the academic year following an exhibition each September in Hayden Galleries. The Permanent Collection is sited in offices and public spaces throughout the Institute and is most noted for the outdoor sculpture collection. Educational activities include ArtFacts, a monthly informal gathering open to all members of the MIT community; lectures; symposia; and an extensive publications program in conjunction with Hayden Galleries exhibitions.

The Francis Russell Hart Nautical Museum, housed in the Pratt School of Naval Architecture and Marine Engineering, maintains a fine collection of paintings, prints, photographs, ship plans and models, and working drawings of yachts and small craft by well-known 20th-century designers.

The Creative Photography Gallery displays changing exhibitions of important contemporary photography.

Exhibitions in the Margaret Hutchinson Compton Gallery illustrate the Institute's programs and fields of inquiry. Exhibitions this year included a 10-year perspective of Sea Grant; Heinz Isler as Structural Artist; Paul Lofalley, Class of 1967: Science and Invention as Symbolic Activity; and etchings by three MIT etchers.

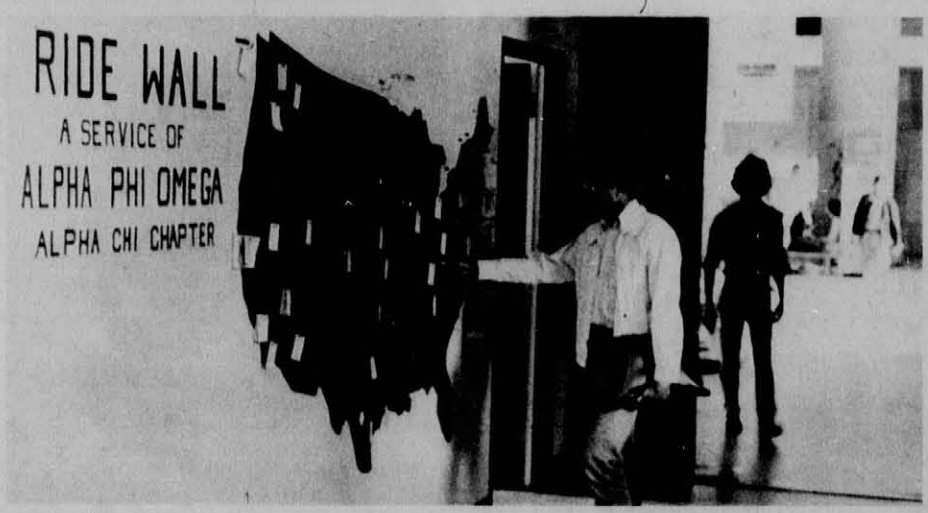


Talbot House

Talbot House, an old New England farmhouse in South Pomfret, Vermont, is owned by MIT and administered by the Office of the Dean for Student Affairs. It was a gift by Laurance Rockefeller to be used by the MIT community.

The atmosphere at Talbot House is relaxed and comfortable. Meals are prepared by a staff cook and served family style. In ever increasing numbers, members of the MIT community are taking advantage of the tranquility at Talbot House to retreat from the noise and commotion of the city. The most frequent visitors to the house have been members of clubs, living groups, and academic groups. Some groups have gone for recreation and a study break; others have found Talbot House to be an excellent setting for special projects, seminars, workshops, or research discussions.

Any group from the MIT community, ranging in size from 15 to 27 people, may request the use of Talbot House. Many considerations, such as the makeup of the group, the intent of the visit, and whether or not the group has ever visited the house, are weighed in determining which groups can be accommodated.



Housing

Undergraduate Single Student Housing

At the undergraduate level, MIT is essentially a residential university. Of the total undergraduate student body of 4,500, about 2,400 single men and women live in the nine Institute Houses on the campus, and about 1,350 single men and women are in other residence groups including 31 fraternities, the cooperative MIT Student House, and the Women's Independent Living Group. A new undergraduate residence which will house 352 students is scheduled to open in the fall of 1981. This will allow for the housing of many transfer students and re-admitted students.

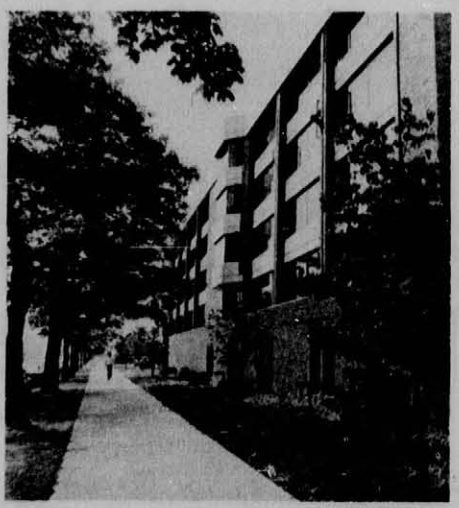
The central purpose of the residential system is to provide an environment conducive to personal development as well as academic achievement. The Institute relies greatly on the initiative and responsibility of both individual students and student government organizations in the residences.

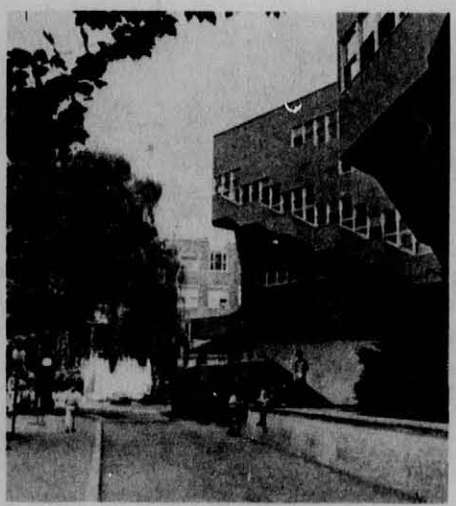
Faculty families chosen for their understanding of and deep interest in students live in each of the Institute Houses. They are not charged with formal academic or operational responsibilities; instead, they welcome informal associations with their fellow residents. In all of the Institute Houses and in some fraternities, Graduate Residents also provide personal and academic assistance to undergraduates.

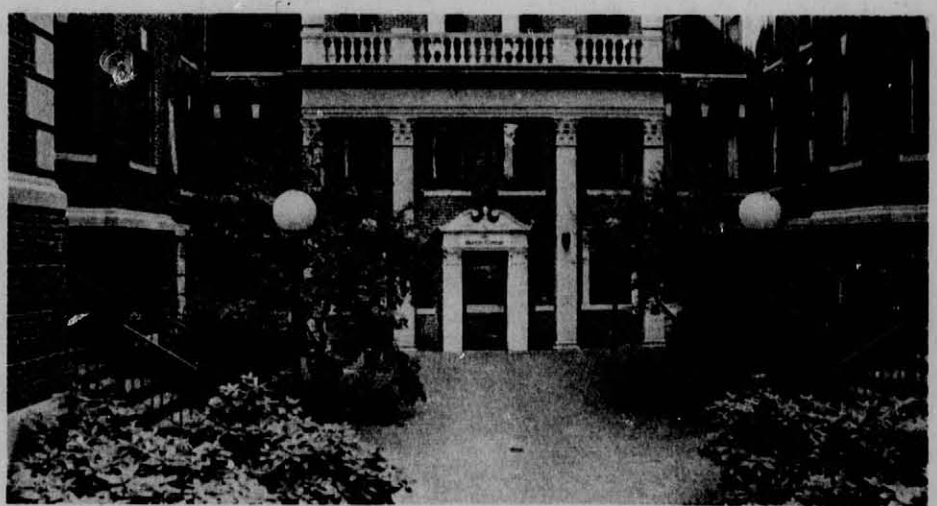
With the exception of McCormick Hall (all female) and MacGregor House (all male), the Institute Houses have coeducational living facilities. However, most of the coed Houses also have "single-sex" living areas within the House. While we are unable to guarantee the assignment of a freshman to any particular House, an effort is made to assign students to one of their top choices. It is also usually possible to transfer from one House to another after the first term.

Student governing groups establish and administer House regulations and maintain acceptable standards of community behavior. Residential student governments also organize a wealth of social, athletic, and intellectual programs for House members. In the Institute House system a house tax determined by the residents of each House is collected by MIT and turned over to the House government to help support these activities. Individual fraternity chapters have similar charges to support their extracurricular programs.

The Institute believes that it is to the great advantage of all undergraduates who do not live at home to reside "on campus" — that is, to live in an Institute House, one of the 31 fraternity residences, the Women's Independent Living Group, or the MIT Student House. Freshmen particularly gain from associations with upperclass students and participation in residence programs. Therefore, all unmarried freshmen who cannot commute daily from their own homes or those of close relatives in the Greater Boston area are required to live "on campus." Exceptions to this "on-campus" living requirement may be made with the approval of the Dean for Student Affairs.







Institute Houses

Everett Moore Baker House

Bexley Hall

Burton-Conner

East Campus Houses — Munroe, Hayden, Wood, Goodale, Beemis, and Walcott

French House

German House

Frank S. MacGregor House

Stanley McCormick Hall

New West Campus Houses — Ballard, Laurence, Coolidge, Desmond

Random Hall

Russian House

Senior Houses — Ware, Atkinson, Runkle, Holman, Nichols, and Crafts

Spanish House

500 Memorial Drive

Rooms in the Institute Houses are engaged for the full academic year. For the year 1981-82, the average rents for the houses range from $677 to $972 per term.

A student cancelling a room assignment later than four weeks before the start of a term will be charged a cancellation fee ranging from $25 up to $60 at the beginning of the term. A student withdrawing from MIT during a regular term will receive a refund based on proration of the term rental over 12 weeks of occupancy.

Meal Plans for 1981-82

The meal plans for all MIT students, graduate and undergraduate, combine the use of points for commons meals and cash for a la carte meals and snacks. This unique plan, with the help of a transaction processor called the Vali-Dine System, provides the students with a wide range of options, flexibility, and financial equity.

In the fall of 1981, freshmen and sophomores living in houses which have dining rooms (Baker House, MacGregor House, McCormick Hall, and 500 Memorial Drive) will be required to take the "360" plan, Basic or Seconds, as a minimum. Freshmen and sophomores in East Campus and Senior House will be required to take the "260" plan, Basic or Seconds, as a minimum.

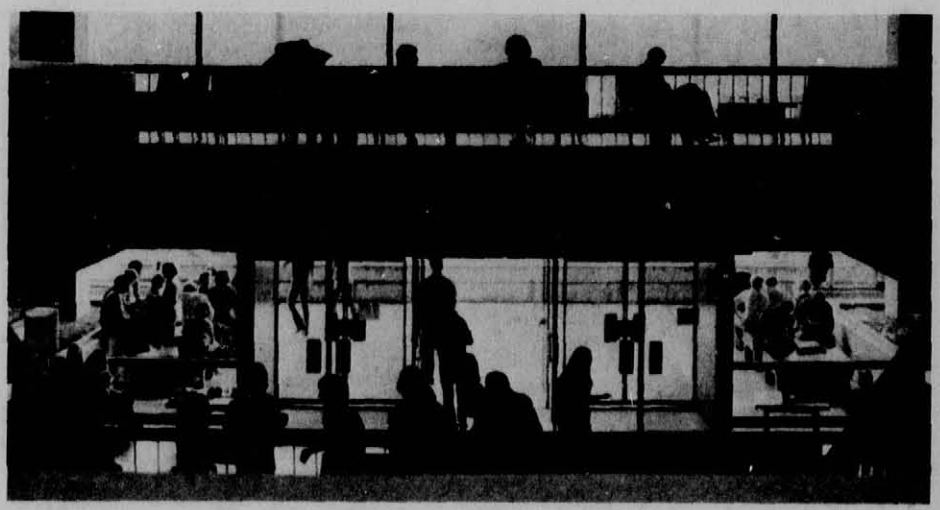
The meal plans as listed are basically the same but with different levels of credit. The plans can be used as points, one point for breakfast, two points for lunch, and three points for dinner in the "commons" house dining rooms or at a la carte prices in Lobdell and 20 Chimneys in the Student Center and Morss Hall and Pritchett in Walker Memorial, and in the snack bar at 500 Memorial Drive. Special arrangements are available for weekends and late evening hours. There will be a full refund of the unused balance on any meal plan to those students who cancel their plan or withdraw from the Institute. The only exception will be for those students who are required to be on a meal plan and do not use their minimum requirement.

Access to the system is through the use of a magnetically encoded photo ID Meal Card and Vali-Dine terminals.

Detailed information about the dining plans, their use during IAP, the options available, the minimum requirements, refunds, the guest policy, and how to use the program is available to freshmen in the *Undergraduate Residence* book and to others in the Food Service Vali-Dine Office in Room E18-375.

Plan Prices per Term

	Basic Plan	Seconds Plan
560 Plan	$698	$826
460 Plan	595	700
410 Plan	544	637
360 Plan	492	574
310 Plan	441	511
260 Plan	389	448
210 Plan	338	385
160 Plan	286	322



Fraternities

Recognized fraternities at MIT include 27 chapters of national fraternities and four local residential groups with no off-campus affiliation. Four are coed. The other 27 house men only. All of the fraternities maintain houses in Cambridge, Boston, or Brookline. Fraternities participate in MIT student government through the Interfraternity Conference.

Each fraternity chapter is self-governing, manages all of its operations and maintenance, and develops its academic, social, membership, recreational, and external policies and programs. The fraternities provide a unique experience in leadership, community planning, and group interactions.

Approximately 95 percent of the fraternity freshmen are pledged during "Residence/Orientation Week," which is held in September just prior to Registration. Normally, about 375 freshmen accept invitations to join fraternities. A few upperclassmen, including transfer students, also pledge fraternities at the beginning of each term.



The Women's Independent Living Group

The WILG is a non-dormitory living group for women in a newly renovated house a short distance from campus. There is a sense of community while allowing for independence and self-governance similar to the fraternities. WILG is also a member of the Interfraternity Conference.

Cooperative Living

The MIT Student House is an independent, coeducational, cooperative living group for financially needy students. It is owned by a corporation of House alumni. The 30 undergraduate members maintain the residence and do all the work except for major repairs. Students cooperate in the management of the House and the academic, recreational, and social aspects of student life. Savings per member are at least $800 a year. Student House is also a member of the Interfraternity Conference.

Nonresident Student Association

Those unmarried undergraduates who commute daily from their own homes or off-campus quarters and who are not affiliated with one of the Institute Houses, fraternity chapters, or the MIT Student House are considered members of the Nonresident Student Association (NRSA). A small fee is charged members to help support the social and cultural programs of this student organization. The fee is currently $5 but may be increased by the NRSA. The focus for NRSA activities is a house on the campus which provides social and study facilities for commuting students, limited overnight accommodations, and a graduate resident tutor. The student governing group has responsibilities similar to those of student governing bodies in the residences.

Off Campus Student Housing

Students who do not live on campus will find help in locating accommodations in the Off Campus Housing Service, Room E18-301, MIT. Listings of available rentals in the Greater Boston area are maintained. The staff attempts, on an individual basis, to help students locate the type of accommodations that will best suit individual preferences and finances. All correspondence should be addressed to Off Campus Housing Service, Box 42, MIT Branch Post Office, Cambridge, Massachusetts 02139.

Additional Information

Additional information on undergraduate housing and application procedures is contained in the publication *Undergraduate Residence at MIT*. Each first-year student is automatically sent a copy of this brochure about three months before registration day of the term for which he or she has been admitted to MIT. Others may request copies from the Office of the Dean for Student Affairs, Room 7-133, MIT, Cambridge, Massachusetts 02139. Information about fraternities also may be obtained by writing to Interfraternity Conference, Room W20-413, MIT, Cambridge, Massachusetts 02139. Information on the MIT Student House may be obtained by writing to the President, MIT Student House, 111 Bay State Road, Boston, Massachusetts 02215.



Graduate Single Student Housing





Approximately 30 percent of the single graduate students reside on the campus in Ashdown House and Tang Hall.

Avery Allen Ashdown House

Ashdown House, located on the corner of Massachusetts Avenue and Memorial Drive directly across from the main buildings of MIT, houses 391 single graduate men and women in single, double, and triple rooms.

A member of the faculty, who is familiar with the aims and problems of graduate students, resides with his family in the House, serving as the Faculty Family in Residence. A student House Executive Committee, acting with the advice and assistance of the Faculty Resident, plans and operates the activities program. Ashdown House, with facilities for social and cultural events, is a center of graduate student activities.

Rooms in Ashdown House are rented for a full academic year; rents average $1,538 per person for the academic year, depending on the type of room.

Ping Yuan Tang Residence Hall

Tang Hall, located on the far western end of the campus, houses 404 single graduate men and women in one-, three-, and four-bedroom apartments. The apartments, unfurnished except for wall-to-wall carpeting, drapes, and kitchen appliances, are rented on a 12-month license to each occupant, beginning September 1. Rents range from $156 to $198 per occupant per month and include all utilities except telephone. Community facilities are available in this building, two tennis courts are located next to it, and limited parking is available nearby at a nominal annual fee.

There is more complete information on both residences in *A Practical Planning Guide for New Graduate Students,* which is automatically mailed to all entering graduate students.

Married Student Housing

Residence in married student housing is limited to regular undergraduate and graduate married students registered and attending MIT whose spouses are present in the residence. Students must be registered for each semester in which they reside in on-campus student housing (except for the summer). Assignments are made on a one-year license-agreement basis beginning on September 1 of each year.

Married student housing is managed by the MIT Housing and Food Services Office, Room E18-301, MIT. Since accommodations in Eastgate and Westgate are limited, married students seeking apartments also are advised to contact the Off Campus Housing Service.

Westgate

This five-building complex, located at the west end of the MIT campus, provides 209 apartments for married student families.

Westgate consists of a 16-story tower with 90 one-room efficiency apartments and 60 one-bedroom units, and four three-story garden-type buildings with a total of 59 two-bedroom apartments.

Eastgate

Located adjacent to Kendall Square at the east end of the MIT campus is Eastgate, a 30-story apartment tower with 197 family units for married students.

In the tower building there are 94 one-bedroom apartments, 84 large one-bedroom apartments, and 19 two-bedroom apartments.

Student Services

Advising and Counseling

The Institute offers a variety of advising and counseling resources. By intention, they are not centralized in a "counseling center." A student is free to choose the resource which appears to be most helpful. Counseling, as the word is used here, refers to casual conversations and to scheduled appointments; it ranges from the providing of information to skilled psychotherapy.

The Freshman Handbook and *How to Get Around MIT* list in detail the counseling resources at MIT. Only a short summary is given here. Each student has a faculty advisor. The Office of the Dean for Student Affairs has several members whose time is almost entirely devoted to counseling all students, whether the situation is academic or personal or both. Faculty and graduate residents and tutors are available in the Institute Houses, and some fraternities have graduate residents. Frequently a student is able to get the help he or she wants from a fellow student or from an instructor who is not officially a faculty advisor. Coaches and activity advisors also can often be helpful.

Several offices specialize in particular areas. They include the Student Financial Aid Office, which includes student employment, the Office of the Advisor to International Students, the Religious Counselors, and the Career Planning and Placement Office. The Campus Patrol is frequently of help to students. For students considering particular fields, there is a Premedical Advisory Council, a Prelaw Advisory Council, and a Foreign Study Advisor.

The services provided by the Medical Department are described next. Many students consider the members of the psychiatric staff to be among the Institute's most skilled counselors.

Medical

The MIT Student Health Program consists of medical services available on campus and of hospital and accident insurance in which all regular students are enrolled unless they submit a written request to waive coverage.

All regular and special students are entitled to comprehensive health care services given by the Medical Department on campus and in the MIT Infirmary without further charge except for obstetrical care, routine eye examinations, contact lens service, ear piercing, dental care, missed appointments, contraceptive devices, and those surgical procedures and outside diagnostic tests which should be covered by the student's hospital and accident insurance policy. Student spouses may use the Department on a fee-for-service basis or receive the same benefits as a student at no extra charge by paying the $250 Health Service fee for coverage from September 1, 1981 through August 31, 1982.

The MIT Medical Department is a multispecialty group practice which employs 30 full-time and 40 part-time physicians as well as other professional support personnel. The Department's medical staff provides primary care in the areas of internal medicine, surgery, and pediatrics. Specialists are also available in gynecology, orthopedics, ophthalmology, urology, allergy, neurology, nutrition, endocrinology, dermatology, otolaryngology, pathology, radiology, psychiatry, and social work services. The Department provides a full-time optometry service including contact lens services. Laboratory, x-ray, and other diagnostic testing facilities are also available, as is a health education and patient advocacy service.

A dental service, which offers dental treatment for students and their spouses, is available on a fee-for-service basis. Pediatric service is also available on a fee-for-service basis.

Initial consultations with a member of the psychiatric service are available to all students and their spouses without charge. Prolonged psychiatric treatment cannot be provided by the Institute psychiatric staff; students requiring such treatment will be referred to private psychiatrists or psychiatric clinics in the area.

Prior to matriculation, every student, undergraduate or graduate, is required to submit an MIT entrance medical form completed by the student and his or her personal physician, which is mailed to the Assistant Medical Director. This form consists of historical information, immunization record, physical examination, and specified laboratory studies. In addition, freedom from active tuberculosis as evidence by an intradermal skin test or chest x-ray is mandated by public health requirements and cannot be waived. If a student has not returned the pre-entry physical form by the time he or she enters MIT, the student will be required to have it completed by the Medical Department. There will be a charge for this service.

An 18-bed infirmary is operated by the Medical Department for students with acute illness or contagious diseases who cannot be cared for in their dormitories or other living groups but for whom hospitalization in a general hospital is inappropriate. Children are not admitted to the Infirmary, but if necessary, are referred to a nearby hospital offering pediatric care. Patients requiring major surgery or treatment for serious illness are sent to one of the Boston or Cambridge hospitals where their care is usually supervised by one of the Medical Department physicians or surgeons.

All visits to the Medical Department are by appointment except in emergencies. The regular hours of the Department are from 8:30 am to 5 pm, Monday through

Friday except for holidays. At all other times emergency medical care is available through the MIT Off-Hours Service. Advice may be obtained day or night by calling 253-1311. Visits to dormitories, fraternity houses, or private dwelling units are not made, but if a student is too ill to come to the Infirmary without assistance, the Medical Department should be notified and will recommend suitable help.

Except under unusual circumstances and with the approval of the Medical Director, health care services covered by the MIT Medical Department do not include the cost of medical care given off campus or hospitalization except in the MIT Infirmary. The cost of hospitalization and outside medical care for serious illness or injury is extremely high; in Boston-area hospitals it exceeds $400 per day. For this reason, it is extremely important that students maintain adequate health insurance. All regular students will be enrolled automatically in the MIT hospital insurance program. US citizens covered under their own or their family's policy must request waiver of the MIT coverage by completing the form enclosed with the Financial Registration material. All non-US citizens must demonstrate that they have coverage equivalent to the MIT insurance by submitting a copy of their insurance policy to the MIT Medical Department Student Insurance Office together with the completed waiver request.

Special students taking two or more courses may elect to purchase the MIT hospital and accident insurance.

Annual Rates (September 1, 1981–August 31, 1982)

	MIT Medical Department	Hospital & Accident Insurance
Student	included in tuition	$168
Spouse	$250	$456
Child(ren)	fee for service	$156

Career Planning and Placement

The Career Planning and Placement Office serves students seeking information and advice on employment, opportunities for further study, and careers.

The Office staff are happy to talk with students on an individual basis about their plans. The Office also arranges seminars at which alumni and others discuss the rewards and frustrations of their own career fields. The Office maintains a comprehensive library containing information on careers, specific employers in industry and government, courses of graduate study, and fellowships. Information about opportunities for work and study abroad is also available.

More than 350 companies, government agencies, and graduate schools make recruiting visits to the Career Planning and Placement Office each year. These visits are publicized in descriptive notices which are posted throughout the Institute. All bona fide employers (employment agencies are excluded) are given access to the facilities of the Office on equal terms. Their coming to the campus gives students a valuable opportunity to discuss employment prospects with different organizations.

The Office, through its Alumni Placement section, is in continual correspondence with employers seeking experienced personnel. Notices of vacancies are received from all parts of the nation and abroad. The Office also assists alumni interested in a change of job or of career.

Child Care Services

The Child Care Office was established to help families with young children locate suitable child care arrangements. There are currently four programs operating on the MIT campus which between them can accommodate children from infancy through kindergarten. All of the programs reflect the great diversity of cultures that one finds at the Institute.

Family Day Care is organized by the Child Care Office and is an arrangement in the home of a day care provider who has been licensed by the Commonwealth of Massachusetts. Each family day care home operates independently offering its own attitudes and activities. The Child Care Office puts providers and users in touch with each other. Actual arrangements are made by the families involved. Fees range from $1.75 to $3.50 per hour. Family day care homes are located in Eastgate and Westgate, as well as in other parts of Cambridge and surrounding communities.

Technology Children's Center, Inc. (TCC) is a private, non-profit corporation which operates a variety of programs on campus for children who are at least two years and nine months old.

The nursery school follows the academic calendar and offers a morning program from 8:30 am to 1 pm. Children may be enrolled for two, three, or five mornings a week. In addition to the regular session from September to May, there is also a six-week summer program. There are two nursery school classrooms, one in Eastgate and one in Westgate. Fees for the 1981-82 school year are $1,558 for five mornings; $935 for three mornings; and $623 for two mornings.

Rules and Regulations

Conduct, Discipline, and Grievance Procedures

The day care program offers full-time, year-round care from 8 am to 5:30 pm, Monday through Friday. The center is located at Eastgate. The comprehensive fee for 1981-82 is $3,850. Fees are prorated for less than full-year enrollment.

For children who need kindergarten plus full day care, the Extended-Day Kindergarten program is available at Eastgate. Children must be at least four years and nine months old. The program operates from September until mid-June when summer camp season begins. The hours are 8 am to 5:30 pm, Monday through Friday. The comprehensive fee for 1981-82 is $3,528.

In addition to coordinating all of the programs on campus, the Child Care Office maintains information about programs located in other parts of Cambridge and surrounding communities. Every effort is made to find the arrangement that is most suitable for an individual family. Further information may be obtained from Margaret Sand, Child Care Coordinator, Room 4-144, MIT Cambridge, Massachusetts 02139, (617) 253-1592.

MIT assumes that all students come to the Institute for a serious purpose and expects them to be responsible individuals who demand of themselves high standards of honesty and personal conduct. Disappointments in this expectation have been rare.

Fundamental to the principle of independent learning and professional growth is the requirement of honesty and integrity in the conduct of one's academic and nonacademic life. Maintenance of a healthy living and learning environment requires that all members of the community exercise due respect for the basic rights of one another. Cheating, plagiarism, and other forms of intellectual dishonesty are considered serious offenses against the academic community. In addition, harassment on the basis of sex, race, color, religion, national origin or sexual orientation is specifically in conflict with Institute policy.

Violations by students of MIT regulations such as those governing living groups, parking, and the improper use of MIT's name, keys, telephones, and so forth, render the offender subject to institutional penalties.

Off-campus misconduct will not be the basis for disciplinary action unless it is deemed by the Institute a clear and present danger to the functions of the Institute. The Institute determines its jurisdiction under this policy for each case. Student status in no sense renders a student immune from the jurisdiction of civil courts and other civil authorities according to the law of the land. However, MIT does handle many infractions of the civil or communal code internally — according to Institute policies and procedures. This is done with the understanding by the outside community that MIT will deal seriously with such offenses. (Almost every large institution in society has its own processes which are deferred to by the civil authorities so long as the internal processes are adequate and functioning.) Serious infractions of city, state, or Federal laws, however, are referred to the civil authorities.

If an infraction causes a student to be involved both in Institute judicial proceedings and court proceedings, and if an Institute decision might prejudice the court case, the Institute will usually hold its decision in abeyance until after the court proceedings have reached a conclusive point.

MIT traditionally has placed considerable responsibility on student governing groups to deal with problems in the student community. Nearly all Institute Houses and independent residences have judicial procedures, organizations, and/or designated persons who deal with disputes and violations of rules and regulations occurring in their living groups.

Many problems, difficulties, and disputes which involve possible infractions are referred to the Office of the Dean for Student Affairs for advice and guidance. For many minor infractions, where the facts of the case are not in dispute and there is no reason to carry the case further, the Dean may put a student on informal probation by placing a disciplinary notation on the student's record in that Office.

Most cases of academic offenses are properly handled directly between the faculty member and the student involved. In some cases it may be appropriate to have the department head assist in the resolution of the matter. In those or any other situation where a student feels wrongly accused and unjustly penalized, the student may request the Dean for Student Affairs Office to enable the case to be brought to the Committee on Discipline (COD) for a hearing.

The COD is composed of seven faculty members, five students, and the Dean for Student Affairs, ex officio. This Committee handles allegations of academic offenses, violations of Institute regulations and standards, and those infractions of city, state, and Federal laws which are referred to it. The Committee may also hear appeals of cases heard elsewhere within the Institute.

The procedures of the Committee on Discipline are given in the "Statement of Disciplinary Committee Procedures" which is available from the Office of the Dean for Student Affairs. Anyone in the MIT community may bring charges (including individual students, faculty members, and those who have particular or general administrative responsibility at the Institute). To bring charges against a student, a written complaint must be submitted to the Office of the Dean for Student Affairs or to the chairperson of the Committee on Discipline. There are procedures by which the rights of a student are ensured, including assistance in preparing a defense. Statements at the Committee hearings are made by the person who brought the original charge, by the student who is charged, by an advisor from the MIT community chosen by the student, and by witnesses. The sanctions available to the Committee include a reprimand, informal probation, and formal probation with or without monitoring. In an extreme case, the Committee may recommend to the President that the student be suspended or expelled. Formal probation may be noted on the student's transcript; suspension and expulsion will always be so noted. Such notation may be removed upon written application to the Committee under conditions given in the statement referred to above.

Students who believe that they have been treated improperly for any reason are encouraged to seek resolution of their grievances. Grievances vis-a-vis other students should be pursued as outlined in the paragraphs above. For grievances relating to their academic or work situations, students should seek resolution directly with their professors, instructors, academic advisors, and immediate work supervisors — as appropriate to the nature of the perceived unjust treatment. If a problem cannot be resolved at this level, students should either seek assistance from their department heads or deans or avail themselves of the assistance of the Office of the Dean for Student Affairs or the Office of the Dean of the Graduate School. Students may also choose to bring the problem to the attention of the two Special Assistants to the President.

It is Institute policy that individuals will not be reprimanded or discriminated against for initiating an inquiry or complaint and that the rights of the individual against whom a complaint is made are protected.

Additional information on conduct and discipline may be found in the position paper by the Committee on Discipline entitled "Infractions of the MIT Code and Violations of Law," which is available from the Office of the Dean for Student Affairs. Section 3.16 of the MIT *Policies and Procedures* contains a statement of the Institute's policy on harassment, and a description of the Revised Grievance Procedures for students and all persons employed at MIT may be found in section 3.24 of that publication.

Privacy of Student Records

The Family Educational Rights and Privacy Act of 1974 (FERPA) gives students certain rights, consistent with the privacy of others, to review records, files, and data held about them on an official basis by the Institute, and also gives students a right to challenge the content of those records, files, and data which they believe are inaccurate, misleading, or otherwise in violation of their privacy and other rights. This Act also imposes certain controls on access to information about students.

Under the Act, "education records" means those records which are directly related to a student and are maintained by MIT. Education records at MIT include those that are kept by the offices of the Registrar, Admissions, Dean for Student Affairs, Dean of the Graduate School, Student Accounts, Student Loans, Student Financial Aid, UROP, academic departments and advisors, standing committees of the faculty, Alumni Association, and the Archives. Certain records are not included as education records under the Act. They include: personal files held by Institute faculty and staff that are not accessible or revealed to others, certain records of the Campus Patrol, and medical records maintained by the Medical Department.

Review of Records and Challenges to Record Content

Subject to the exceptions stated below, all education records of the Institute that are identified with an individual student or former student will be available for review at the request of that individual. A student may make a request directly to the custodian of the record or to the Office of the Dean for Student Affairs. A student shall not be permitted to review those portions of his or her education record that refer to other identified students. Individuals may challenge the content of their education record with the custodian or through the Office of the Dean for Student Affairs. If a dispute remains pertaining to the accuracy or completeness of the record, the student shall be afforded a hearing.

Information about students assembled prior to January 1, 1975, under promises of confidentiality, explicit or implicit, will not be made available for review by the concerned students without the written consent of the author. A letter of recommendation that was placed in a student's education record after January 1, 1975, will not be made available to the student for review, if the student has previously waived his or her right to review that specific letter.

Under the Family Educational Rights and Privacy Act of 1974, an MIT student who has applied for admission, but has not yet attended, another component unit of MIT (e.g., a graduate school or department) does not have the right to review his or her education record within that component unit unless and until the student begins to attend that unit. However, individual departments may choose to disclose such information to such a student.

Although medical records maintained by the Medical Department are not considered education records under the Family Educational Rights and Privacy Act of 1974, tney are regulated by Massachusetts law relating to the rights of patients and residents of health facilities. Under this law, students have the right to confidentiality of their medical records as well as the right to inspect and to obtain a copy of these records.

Disclosure of Information about Students

Disclosure of information in education records to persons within or outside the Institute, except as indicated below, requires the student's written consent. The written consent must be signed and dated and must include a specification of the records to be disclosed, the purpose of the disclosure, and the party to whom the disclosure may be made. Upon request, the student shall be provided with a copy of a record that is disclosed pursuant to this consent. A record of each request and of each disclosure must be made part of the education records to which a student has access. Institute officials may have access, without the student's prior consent, and without a record being made, to specific student records in which they have a legitimate educational interest. For this purpose, Institute officials include both academic and administrative personnel. Only those Institute officials acting in a capacity intended to further the educational interests of the student and possessing a clear need to obtain information about the student may have access to that information. For example: faculty advisors may have access to relevant education records of their advisees. In addition, custodians of students' educational records shall exercise responsibility to treat personal information with appropriate care and discretion and not exchange such information unnecessarily, and to ensure that the transfer of information between persons not in the same office or working group serves a legitimate Institute purpose. (Where such transfer is unusual, prior notice should be given to the individual and where practicable, permission should be obtained.)

Under the Family Educational Rights and Privacy Act, education records may be disclosed without a student's prior consent to officials of another institution in which the student seeks or intends to enroll, or in which the student is enrolled concurrently. In such cases, the student must be notified of the disclosure, provided with a copy of the disclosed records if he or she requests, and granted an opportunity for a hearing to challenge the contents of the disclosed records. All education records that are released to persons or organizations outside of MIT must be released on the condition that they will be used only for their stated purpose and that no other party will have access to them without the student's written consent. The disclosed material should contain a statement to the effect that acceptance of these materials constitutes an agreement to abide by this condition.

Certain personally identifiable information from a student's education record, designated by the Institute as directory information, may be released without the student's prior consent and without a record being made. This information includes: name, term and permanent addresses, term phone number, department, class, degrees received, dates of attendance, and, for an intercollegiate athletic team member, weight and height. A student has the right to withhold the designation of any or all of these categories of information on himself or herself as directory information. To exercise this right, a student should submit by the end of the second week of the fall term a request form available from the Registrar. Intercollegiate athletic team members who wish to withhold the designation of weight and height as directory information should contact the Sports Information Director in the Athletic Department. The *Student Directory*, although it contains most of the information listed above, is intended primarily for use by members of the MIT community. Information in the *Directory* may be made available to persons outside of MIT only in response to inquiries about specified individuals. Providing the *Directory* or similar listings to persons outside MIT or using the *Directory* for non-Institute purposes is prohibited. Massachusetts law permits local municipalities to obtain census information, similar to directory information, pertaining to students living in MIT residences. In the case of court orders or subpoenas for information, the affected individual should be notified immediately and the release of such information should then be made only by an officer of the Institute who has been specifically authorized to do so.

Letters of Recommendation

A student's request for a letter of recommendation to be written by Institute faculty or staff constitutes a consent to disclosure and should, therefore, be made in writing.

A student or former student may **voluntarily** waive his or her right to review or receive copies of letters of recommendation or other documents sent to MIT or written by a member of the MIT faculty or staff in connection with admission to educational institutions, employment, or consideration for an honor or recognition. Such a waiver must be in writing and must include adequate identification of the concerned individual, the author of the letter, and the purpose for which the letter is intended. Such waivers must not be required as a condition for admission to, receipt of financial aid from, or receipt of any other services or benefits from any agency or institution. Faculty and staff should take care not to encourage waivers unnecessarily.

Personal Files

The personal files of members of the faculty and staff which concern students, including private correspondence and notes which refer to students, are not regarded as education records and are not per se subject to review by students. However, if the personal files are made available to others within the Institute or to parties outside MIT, then they are part of a student's education records, and the student has a right to review those personal files.

Statement of Institute Policy

Questions concerning the policy may be directed to the Dean for Student Affairs; Chairman of the Committee on Privacy; or the Vice President in the Office of the President, who is the senior officer responsible for overseeing Institute operations with respect to the protection of individual privacy. Students who believe that their rights under the Act have been abridged by the Institute may file complaints with the FERPA Office, Department of Education, Washington, DC 20201.

Motor Vehicles

All motor vehicles operated by students must be registered each year with the MIT Campus Patrol. Failure to register will result in a $25 fine. This registration is required whether or not a parking sticker is obtained. Students also should note that state law requires that out-of-state cars operated by students be registered with the Campus Patrol.

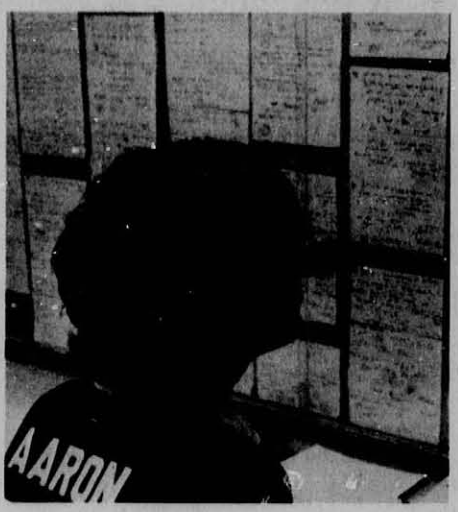
Parking facilities at MIT are limited. In general, the Institute cannot provide parking for resident students. With the approval of the Dean for Student Affairs, a limited number of spaces is available for assignment to students with physical handicaps requiring use of an automobile and to a few other undergraduates. Recent regulations issued by the US Environmental Protection Agency require a continual reduction of the total number of available parking spaces. Also proposed is a plan to prohibit on-street parking in Cambridge from 7 am to 10 am.

Students who plan to bring motor vehicles to Cambridge should take careful note of the information regarding pertinent Massachusetts laws which is mailed with registration material. In addition, since the rate of car thefts in this state is the highest in the nation, serious consideration should be given to equipping automobiles with antitheft devices.





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III Undergraduate Education at MIT







Academic Programs

The Freshman Year

The undergraduate programs at MIT are designed to help students develop the understanding, maturity, and capabilities needed to meet the challenges of modern society. An MIT education has its roots in science and engineering, with a view to joining the power of these disciplines with a concern for human values and social goals. As undergraduates, students are encouraged to develop a basic knowledge and a continuing interest in a given field, and to become creative intellectual explorers who know how to keep learning on their own.

One of the most exciting features of undergraduate education at MIT is the opportunity for students to join with faculty in ongoing research projects. Such experiences, through the Undergraduate Research Opportunities Program, encourage intellectual commitments and self-direction, and often provide a focus for students' undergraduate studies. There is also an Independent Activities Period each January during which students can spend time in workshops, independent research projects, intensive seminars, field trips, lecture and film series, and other activities which do not easily fit into the traditional academic calendar.

MIT students base their studies on a core of subjects in science, mathematics, and the humanities (the General Institute Requirements), and then go on to major in one of the engineering fields, in the physical or life sciences, in management, in architecture or urban studies and planning, or in an area in the humanities or social sciences. In the first year, most students take a program of subjects in mathematics, physics, chemistry or biology, and humanities. (In order to enable first-year students to study in ways that best suit their preparation and learning styles, there are a variety of ways to complete the core subjects. Two of these are distinctive freshman programs called Concourse and the Experimental Study Group, which are described later in this chapter.) During the second year, students generally continue their studies with subjects meeting the various Institute requirements and with the beginning subjects in the departmental programs. In the third and fourth years, students concentrate on the departmental program which they selected as their major Course of study.[1] In addition to departmental programs, it is also possible to study and even major in one of a growing number of interdepartmental fields, such as environmental or energy studies, biomedical engineering, communications science, humanities and engineering, and humanities and science.

In addition to the departmental or major program, there is time for students to take elective subjects each year. These elective opportunities allow students to follow special interests or to enrich their educational background. Alternatively, a student may use elective time to prepare for advanced study in a professional field such as medicine or law; for graduate study in an area in which MIT gives no undergraduate degree, such as meteorology or psychology; or for advanced study in an interdepartmental field.

For most students, the program for the Bachelor of Science normally requires four years of full-time study. To complete work for a bachelor's degree in any Course, each student must fulfill the General Institute Requirements and must complete the departmental program specified by that Course. Details on General Institute Requirements and on selecting a major Course of study are discussed later in this chapter.

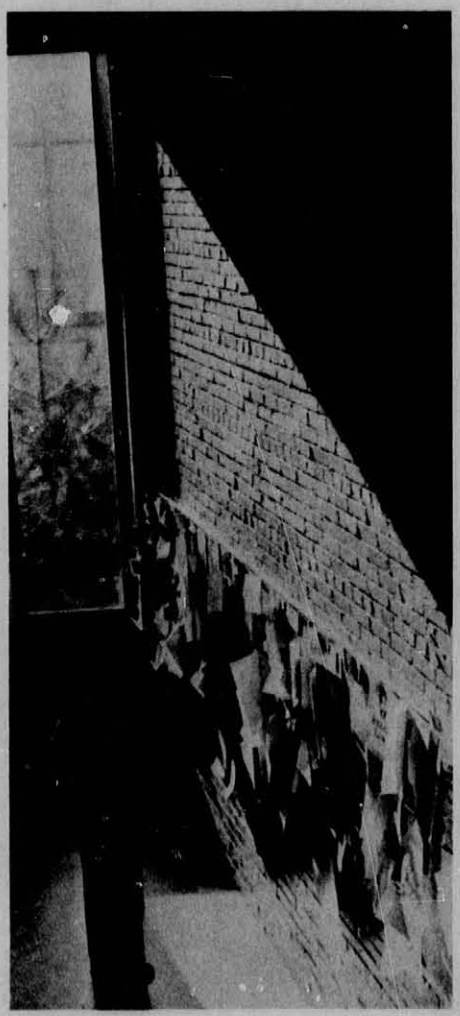
During the first year at MIT, most students take a program which includes among its subjects mathematics, physics, chemistry or biology, and humanities. There is a variety of ways in which a student can prepare for further undergraduate study as well as fulfill the Institute degree requirements. Students may choose from a range of specific subjects, or they may enroll in one of the alternative freshman programs — Concourse or the Experimental Study Group — described below.

In order to fulfill the Institute degree requirements, those freshmen following the more traditional subject-by-subject format may choose one of four sequences in mathematics, one of five subjects in the chemistry/biology area, from among one of three sequences in physics, and from a designated list of subjects in the humanities, arts, and social sciences. Classes typically meet one to four times a week in some combination of lecture and recitation modes, with laboratory and tutorial sessions depending on the subject. All subjects taken by freshmen are graded on a pass/fail basis.

For students entering with only the preparation implied by the entrance requirements, a typical program for the first year would include two terms of physics, two terms of calculus, two terms of humanities, one term of chemistry or biology, plus one or more elective subjects perhaps including an undergraduate seminar. Some freshmen also elect to become involved in the Undergraduate Research Opportunities Program (described later in this chapter). Entering students with degree credit for one or more of the first-year subjects may substitute more advanced subjects or may use the time made available for electives or Science Distribution subjects. The procedures by which degree credit at entrance is earned are described under Admissions in this chapter.

1
A complete list of undergraduate Courses and degrees is given in Chapter I of this catalogue. At the Institute the capitalized word **Course** refers to an organized curriculum leading to a specified degree. The lowercased word **course** or **subject**, on the other hand, refers to the individual classes. Each Course is designated by a Roman numeral; individual subjects are given Arabic numerals to correspond with the Course numbers. For example, Civil Engineering is Course I; 1.05 indicates a subject given in the Course in Civil Engineering.

Most students build their freshman programs from among the basic subjects mentioned above. The Concourse Program and the Experimental Study Group, which offer alternatives to the more traditional lecture/recitation, subject-by-subject format, have their own faculty, meeting place, and methods of operation. In these programs, students make progress comparable to that of other freshmen, but the manner in which individual Institute degree requirements are met varies both between the programs and among students within each program. In both programs there is a high level of student-faculty interaction.



Concourse Program

A student who chooses the Concourse Program becomes a member of a group of about 50 freshmen working with a team of five to seven faculty members in a year-long program of study that deals with interactions of ideas and methods from engineering, science, and humanities. Concourse has operated as an alternative program for freshmen since 1971, and has been made a regular part of the MIT curriculum. A main goal of the Program is to explore both the unity and conflict of humanistic and technical viewpoints and ideas. The general theme is "Man, Machine, and Meaning," a study designed to treat the mutual relevance of freshman calculus, physics, chemistry, biology, and humanities in the context of topics such as information theory, computation, physiological psychology, perception, the structure of history, the uses and construction of models, and the mind-body problem.

The Concourse faculty members, representing different professional disciplines, collaborate closely in the planning and teaching of the curriculum, which fully treats the subject matter of Institute Requirements while branching out into related topics. Regularly scheduled class sessions are supplemented by various kinds of less formal activity. Special provisions for advanced study are made for students who enter with degree credit in one or more of the first-year fields. A student may carry at least one subject per term outside the Concourse Program. Subject matter of the Concourse Program is arranged so that the student receives credit for all of the first-year General Institute Requirements upon successful completion of the program. The structure of Concourse promotes close and sustained contact between students and faculty, and provides a coherent and balanced approach to the diversity of disciplines and research activities at the Institute.

Concourse operates under the aegis of the Department of Electrical Engineering and Computer Science. The program supervisors for 1981-82 are Professors Jerome Y. Lettvin and David Adler. A detailed description of the program may be found in the *Freshman Handbook* or may be obtained by writing to Concourse, Room 20C-224, MIT, Cambridge, Massachusetts 02139.



Experimental Study Group (ESG)

The Experimental Study Group is a small, self-paced academic program for freshmen and sophomores at MIT. Instead of attending lectures and recitation sections in the regular curriculum, ESG students participate in small seminars, work individually with staff or upperclass tutors, or work independently on subjects of their own choice. They organize their programs to include many, but not necessarily all, of the General Institute Requirements in Math, Physics, Chemistry, and Humanities which most students cover during their first year at MIT. However, because of the flexible nature of the program, ESG students can approach their studies in a way that is largely free of the constraints on time and learning method imposed by the regular curriculum.

Once a freshman decides to join ESG, he or she chooses one of the ESG staff as an advisor. The student and the advisor meet every two weeks (but often more frequently) to plan and evaluate the student's progress throughout the term. Although ESG is essentially a full-time activity for freshmen (and a part-time program for sophomores who have been in ESG as freshmen), students are free to take subjects in the regular curriculum which are not offered through ESG. Each freshman receives at least 50 units of credit per term, through a combination of specific credit for subjects completed in ESG and in the regular curriculum, and free elective credit for work done that is not covered by a particular subject number.

ESG is more than just an academic program — it is also a community where students and staff use the ESG facility (a 10-room suite with a library, kitchen, music room, and computer terminal) to study and socialize together. Each year there are approximately 40 freshmen, 20 sophomores, 10 staff members, and about 15 upperclass tutors who were formerly enrolled in ESG. Staff at ESG are drawn from the Departments of Physics, Humanities and Social Sciences, Chemistry, Mathematics, and Electrical Engineering at MIT, and range from graduate students to full professors. Sharp distinctions are not drawn between members of the community, or between academic and nonacademic learning situations. In such an atmosphere, students are encouraged to explore the opportunity of taking responsibility for their own education.

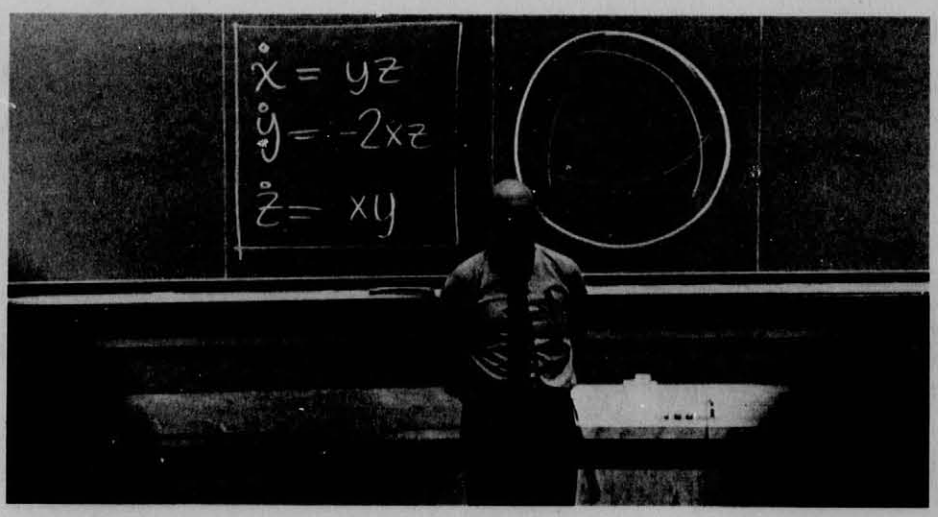
More information may be found in the *Freshman Handbook* or by writing to the Experimental Study Group, Room 24-612, MIT, Cambridge, Massachusetts 02139.

Freshman Handbook

The preceding brief overview of the first-year academic program is meant to convey the nature and scope of the options available, but it is hardly a sufficient basis for the individual freshman to plan his or her year. Shortly after they are admitted to MIT, freshmen receive the *Freshman Handbook,* a compendium of detailed information on academics, athletics, extracurricular activities, the advisory system, and an outline of Residence/Orientation Week. Freshmen also receive the *Undergraduate Residence* book, which describes housing options. *The Handbook,* also distributed to freshman advisors, is a primary reference document for the first year.

Freshman Grading

Freshmen presently receive grades of either pass or fail in all subjects they take; failing grades in the freshman year do not appear on the permanent record. Pass/fail grading for freshmen was introduced experimentally in 1968 with a variety of objectives, among them a reduction of the stresses of the first year (anxiety about time, class rank, the failure to do A work) and the development of more mature attitudes about learning and about managing one's time. At the middle and end of each term the freshmen and their instructors, in turn, are asked to complete written evaluations of the student's work. This process usually provides the student with a more comprehensive and useful evaluation than A-F grades alone communicated under the conventional system.

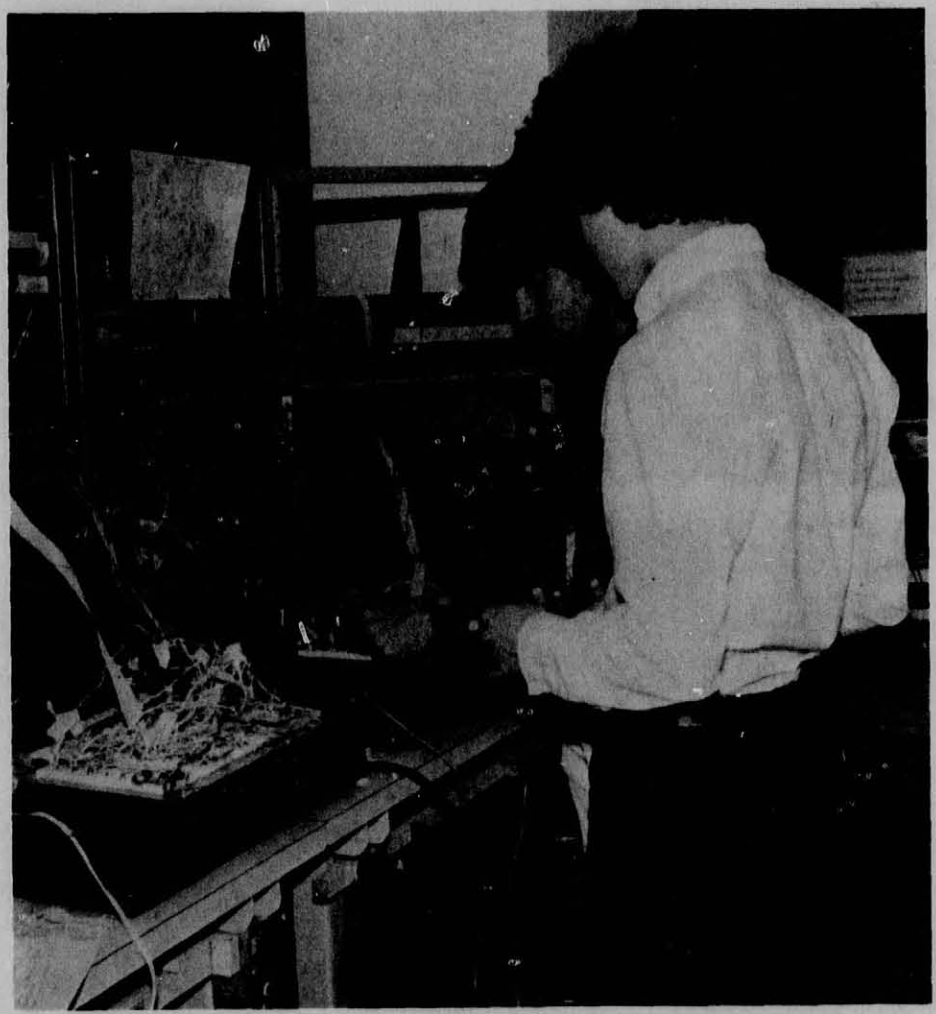


Selection of Major Course of Study

Many entering students have a well-defined preference for a specific field, while others have interests in several areas and have not yet decided on a field of concentration. A substantial percentage of those who do enter with a decided preference, however, later find other areas more to their liking; therefore every student should be prepared to examine with an open mind the various Courses available at the Institute. Students are encouraged to attend departmental orientation programs to seek out and talk with faculty and others who have experience in fields of potential interest to them. They are also urged to select electives which will help them in deciding about their future careers. For many, this consideration of fields will reinforce existing convictions, while for others it will open up new avenues of interest.

Each of the undergraduate Courses combines the study of basic principles with the study of their practical applications. This combination of principles and applications studied in depth helps to foster the motivation for the continuing learning which leads to professional competence.

Students usually choose a Course at the end of the first year though they need not do so until the end of their second year. There is sufficient overlap and flexibility so that a change in Course can be made with relative ease in the second year.



Thus, even though a student has doubts about which of two Courses to choose, it is usually wise to enroll in one of them for a year to get the true flavor of being an undergraduate in that department.

All undergraduate and graduate academic programs, as well as faculty listings, for each of the Institute's 23 Courses are described fully in the chapter entitled Departmental Programs and Requirements.

Each student entering MIT is assigned an advisor who assists the student in designing an effective program of study appropriate to individual interests and aspirations. The selection of electives is one of the important problems on which all students should work in detail with their advisors. For example, if a student has not decided on a specific Course, he or she may wish to register for electives and Science Distribution Subjects that are relevant to the Courses under consideration. It is important that these subjects be selected with care because each department has different recommendations for Science Distribution Subjects.

Electives

Any subject offered by the Institute is open to first-year students, provided they can satisfy the prerequisites. There are several hundred subjects without prerequisites from which a student may select during the freshman year.

Electives can be used for several different purposes. For example, many students who are undecided about their eventual program of study will use part or all of their elective time to get more information about the various departments or fields they are considering. Other students who are more certain of their professional goals will use elective time to explore areas of secondary interest. Still others will choose to begin work on departmental or Institute requirements, deferring subjects of a more supplemental nature until a later year. The study of a language may be started or continued; most of the ROTC programs are normally begun as electives in the first year. Freshmen should select electives that best suit their individual needs.

Undergraduate Research Opportunities Program (UROP)

UROP invites undergraduates to participate with MIT faculty and staff members in a wide range of research activities in every academic department and in many interdisciplinary laboratories.

There are many advantages to becoming involved in such pursuits as early as possible in an undergraduate career: establishing ties to faculty; having access to the advising, counseling, and tutoring resources of a professional group; trying out a potential major; acquiring data-gathering and laboratory techniques; exploring the frontiers of a field; undertaking topics not amenable to the classroom; facing a real-world problem, and establishing a focus for educational experiences. Through UROP, students can come to have a better understanding of the intellectual process of inquiry, while experiencing an opportunity for personal and professional growth.

Ground rules for participating in UROP are contained in the current *UROP Directory*. Coordinators for Institute departments, laboratories, and offices are listed under each *Directory* entry. These people are prepared to assist students, but a certain amount of footwork and negotiation will be required in order to achieve a satisfying collaboration. Once a commitment to an undertaking is made, students are expected to conduct themselves responsibly in the enterprise. The UROP experience will be unlike any other; its benefits and rewards are great, but expectations and standards are commensurately demanding. Call or visit the UROP office at any time, Room 20B-141, (617) 253-5049; advice, consolation, or congratulations await.



Undergraduate Seminars

The Undergraduate Seminar Program offers students an opportunity to interact closely with faculty members on topics which are of current interest. Seminars vary tremendously both in style and topic. Some are oriented around small group discussions; others have speakers, go out on field trips, or engage in "hands-on" research. Many topics are interdisciplinary in nature.

Most seminars carry six units of pass/fail credit and the class size is generally restricted to a small group. Titles and descriptions of seminars to be offered in the upcoming term are published in the Undergraduate Seminar Program booklet, published twice yearly. Copies of the current booklet are available in the Undergraduate Academic Support Office, Room 7-103.



Preprofessional Advising and Education

Within the Office of the Dean for Student Affairs, the Preprofessional Advising programs serve all students who are interested in postgraduate education, particularly in the fields of medicine, law, education, and health-related or law-related professions. The staff in the Office works closely with three faculty/student committees: the Committee on Preprofessional Advising and Education, the Premedical Advisory Council, and the Prelaw Advisory Council.

Students in all fields are encouraged to seek specific departmental advising as the need arises. Each department has advisors who are available to counsel any student on his or her particular area of interest.

Premedical Education

In recent years increasing numbers of students have entered medical school upon graduation from MIT. Students in mechanical engineering, chemical engineering, biology, physics, chemistry, electrical engineering, mathematics, and urban planning are regularly represented among the applicants. Since there is no formal program of premedical study at MIT, students have great flexibility in their choice of major fields, and are encouraged to take advantage of the diversity of subjects offered at the Institute. Medical school entrance requirements can be met through selection of electives; such programs fully meet the specifications of the Association of American Medical Colleges.

The Premedical Advisory Council, whose members are directly involved in medical practice, related medical research, or student counseling, provides guidance and information to students interested in medical careers.

Education Studies

MIT students may receive certification to teach in the Commonwealth of Massachusetts by taking a prescribed series of subjects through the MIT-Wellesley Exchange Program. Subjects in political science, psychology, humanities, and management deal with specific educational problems. Students may work with faculty members on special problems of education ranging from curriculum development to psychology of learning. The MIT-Wellesley Upward Bound Program provides a challenging set of experiences under the direction of the professional staff involved. There is a teaching intern seminar which provides an opportunity for students to teach in public schools.

Prelaw Education

A number of MIT students enter law school each year. Law schools do not require a particular undergraduate program as a condition for admission; students from every Institute School — Engineering, Science, Humanities and Social Science, Architecture and Planning, and Management — have been admitted to law school. Prelaw students should consult members of the Prelaw Advisory Council regarding preparation for a legal education.

The Preprofessional Advising and Education Office maintains the catalogues of accredited law schools, the dates and application materials for the Law School Admissions Test, and other information pertinent to the study of law. *A Handbook for MIT Students Interested in Law* has been prepared to answer questions commonly asked by students interested in a legal education. The *Handbook* contains information on the selection of law schools, the admission decision process, and the wide range of roles for lawyers. Copies of this and other helpful publications are available in the Office of Preprofessional Advising and Education. Please see the section on Law-Related Studies in the Interdepartmental Study and Research chapter for a further discussion of opportunities and programs in this area.

Full-time Study at Other Universities

Junior Year Abroad

Many opportunities are open for study in foreign countries through participation in one of the excellent programs administered by nonprofit educational organizations or through an individually arranged program. Plans for study abroad should be worked out by each student with his or her Faculty Advisor and the Dean for Student Affairs' Office of Foreign Study, Room 5-108, (617) 253-7979. Although almost any field can be studied abroad, it is generally advisable to take most professional subjects at MIT. By emphasizing the language, literature, history, and culture of the host country, the year abroad can be a valuable learning experience.

Effective working command of the language of the host country is vital. By conscientious work in language subjects here, even a student without prior study frequently can achieve proficiency in a foreign language by the beginning of the junior year if he or she begins by the second term of the freshman year. The orientation period provided by most organized programs will be a necessary complement in many cases. For a mature student with exceptional competence in the language and some knowledge of the culture, an individual program may be desirable, but careful planning is essential.

A student on an approved "junior year abroad" program maintains, without payment of MIT tuition, official MIT registration as an "undergraduate on foreign study," and thereby student aid status and dormitory priority. Total costs including travel have often proved to be less than that at the Institute.

Students who have participated in an approved one-year program may normally expect to receive a minimum of 90 units of credit toward their MIT degree, upon successful completion of their studies and subsequent return to MIT.

Domestic Year Away

A "domestic year away" for study at another US institution is an experimental program sponsored by the Committee on Educational Policy and approved by the faculty. Registration at the Institute as "undergraduate on leave" without MIT tuition requires that:

1
the student show that the objectives of the planned program of studies are consistent with his or her overall degree program at MIT and that he or she has the academic and personal qualifications which will ensure maximum benefits from the experience;

2
the student demonstrate and have certified by the departmental advisor that the planned program of study draws on resources available at the second institution which are not generally available at MIT or at the institutions with which MIT has substantial cross-registration privileges; and

3
the student be accepted by a school of established academic merit for a program involving a work load comparable to that at MIT.

Those students interested in these programs should consult the Dean for Student Affairs' Office of Foreign Study, Room 5-108, (617) 253-7979.

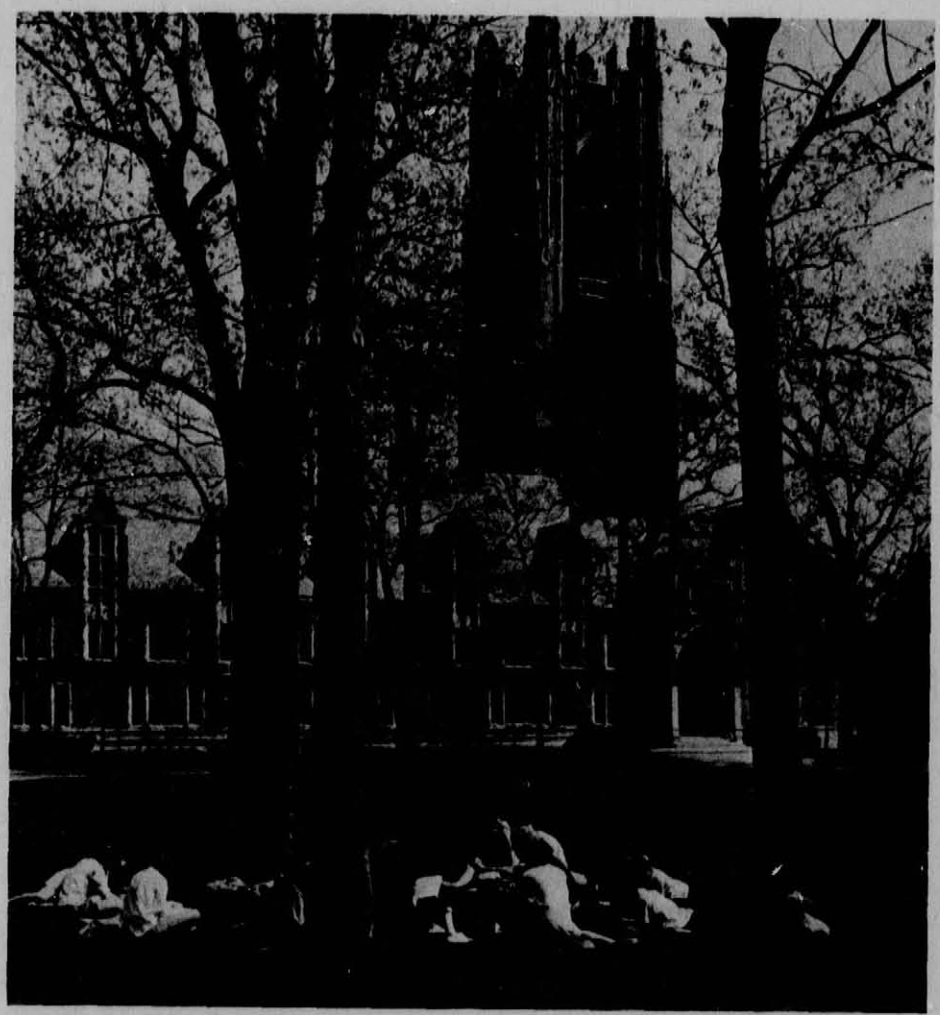
Harvard University

A limited number of MIT undergraduates are permitted to take one or two subjects at Harvard University (Faculty of Arts and Sciences) for degree credit at no extra charge, provided the subjects are not offered regularly at MIT. No more than two regular subjects nor more than one intensive subject may be taken at Harvard in any one term. Arrangements are made through the Office of the Dean of the School of Humanities and Social Science.

Wellesley College

The Wellesley-MIT Exchange Program was established in 1968 to extend and diversify the educational programs available to students of both institutions. Under this program, students may cross-register for any courses at the other school, with the only requirement being that they present the necessary prerequisites. MIT students may use Wellesley courses to meet certain Institute requirements as described later in this chapter in the section on the Wellesley-MIT Exchange.

Copies of the Wellesley catalogue, a fact sheet on cross-registration procedures, and other information on the Exchange are available from the Wellesley-MIT Exchange Office, Room 7-108, (617) 253-1668, and the Information Center, Room 7-121, 253-4795. Free weekday bus service is available between Wellesley and MIT as part of the Exchange. Cross-registered students have priority in boarding, but others with MIT or Wellesley identification cards may use the bus on a space-available basis.



Undergraduate Registration and Academic Performance

Complete information on registration procedures may be found in the "MIT Registration Material" packet which is available to students in December and May in the Building 10 Lobby. Additional details may be found in the *Guide for Undergraduates and Faculty Advisors* and the *Graduate School Manual.*

Definition of Student Status

Once admitted (or readmitted) to MIT, a person becomes an MIT student at the start of the term for which he or she was admitted. Student status is retained until graduation, unless the student withdraws or is required to withdraw or fails to complete registration in a given term. For the fall and spring terms, completion of the four steps listed below is necessary for continuing student status during that term: 1) registration material issued by the Registrar has been completed and returned, 2) fees have been paid to the Cashier's Office, or, the student has made satisfactory arrangements with the Student Accounts Office for payment, 3) the faculty advisor or registration officer has signed the student's registration form and this form has been received by the Registrar's Office, and 4) an ID validation sticker has been picked up.

Registration Procedures

All subjects to be taken during the current term, including thesis, cross-registration with Wellesley or Harvard, and ROTC, should be listed on the Registration Form. A third- or fourth-year undergraduate student who wants to take an elective subject Pass/Fail using the Junior-Senior Pass/Fail option should be sure to indicate P/F beside the subject on the Registration Form. The faculty advisor and student should be sure that the subject to be designated Pass/Fail is not being used to fulfill either a department or an Institute requirement, and that the student does not take more than a total of two subjects under this option. The units for independent study and thesis subjects should be indicated. The units for thesis are listed as laboratory units.

Correction Cards signed by the student's faculty advisor for undergraduates and registration officer for graduate students should be used for all changes in registration after Registration Day. The specific deadlines for such changes are listed in the Academic Calender in this catalogue. The instructor's signature is also required if a subject is added after the first week of the term. All Correction Cards should be hand delivered **by the student** to the Registrar's Office, Room E19-335.

The Registrar's Office sends out a "Status of Registration Form" to every student during the fourth week of the term. Subsequently additional Status Forms are sent out at three-week intervals to every student for whom the Registrar has received a Correction Card since the previous set of Status Forms was issued. On these forms will be listed the student's program as it stands in the Registrar's Office. This will confirm the student's registration and point out any discrepancies. If the Registrar's Office has received no change in the student's record, then no further Status Forms are generated after the fourth week of the term.

The Institute holds each student fully responsible for checking the accuracy of his or her initial Registration Form and any subsequent Correction Cards submitted to the Registrar's Office, for assuring that the Registrar is provided with a correct current mailing address, and for carefully reviewing each Status of Registration Form generated by the Registrar to make sure that it accurately reflects his or her registration. Steps to eliminate any discrepancies should be taken promptly by the student. The student should keep copies of the original Registration Form and all subsequent Correction Cards and Status of Registration Forms as evidence of having followed these procedures.

If an undergraduate wishes to add or drop a subject or to make or change a Pass/Fail designation after the deadline dates, the student must petition the Committee on Academic Performance (CAP). Such petitions are not automatically approved.

An undergraduate student who wishes to withdraw during a term or arrange for a leave of absence must see the Dean for Student Affairs, Room 5-104.



Credits

The credit hours (units) for each subject indicate the number of hours spent each week in class and laboratory, plus the estimated time which the average student spends each week in outside preparation, for one regular term. Each subject is listed with three credit numbers, showing in sequence the units allotted to: class; laboratory, design, or fieldwork; and preparation. Each unit represents 14 hours of work per term. The total unit credit for a subject is obtained by adding together all the units shown. The typical undergraduate student load, based on a four-year program, is 45 to 54 units per term. However, if approved by his or her faculty advisor, a student may follow a program leading to an S.B. degree in either more or less than eight terms.

Credit Limit for Freshmen

A freshman may register and receive credit for a maximum of 60 credit units in the fall term and 63 credit units in the spring term. Credit earned for passing an Advanced Standing Examination will be counted toward this credit limit unless such an exam is taken either in the September or February examination period. Petitions for individual exceptions should be submitted to the Committee on Academic Performance. However, the Committee enforces the credit limit rigidly and only allows exceptions on purely technical grounds.

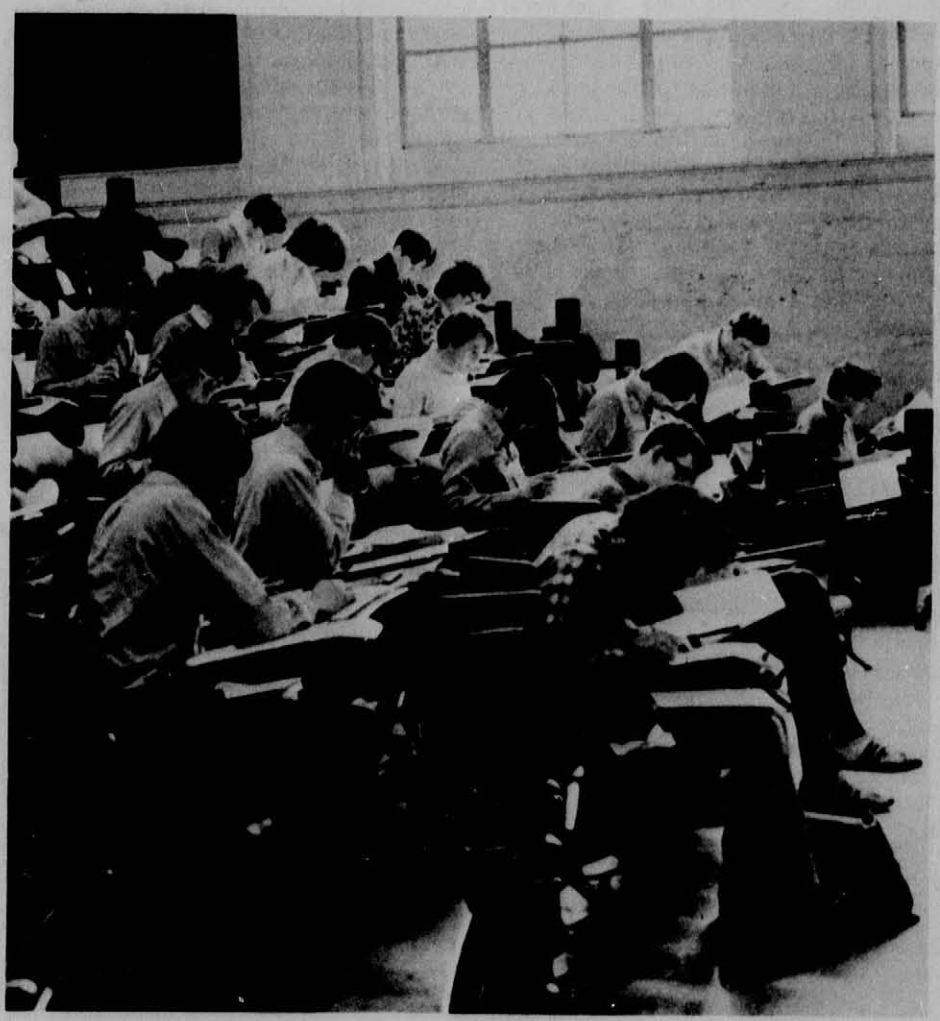
Light Load Registration by Undergraduates

The Institute feels that the concept of a four-year residential college, requiring a full-time academic program, is central to the MIT undergraduate experience. An MIT degree represents not only a specified number of credit units and a collection of subjects, but an intensity and continuity of involvement in an academic enterprise and an immersion in the culture of MIT as well. In general, therefore, MIT is not an appropriate place for pursuing an undergraduate education on an extended, part-time basis.

Requests from students for light-load registration status are handled under the following policy. Once enrolled as a regular student, an undergraduate may not lapse to a light load of subjects (register for fewer than 32 units) for more than a total of two terms without petitioning the Committee on Academic Performance. The CAP allows use of the light load beyond a second term only for very special circumstances. Arrangements to take a reduced load of subjects should be initiated prior to the beginning of the term. The procedure to be followed in this regard is described in the *Guide for Undergraduates and Faculty Advisors.*

Advanced Standing Examinations

To qualify for an Advanced Standing Examination, a student must never have been registered for or attended class in the subject concerned. A freshman who takes such an exam shall receive the grade of P for passing performance, but no record will be kept of failing performance. For all other students, a grade ranging from A to F as usual will be recorded on the transcript. Any passing grade entitles a student to full credit for the subject. For freshmen, such credit will count toward the 60- or 63-unit credit limit unless the exam is taken either in the September or February examination period (see Credit Limit for Freshmen).



Program for Two Bachelor's Degrees

A student may work for two Bachelor's degrees to be received separately or concurrently. He or she must submit to the Registrar a petition which indicates the desire to work for two degrees and which has been approved by faculty advisors in each of the two departments concerned at least two full terms before the student would normally receive the second of the two S.B. degrees. The requirements of each department must be satisfied and the combined program must contain at least 450 units. Both faculty advisors should take responsibility for examining the entire program in the same way as they would for a candidate for a single S.B. degree.

Information about the Simultaneous Award of Two Masters' Degrees and the Simultaneous Award of a Bachelor's and Master's Degree may be found in Chapter IV of this catalogue.

Grade Reports and Transcripts

Grade reports are issued by the Registrar at the end of each term and summer session to all registered students. Students may order transcripts of their academic record at the Registrar's Office, Room E19-335, upon presentation of a receipt from the Cashier's Office, Room 10-180, or the Student Loan Office, Room E19-225 at a cost of $2 per copy.



Final Examinations

Final examinations are held at the end of each term; the schedule is issued about a month before the examination period. Each student is held responsible for obtaining an examination schedule at the Information Center, Room 7-121, for reporting any conflicts in examinations to the Schedules Office, Room E19-338, in the Office of the Registrar before the time limit given on the examination schedule, and for attending the final examinations required in the subjects for which he or she is registered.

No member of the instructing staff is empowered to grant excuse from a scheduled final examination. Absence from any final examination is equivalent to complete failure except on presentation of adequate evidence of sickness or other valid reason for the absence. The Dean for Student Affairs may permit a student whose term work has been satisfactory to take the next scheduled examination on the subject. The instructor may, if the evidence warrants, issue a final grade without requiring a postponed final examination.

Minimum Undergraduate Academic Standards and Ratings

It is the responsibility of the Committee on Academic Performance (CAP) to see that minimum academic standards proposed by the individual departments are consistent throughout the Institute for undergraduates and conform with the Rules and Regulations approved by the faculty. In view of the individual nature of student academic performance, it is impossible for the CAP to set forth rigid standards of academic performance to be used throughout the Institute. The Institute generally expects undergraduate students to complete the requirements for a single S.B. degree in four years; this establishes a normal load of subjects at approximately 45 units of credit per term. Normally, however, the CAP accepts a minimum academic record reflecting the satisfactory completion of 36 units of credit with a term rating **above** 3.0 on a 5.0 scale at the end of any regular semester, unless the Committee has specifically notified an individual student that a higher level of performance is required. (The latter would only occur as a result of previously poor performance.)

In cases where the above criteria are not met the CAP considers the academic performance of each student on an individual basis. Consideration is given not only to the grades received in the various subjects for which the student is registered, but also to the total number of subject units, the nature of the subjects themselves, and all those factors in the student's own personal situation which may have affected his or her academic performance in a given term. More detailed information concerning the procedures followed by the CAP at the end of term in reviewing the academic records of undergraduate students is given in the *Guide for Undergraduates and Faculty Advisors.* This booklet is published by the CAP approximately every two years. Copies are mailed to all undergraduate students and faculty members by the Committee at the time of publication, and additional copies may be obtained from the CAP Office, Room 7-101, 253-4164.

Grades

The grades to be used for students who satisfactorily complete the work of a subject by the end of the term are:

A
Exceptionally good performance, demonstrating a superior understanding of the subject matter, a foundation of extensive knowledge, and a skillful use of concepts and/or materials
B
Good performance, demonstrating capacity to use the appropriate concepts, a good understanding of the subject matter, and an ability to handle the problems and materials encountered in the subject.
C
Adequate performance, demonstrating an adequate understanding of the subject matter, an ability to handle relatively simple problems, and adequate preparation for moving on to more advanced work in the field.
D
Minimally acceptable performance, demonstrating at least partial familiarity with the subject matter and some capacity to deal with relatively simple problems, but also demonstrating deficiencies serious enough to make it inadvisable to proceed further in the field without additional work.
P
When the use of the single passing grade **P** is authorized, it may reflect performance at any of the levels, A, B, C, D.

The following notations are used by the Registrar for satisfactory completion of work in the circumstances indicated:
S, notation for credit awarded for work done elsewhere
SA, notation for satisfactorily completed doctoral thesis. Doctoral theses are not graded.

The grades and notations to be used for subjects not passed or not completed are:
F, failed. This grade also signifies that the student must repeat the subject to receive credit.

O, absent. This grade indicates that the student was progressing satisfactorily during the term but was absent from the final examination or absent during the last two weeks of the term, or both. An **O** grade carries no credit for the subject. Unsatisfactory performance because of absence throughout the term should be recorded as **F**.

OX, absence satisfactorily explained to and excused by the Dean for Student Affairs in the case of an undergraduate student or by the Dean of the Graduate School in the case of a graduate student. The faculty member in charge of the subject will be notified when an **O** is changed to an **OX**. An **OX** carries no credit for the subject. However, the faculty member in charge must provide the student the opportunity to receive a credit-carrying grade. This may be done with or without the instructor requiring a postponed final examination or other additional evaluation procedure.

DR, a notation to be used only on the student's internal record for a subject dropped after the fifth week of the regular term.

I, incomplete. The grade of **I** is to be used only for subjects for which a minor portion of the work required has not been completed and when a passing grade is expected when the work is completed. A typical example of a "minor portion of the work required" might be a paper or a laboratory report. If the work is not completed before the end of the fifth week of the succeeding term of the regular academic year, explicit approval of the faculty member in charge is required to extend this deadline. If the instructor does grant such an extension, the outstanding work must be submitted to the instructor by the last day of classes of the same sernester. If the work is not completed before the end of the succeeding term of the regular academic year (with the exception noted below) the student must register for and repeat the subject in order to receive credit. Under these circumstances, the grade of **I** will remain on the record **and will not automatically be converted to any other grade.** However, the instructor may choose to change the grade if a commitment made by the student is not fulfilled. The only alternative to this procedure is for the student to petition the CAP or the CGSP for an extension to the end-of-term deadline. Such a petition will only be approved in the case of extenuating circumstances. When completion of the subject requires facilities which are normally but not continuously available, this must be indicated on the form reporting the **I** grade and the work must be completed in the earliest term in which the facilities are available. Under these circumstances, an undergraduate student must submit a petition to the CAP and a graduate student must submit a petition to the CGSP.

J, a notation assigned for work such as thesis, UROP, or "At Plant" registration (internship or industrial practice), which has progressed satisfactorily, but has not been completed. Grade given upon completion of the work in a later term also covers this term. Faculty members and instructors must obtain approval from the Committee on Curricula to use the grade of **J** in subjects other than those mentioned above.

U, a notation for thesis work which has not been completed and in which progress has been unsatisfactory. Grade given upon completion of the work in a later term also covers this term. Unless a student's progress improves significantly, the student may expect that grade to be failing.

T, temporary notation. It is used for subjects which cover the equivalent of one term's work, but are scheduled over parts of two normal grading periods. Prior approval must have been obtained from the Committee on Curricula for undergraduate subjects or the Committee on Graduate School Policy for graduate subjects. This notation is recorded only on the student's internal record. A permanent grade must be assigned when the subject is finished.

General Institute Requirements

Science Requirement

To be recommended for the degree of Bachelor of Science, students must have attended the Institute not less than one academic year, which ordinarily must be the year of graduation. Students must have completed satisfactorily programs of study approved in accordance with the rules and regulations of the faculty, including General Institute Requirements and the Departmental Program of the Course in which the degree is to be awarded. A student must petition the Committee on Curricula for any substitutions in the General Institute Requirements. Departures from the Departmental Programs are permitted with the consent of the faculty advisor. The Departmental Program and the total number of units required are shown for each Course in the Departmental Programs and Requirements chapter.

General Institute Requirements include: 1) completion of the Science Requirement; 2) completion of the Humanities, Arts, and Social Sciences Requirement; 3) completion of the Science Distribution Requirement; 4) completion of the Laboratory Requirement; and 5) completion of the Physical Education Requirement.

In summary, to be recommended for the degree of Bachelor of Science, students must have satisfactorily completed the following units:

General Institute Requirements	Total Units
Science Requirement	**60**
Chemistry/Biology (3.091 or 5.40 or 5.41 or 5.60 or 7.01)	12
Physics (8.01 or 8.011 or 8.012 or 8.013J and 8.02 or 8.021 or 8.022 or 8.023J)	24
Calculus (18.001 or 18.01 or 18.011 or 18.012 and 18.002 or 18.02 or 18.021 or 18.022)	24
Humanities, Arts, and Social Sciences Requirement	
Eight subjects totaling at least	72
Science Distribution and Laboratory Requirements	
Science Distribution Subjects	36[1]
Laboratory Subjects	12[1]
Departmental Program	
As specified for each Course, a minimum of	180[2,3]
Total units required for the S.B. Degree, at least	**360[4]**

1
Each department may specify some of the Science Distribution and Laboratory Subjects.
2
Departments may require up to 205 units (leading to a total of 385 units) for graduation.
3
Departmental Programs include at least 36 units of electives, usually more.
4
This total does not include ROTC subjects, if elected.

MIT expects its graduates to have an understanding and appreciation of the basic concepts and methods of the physical sciences. These concepts and methods are needed in most degree programs at the Institute. More importantly, they are an essential part of the background that MIT graduates bring to their roles as professionals and as citizens in a world deeply influenced by science and technology.

To provide this understanding, the Institute offers a variety of programs by which the student can satisfy the science, laboratory, and science distribution requirements. These programs introduce the student to three basic elements of the scientific method: experimental foundations and techniques, mathematical analysis, and conceptual models for experimental facts. Important experimental, as well as conceptual, aspects are introduced by the chemistry/biology requirement and by the laboratory requirement. Mathematical methods common to much of science and technology are explored in the calculus requirement. Basic concepts that underlie many physical phenomena are defined and elucidated in the physics and in the science distribution requirements.

In addition to a rigorous introduction to the elements of the scientific method, these requirements are intended to stimulate and challenge each student to review critically his or her knowledge and to explore alternative conceptual and mathematical formulations which may provide better explanations of natural phenomena or may lead to better applications of technology.

The development of critical and constructive approaches to both theory and practice in science, engineering, and other professions is a central objective of the Institute's educational programs.

Chemistry/Biology Requirement

The requirement that students take a term of chemistry has been broadened so that it can be satisfied in five different ways. The alternatives are 3.091 Introduction to Solid State Chemistry; 5.40 General Chemistry; 5.41 Introduction to Structure, Bonding and Mechanism; 5.60 Chemical Thermodynamics; and 7.01 General Biology. 3.091 is designed for students who are particularly interested in the chemistry of the solid state. 5.40 is designed for students with no preparation beyond introductory high school chemistry. 5.41 presents an introduction to structure, bonding and mechanism. 5.60 is provided as an option for students who have a foundation in chemistry upon which a more specialized study of chemical equilibrium can be based, have the equivalent of 18.01, and are taking 18.02 concurrently. The faculty responsible for 7.01 prefers that the student take this subject as a sophomore rather than as a freshman. A solid background of chemistry at the high school level is assumed.

Physics Requirement

The Institute requirement in physics may be satisfied through a variety of combinations of first- and second-term physics subjects. The sequence 8.01-8.02 is the "standard" combination, designed to be followed by one or two further terms of physics in the sophomore year. A majority of students find this sequence suited to their needs. 8.012-8.022 covers essentially the same subject matter as 8.01-8.02, but is more advanced mathematically; calculus is used freely from the beginning of the term. 8.013J-8.023J constitutes the first two terms of a three-term physics program developed under the auspices of the joint Harvard-MIT Division of Health Sciences and Technology. This sequence is at about the same level of difficulty as 8.01-8.02, but with particular emphasis on topics relevant to biology, biophysics, and biomedical research and engineering.

The student is not obliged to follow through the whole of any of the above sequences as a package, should some other choice be more suitable. There are many possibilities for switching from a first-term subject in one sequence to a second-term subject in another. In particular, there is a single second-term subject, 8.021, suitable for students who have decided that their subsequent work will not require continued use of physics.

Calculus Requirement

The Department of Mathematics currently offers several basic calculus sequences. The standard sequences are: 18.001-18.002, 18.01-18.02, and 18.011-18.021. All three subjects attempt to present calculus as it will actually be used in science and engineering. The subjects differ in several respects: 1) content and intensity; 2) textbook (18.001-18.002 uses *Calculus: An Introduction to Applied Mathematics* by Professors Greenspan and Benney — the other two use *Calculus and Analytic Geometry* by Thomas and Finney); 3) structure (although all three subjects use lectures and recitations, homework and testing practices vary); 4) teachers (18.001-18.002 is taught by the Applied Mathematics group while the others are taught by the rest of the Mathematics Department); and 5) prerequisites (18.011-18.021 assumes high school calculus).

In addition, there is a fourth sequence, 18.012-18.022 Calculus with Theory. This is designed for those who want and qualify for a more theoretical and rigorous treatment of calculus. It assumes an extensive prior background in calculus, and emphasizes proofs.

Students with advanced placement or advanced standing credit for 18.01 will lose it upon taking 18.001, 18.01, 18.011, or 18.012. However, for students taking 18.011 or 18.012, it will be replaced by six units of elective credit.

Humanities, Arts, and Social Sciences Requirement

MIT provides a substantial and varied program in the humanities, arts, and social sciences which forms an essential part of the education of every undergraduate. Through this program, students can deepen their knowledge in a variety of cultural and disciplinary areas and can develop sensibilities and skills vital to an effective and satisfying life as an individual, a professional, and a member of society.

More specifically, the objectives of the program are to develop: 1) skill in communication, both oral and written; 2) knowledge of human cultures, past and present, and of the ways in which they have influenced one another; 3) awareness of concepts, ideas, and systems of thought that underlie human activities; 4) understanding of the social, political, economic, and legal framework of our society; and 5) sensitivity to modes of communication and self-expression in the arts. Work in these areas will, where appropriate, display a special concern with the relation of science and technology to society.

The student's program in the humanities, arts, and social sciences is based on the following Institute Requirement:

1
Every candidate for a bachelor's degree must have completed a **minimum of eight term subjects (of at least nine units each)** in the humanities, arts, and social sciences, normally at the rate of one subject each term. Each field except Foreign Languages offers a mixture of nine- and 12-unit subjects. It is possible for students to satisfy the Requirement with eight nine-unit subjects.

2
Distribution. At least three of the eight subjects must be chosen from a specially designated list of humanities distribution subjects. The three subjects are to be selected from three separate Fields from the list given below and may be taken at any stage of the student's undergraduate career.

3
Concentration. Before the third year, each student selects a Field of Concentration. The requirements for Concentration are set by each Field and consist of either three or four subjects. An individual's program of Concentration is arranged in consultation with a designated advisor in the Field. A Distribution subject in a given Field may be counted also as one of the required Concentration subjects in the same Field with the permission of the Concentration advisor. In individual cases a special interdisciplinary program of Concentration may be arranged with the approval of an advisor designated by the Dean of Humanities and Social Science. This approval **must** be obtained ahead of time, before the desired combination of subjects has been completed.

The following **Fields of Concentration** currently are offered:

American Studies
Ancient and Medieval Studies
Anthropology and Archaeology
Drama
Economics
Foreign Languages and Literatures
History
History of Art and Architecture
Labor in Industrial Society
Linguistics
Literature
Music
Philosophy
Political Science
Psychology
Russian Studies
Science, Technology, and Society
Technology, Culture, and Development
Urban Studies
Visual Arts and Design
The Western Tradition
Writing

Students interested in exploring or registering for a Field of Concentration should speak with an advisor designated by that Field. Descriptions of the offerings of each Field and a list of advisors may be obtained at the appropriate department headquarters or at the office of the Dean of Humanities and Social Science.

Distribution Subjects

Students may meet the Distribution component of the Requirement by completing three subjects from the following list. These subjects must be from three different Fields. The subjects have been selected according to the following principal criteria: 1) they are humanistic in orientation; 2) they display a concern for the understanding of human values in their social, historical, and cultural context and call for reading, writing, and classroom discussion that demonstrate that concern; 3) they stress issues of general significance rather than narrow disciplinary issues.

Almost all of these subjects are without prerequisites and are appropriate for students at all levels. Students are encouraged, though not required, to take one or two Distribution subjects in their freshman year, in order to begin satisfying the Institute Requirement and to sample the offerings of different Fields.

Students are free to take more than the necessary minimum of three Distribution subjects; those taken in excess of the minimum may be used as electives toward completion of the eight-subject requirement (see below) or in some cases, with the approval of the relevant Field, may be accepted as part of a program of Concentration. Note, however, that in no case may more than one subject in a given Field be counted toward both Distribution and Concentration.

The following is the final list of courses offered for **Humanities Distribution** credit:

American Studies

21.103J Literature, Ideology and National Experience in the United States [STS 601J]

Anthropology and Archaeology

21.50 An Introduction to Anthropology
21.501 Crossing Cultural Boundaries
21.502 Controversies and Core Ideas in Anthropology
21.503 Paths to Civilization
21.505 Anthropology and Technnology
21.513 Religious Movements and Social Change
21.542 Culture and the Visual Arts
21.581 The Family in Contemporary Society
21.584 Agrarian Society

Economics

14.71 Economic History

Foreign Languages

21.203 French III
21.204 French IV
21.233 German III
21.234 German IV
21.263 Russian III
21.264 Russian IV
21.277 Spanish III
21.278 Spanish IV
21.282 Spanish for Bilingual Students

History

21.350 The Ancient World I: Ancient Near East and Greece
21.351 The Ancient World II: Rome
21.352 The Middle Ages I
21.353 The Middle Ages II
21.356 History of the Western World I: 1500-1815
21.357 History of the Western World II: 1815-1970
21.367 Ideas of Progress
21.369 Marx, Darwin and Freud
21.376 Imperial and Revolutionary Russia: Culture and Politics
21.383 Revolution in the 20th Century
21.390 American History to 1865
21.391 American History since 1865
21.410 American Intellectual and Cultural History: From the Puritans to the Civil War
21.411 American Intellectual and Cultural History: Civil War to 1960s
21.450 The History of Africa
21.451J Nationalism and Nation Building in 20th Century Africa [17.551J]
21.460 East Asian History: China
21.461 East Asian History: Japan
Wellesley History 320: Social History of American Law: The Formative Era

History of Art and Architecture

4.601 Topical Studies in the History and Theory of Art
4.602 Introduction to the History and Theory of Architecture
4.636 Introduction to Renaissance Architecture
4.642 Modern Art from Impressionism to Cubism
4.651 Modern Art from Cubism to the Present
4.683 Introduction to the Muslim World through Its Monuments
Wellesley Art 215: European Art to the Renaissance
Wellesley Art 216: European Art from the Renaissance through the Nineteenth Century

Labor in Industrial Society

14.63 Labor in Industrial Society

Linguistics

24.900J The Study of Language [21.321J]

Literature A[1]

21.001 Literature I: World Masterpieces
21.003 Introduction to Fiction
21.004 Major Poets
21.005 World Drama
21.006 Introduction to American Literature I
21.007 Introduction to American Literature II
21.009 Shakespeare
21.010 Literature and Film
21.021 Comedy
21.022 Tragedy
21.031 The Film Experience
21.079 Modern Russian Literature and Its Historical Structure
21.101 The American Novel
21.104 Race and Identity in American Literature
21.296 Introduction to European Fictional Modes
21.299 The Don Juan Legend
21.302 French Literature in Translation: The Search for Identity in an Alien World
21.305 German Literature in Translation
21.306 Rogues and Rascals: The German Picaresque and a Literary Tradition
21.310 Slavic Civilization: Magic, Vampires, and Sorcerers
21.314 Russian Novel of the 19th Century
21.317 Latin American Literature: Civilization vs. Barbarism
Wellesley Extradepartmental 247: Arthurian Legends
Wellesley Extradepartmental 211: Dante in Translation

Literature B[1,2]

21.208 French Civilization I
21.209 French Civilization II
21.210 Introduction to French Literature
21.219 The Adolescent in French Literature
21.220 The Intellectual and Modern Society: Literature and Ideology
21.221 French Romanticism
21.226 Introduction to the French Short Story

1
Students may choose only *one* Distribution subject in Literature, *either* from list A *or* B.

2
Students who have taken any third- or fourth-level foreign language subject as a Distribution subject may not take a subject from Literature B to satisfy the Distribution Requirement unless it is in a different foreign language.

21.227 Representations of Love in French Literature
21.238 German Culture and Society: 1500-1789
21.239 German Culture and Society: 1789-1918
21.240 German Culture and Society: 1918-1933
21.241 German Culture and Society: 1933-1949
21.243 Introduction to German Literature
21.244 Introduction to German Poetry
21.247 Introduction to German Drama
21.268 Russian Culture and Civilization
21.284 An Introduction to Latin American Culture
21.285 An Introduction to Spanish Culture: The People and Civilization of Spain
21.289 The Novel in Spain
21.290 Literature and Social Conflict: Perspectives on Spain: 1820-Present
21.292 Latin American Literature 1492-1898: Creation of a Continent
21.293 20th Century Latin American Literature: The Alchemist's Laboratory

Music

21.60 Introduction to Music
21.601 Vivaldi, Bach, and Handel
21.602 Hayden, Mozart, and Beethover.
21.603 Music from Schubert to Mahler
21.605 The Symphony
21.621 History of Music to 1600
21.622 History of Music, 1600-1900
21.624 Musical Traditions in America

Philosophy

24.01 Contemporary Moral Issues
24.02 Philosophy of Art: Classic and Contemporary
24.03 Logic, Language and Values
24.04 Problems of Philosophy
24.05J Nature of Scientific Knowledge [STS 205J]
24.07 Classics in the History of Philosophy
24.09 Freedom and Authority

Political Science

17.101 Revolution and the Theory of Politics
17.103 Socialism
17.107 Introduction to Political Theory: Individual and Community
17.201J Politics and Public Policy [11.007J]
17.241 Introduction to the American Political Process
17.243 American Politics and Social Change
17.283J Urban Politics, Planning and Public Policy [11.164J]
17.305J Rationality, Risk, and Choice in Industrial Society [STS 401J]
17.401 Aggression, War and Civilization
17.403 American Foreign Policy in a Changing World
17.501 The Quest for Equality and Development in Third World Countries
17.549 Political and Economic Development of Tropical Africa
17.581 Religion, Politics and Social Change
17.707 Mass Communication and American Culture

Religious Studies

Wellesley Religion 107: Crises of Belief in Modern Religion
Wellesley Religion 108: Introduction to Asian Religions
Wellesley Religion 252: Islamic Tradition

Sociology

Wellesley Sociology 102: The Sociological Perspective

Science, Technology, and Society

STS 200 The Scientific Revolution
STS 201 History of 19th- and 20th-Century Science
STS 210 American Science since the 1930s
STS 300 History of Technology in America I: 1787-1876
STS 301 History of Technology in America II: 1876-the Present
STS 400 Science, Technology, and Society: Problems of Innovation
STS 402 Innovation and Society
STS 501 The Automobile: Mass Production and Mass Consumption
STS 502 The Profession of Engineering: Past, Present and Future
STS 511 Capitalism and its Critics
STS 600 Technological Society and Its Critics
STS 602 The Machine: Metaphor, Fact and Theory

Urban Studies

11.005 Urban Social Structure and Process
11.013J American Urban History [21.412J]
11.131 The Urban Neighborhood
11.165 Law and Public Policy

Visual Arts and Design

4.802 Visual Form and Expression
4.901 Creative Seeing

The Western Tradition: Issues and Texts

21.710 The Bible
21.711 The Greeks
21.712 The Romans
21.713 Major Medieval Texts
21.714 The Renaissance and Reformation
21.715 The Enlightenment
21.716 Romanticism
21.717 The Modern Period: 1900-1970

Writing

21.727 Beginning Prose and Poetry
21.743 Writing and Reading Short Stories
21.744 Writing and Reading Poems
21.750 Writing and Reading the Essay
21.761J Writing: Technology and Society [STS 611J]
21.762 The Scientific Essay

Interdisciplinary Subject

SEM 212 A Reading Course in the Role of Education in Society

Elective Subjects

The remainder of the eight-subject Requirement, above and beyond Distribution and Concentration, may be fulfilled by the approved subjects in the humanities, arts, and social sciences. These elective subjects may be chosen from among most undergraduate subjects offered in the School of Humanities and Social Science, a substantial number of subjects in the School of Architecture and Planning, and a smaller number from the other Schools. (Please note, however, that subjects in the Sloan School of Management cannot be used to satisfy the Humanities Requirement.) Appropriate subjects taken by cross-registration at Harvard University or Wellesley College may also be counted toward the Requirement; however, a petition must be submitted. **Graduate Subjects** (designated "Year: G") may be used to satisfy the Requirement only by petition, which must include the instructor's signature. **Undergraduate Research and Reading Seminars** and other similar subjects of which the content is not specified in the catalogue may be used to satisfy the Requirement only by petition, which must include the instructor's signature and a description of the content.

Rules concerning **Other Subjects** which may be used to satisfy the Requirement in the several Schools are as follows:

1
Subjects in the School of Humanities and Social Science: See the general rules specified above concerning electives. In addition, the following subjects are **not** eligible toward the Requirement:

Psychology

9.01 [1]Neuroscience and Behavior
9.35 [1]Perception: Mechanisms and Models
9.36 Natural Computation and Control

[1] Students concentrating in Psychology may, by petition, count either one, but not both, of these subjects toward the Humanities Requirement.

Economics

14.04 Intermediate Microeconomic Theory
14.11 Mathematical Economics
14.30 Introduction to Statistical Method in Economics
14.31 Econometrics

Political Science

17.203 Evaluation Research Laboratory

Humanities

21.651 Early Music Repertoire and Performance
21.653 Vocal Music Repertoire and Performance
21.655 Chamber Music Study and Performance
21.657 MIT Symphony: Study and Performance

2
Subjects in the School of Architecture and Planning: The following rules govern the use of subjects in the School of Architecture and Planning to fulfillment of the Institute Requirement:

Architecture

All undergraduate subjects of at least nine units in the following number sequences (except subjects whose content and units are not specified in the catalogue description of the subject and which are eligible only by petition) are eligible as electives:

A) 4.601 through 4.683
B) 4.742J Shaping the Urban Environment [11.132J]
C) 4.801 through 4.876
D) 4.901 through 4.992

Urban Studies and Planning

The following subjects are eligible toward the Requirement:

11.005 Urban Social Structure and Process
11.007J Politics and Public Policy [17.201J]
11.008J Urban Economics [14.51J]
11.009 Technology and the City
11.010 Community Sociology
11.012 Institutions and Communities
11.013J American Urban History [21.412J]
11.014J History of the Physical Environment of Urban America [21.413J]
11.016 Introduction to Environmental Analysis
11.017 Introduction to the Political Economy of Urban Poverty
11.122 Environmental Policy and Regulation
11.131 The Urban Neighborhood
11.132J Shaping the Urban Environment [4.742J]
11.139 Introduction to Community Development
11.143 Urban and Regional Planning in Developing Countries
11.164J Urban Politics, Planning and Public Policy [17.283J]
11.166 Legal Institutions and Social Change
11.167 Seminar on Legal Institutions
11.197J State and Local Government Internships [17.351J]

3
Subjects in Other Schools: The following subjects **may be used** as electives in fulfillment of the Institute Requirement:

1.01J Engineering Aspects of Economic Analysis [14.014J]
1.12J Ethics and Technocrats [STS 412J]
8.206J Public Controversies on the Control of Technology [STS 413J]
20.029J Food, People, and Cultures [21.592J]
22.003J In Pursuit of Arms Control: Analysis of the Past and Choices for the Future [17.465J]
HST901J Health Economics [14.21J]
SRE107J Human Development: Individual and Social Perspectives [9.90J]
SRE108J Introduction to Cognitive Science [9.62J, 24.116J]
SRE244J Developing Musical Perception: Cognitive and Educational Implications [21.616J]
SRE245J Cognitive Processes [9.65J]

Science Distribution Requirement

The Science Distribution Requirement of 36 units is met by taking subjects especially designed for this purpose. Available subjects are listed below. To fulfill the requirement, students must study subjects totaling 36 units of which no more than 12 units may be taken in subjects offered by a student's own department. Subjects designated "J" which are cooperatively taught by faculty members in the student's own department also fall under the 12-unit departmental limitation. If 5.41 or 5.60 or 7.01 is used to satisfy the General Institute Requirement in Chemistry/Biology, then it cannot be used for the Science Distribution Requirement. The combination of subjects chosen must be approved by the student's Faculty Advisor. Science Distribution Subjects normally are taken in the second year, but students who have the proper prerequisites may take them in the first year.

Through Science Distribution Subjects the student can broaden and deepen the educational foundation in basic science begun in the first-year program. These subjects are designed to give each student the opportunity to proceed further in areas already studied, or to explore other areas of potential interest.

The available Science Distribution Subjects vary among themselves in approach and emphasis. Some give a systematic introduction to the fundamental concepts and principles of a field; others illustrate, through examples, some of the attitudes, concerns, and methods that are characteristic of professional work in a field.

Most Departmental Programs require 48 units in the second year. In many cases, subjects required by a department are also on the list of Science Distribution or Laboratory Subjects. Thus students following a particular Departmental Program may satisfy simultaneously part or all of the Science Distribution or Laboratory Requirements. This provides additional flexibility in the planning of a second-year program.

Science Distribution Subjects

1.00	Principles of Computer-Based Engineering Problem Solving (3-1-8)
1.04	Behavior of Physical Systems I (3-1-8)
1.16	Computer Models of Physical and Engineering Systems (3-0-9)
1.32	Introduction to Engineering Geology (3-3-6)
1.59J	Materials of Construction (3-0-9)
1.86	Element Cycles in the Environment (2-0-4)
2.01	Mechanics of Solids (4-0-8)
2.02	Introduction to System Dynamics (4-0-8)
2.101	Computer Models of Physical and Engineering Systems (3-0-9)
2.131	Ecodynamic Systems I (2-1-6)
2.132	Ecodynamic Systems II (3-0-6)
2.20	Fluid Mechanics (4-0-8)
2.40	Thermodynamics (4-0-8)
2.901J	Introduction to Polymer Science and Engineering (3-0-9)
3.00	Thermodynamics of Materials (4-0-8)
3.05	Computer Models of Physical and Engineering Systems (3-0-9)
3.061J	Introduction to Polymer Science and Engineering (3-0-9)
3.07	Introduction to Ceramics (4-0-8)
3.091	[1]Introduction to Solid-State Chemistry (5-0-7)
3.093	Magnetic Materials (3-0-9)
3.10	Chemical Physics of Materials (3-0-5)
3.11	Mechanics of Materials I (4-0-8)
3.141	Engineering Materials (3-3-6)
3.143J	Materials of Construction (3-0-9)
3.145	Introduction to Systems Analysis (3-0-9)
4.30	Basic Structural Theory (3-3-6)
4.43	Environmental Control — Acoustics (4-0-4)
5.21	Chemistry in a Technological Society (4-0-8)
5.40	[1]General Chemistry (4-0-8)
5.41	[1]Introduction to Structure, Bonding and Mechanism (5-0-7)
5.60	[1]Chemical Thermodynamics (4-0-8)
5.61	Physical Chemistry (4-0-8)
6.002	Circuits and Electronics (4-2-9)
6.018	Statistical Mechanics and Thermodynamics (4-0-8)
6.030	Introduction to Computation (4-3-5)
6.034	Artificial Intelligence (4-0-8)
6.041	Probabilistic Systems Analysis (4-0-8)
6.071	Introduction to Electronics (4-2-6)
6.524J	General Physiology (3-0-9)
7.01	[1]General Biology (4-0-8)
7.05	General Biochemistry (5-0-7)
7.51J	General Physiology (3-0-9)
8.03	Physics III (5-0-7)
8.04	Quantum Physics I (5-0-7)
8.20	Introduction to Special Relativity (2-0-7)
8.201J	Statistical and Biological Physics (5-0-7)
8.211	Introduction to Quantum Physics (5-0-7)
8.243	Modern Optics (3-0-9)
8.263	Physics of Fluids (3-0-9)
8.282	Introduction to Astrophysics and Astronomy (3-0-9)
8.291J	Planetary Physics and Chemistry I (3-0-9)
8.292J	Planetary Physics and Chemistry II (3-0-9)
8.293J	Dynamical Astronomy (3-0-9)
10.10	Process Synthesis (3-0-6)
10.11	Computer Models of Physical and Engineering Systems (3-0-9)
10.13	Mass and Energy Processing (4-0-8)
10.17	Air Pollution Fundamentals (2-0-4)

[1] Not acceptable as Science Distribution Subject, if taken to fulfill the General Institute Requirement in Chemistry/Biology.

11.015 Models and the Metropolis (3-0-9)
11.123 Environmental Quality Assessment (3-2-7)
12.002 The Earth and the Planets (2-0-4)
12.01 Geological Processes, Features and History (3-4-5)
12.02 Chemistry and Physics of Minerals and Rocks (3-4-5)
12.111 Survey of Astronomy I (2-0-4)
12.112 Survey of Astronomy II (2-0-4)
12.113 Astronomy I (3-0-9)
12.114 Astronomy II (3-0-9)
12.115J Dynamical Astronomy (3-0-9)
12.131J Planetary Physics and Chemistry I (3-0-9)
12.132J Planetary Physics and Chemistry II (3-0-9)
12.21 Physics of the Ocean (3-0-9)
13.001 Introduction to Marine Applied Mechanics (4-0-8)
13.013J Water, Air and Interface Vehicles (3-0-9)
13.014 The Oceans (3-0-9)
13.51 Computer Models of Physical and Engineering Systems (3-0-9)
14.30 Introduction to Statistical Method in Economics (4-0-8)
15.053 Introduction to Management Science (4-0-8)
15.852 Principles of Dynamic Systems I (3-0-9)
16.001 Unified Engineering I (4-3-5)
16.008 Computer Models of Physical and Engineering Systems (3-0-9)
18.03 Differential Equations (4-0-8)
18.05 Introduction to Probability and Statistics (3-0-9)
18.055J Biostatistics I (3-0-9)
18.057 Introduction to Applied Statistics (3-2-7)
18.063 Introduction to Algebraic Systems (4-0-8)
18.313 Probability (3-0-9)
18.440 Probability and Random Variables (4-0-8)
18.700 Linear Algebra (3-0-9)
18.703 Modern Algebra (3-0-9)
18.710 Abstract Linear Algebra (3-0-9)
19.02 Descriptive Meteorology (2-2-5)
19.83 Physical Oceanography (3-0-9)
20.021 Physiological and Nutritional Biochemistry (4-0-8)
20.113J Biostatistics I (3-0-9)
22.006 Computer Models of Physical and Engineering Systems (3-0-9)
22.02 Introduction to Applied Nuclear Physics (3-0-9)
22.03 Engineering Design of Nuclear Power Systems (3-0-9)
22.04 Radiation Effects and Uses (2-1-9)
HST 505J Statistical and Biological Physics (5-0-7)
NS51J Water, Air and Interface Vehicles (3-0-9)





Laboratory Requirement

The Laboratory Requirement of 12 units may be met by enrolling in one or two laboratory subjects expressly designed for this purpose. Available subjects are listed below. The Laboratory Requirement is normally fulfilled in the first two years.

A typical Laboratory subject offers the student an opportunity to set up and carry out experiments dealing with phenomena of the natural world. Under faculty supervision the student plays a substantial role in planning a) the design of the experiment, b) the selection of the measurement technique, and c) the procedure to be used for validation of the data.

Hypotheses are formulated and then tested by comparing them with the results of the experiments. The student then compares and discusses the experimental results in terms of the current state of knowledge and prepares progress and final reports of the work.

The Laboratory subjects call for a major commitment of the student's attention to one or a few experimental problems and emphasize as much as possible work of project type rather than routine experimental exercises. They are designed to stimulate the student's resourcefulness and ideas.

The Laboratory Requirement is not intended primarily to teach specific techniques for later experimental work, to provide broad coverage of a particular field, or to be a complement to a specific subject. The Laboratory subjects are planned to give each student, at an early stage of the educational experience at MIT, an opportunity to work on one or a few experimental problems, exercising the same type of initiative and resourcefulness as a professional would in similar circumstances.

1.102 Transportation Laboratory (0-3-3)
1.103 Geotechnical Engineering Laboratory (0-3-3)
1.104 Materials of Construction Laboratory (0-3-3)
1.105J Structural Engineering Laboratory (0-3-3)
1.106 Laboratory Projects in Environmental Fluid Mechanics (0-3-3)
1.107 Laboratory Projects in Aquatic Biology and Chemistry (2-6-4)
2.671 Measurement and Instrumentation (2-3-4)
2.672 Project Laboratory (1-3-2)
2.86 Manufacturing Processes (3-3-3)
3.081 Materials Laboratory I (1-3-5)
4.071J Design with Microclimate (3-6-3)
4.315J Structural Engineering Laboratory (0-3-3)
5.310 Laboratory Chemistry (2-8-2)
5.311 Introductory Chemical Experimentation (2-8-2)
6.101 Introductory Electronics Laboratory (3-8-1)
6.111 Introductory Digital Systems Laboratory (3-7-2)
6.121 Bioelectronics Project Laboratory (2-8-2)
6.141 Power Systems Project Laboratory (0-10-2)
6.151 Semiconductor Devices Project Laboratory (0-12-0)
6.161 Modern Optics Project Laboratory (2-8-2)
6.162 Image Transmission Systems Project Laboratory (0-12-0)
6.163 Strobe Project Laboratory (2-8-2)
6.182 Psychoacoustics Project Laboratory (3-4-5)
7.011 Introduction to Experimental Biology (2-8-4)
7.021 Experimental Immunology (2-16-6)
7.031 Experimental Microbial Genetics (2-16-6)
7.041 Experimental Cell Biology (2-16-6)
7.051 Experimental Biochemistry (2-16-6)
8.11 Physics Project Laboratory I (1-6-5)
8.12 Physics Project Laboratory II (1-6-5)
8.287J Observational Techniques of Optical Astronomy (3-4-5)
9.50 Research in Psychology (2-8-2)
11.185J Design with Microclimate (3-6-3)
11.188 Laboratory in Research Methods (2-5-5)
12.117J Observational Techniques of Optical Astronomy (3-4-5)
13.901 Ocean Engineering Laboratory I (1-5-0)
13.902 Ocean Engineering Laboratory II (1-5-0)
14.31 Econometrics (3-4-5)
15.301 Managerial Psychology Laboratory (2-6-4)
16.62 Experimental Projects (2-6-4)
16.622 Experimental Projects II (1-7-4)
17.203 Evaluation Research Laboratory (3-5-4)
20.002 Laboratory in Applied Biology (2-8-4)
22.069 Undergraduate Plasma Laboratory (1-8-3)
22.09 Introductory Nuclear Measurements Laboratory (2-6-4)



[1] Students taking 2.671 or 2.86 (9 units) receive 6 units of laboratory credit.

Physical Education Requirement

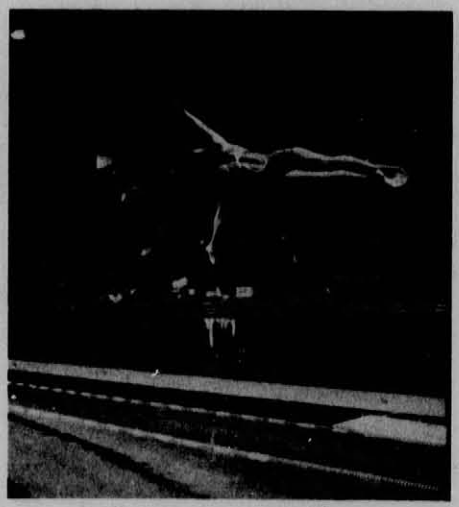
The Institute expects each student to gain experience in recreational athletics during his or her first two years at MIT. By the end of this period each student must have compiled at least eight points of athletic credit and must have completed the swimming test. These points may be acquired by participation in physical education classes, or by active membership on one of the freshman or varsity teams. In addition, a student may elect to take an advanced credit exam in one or more of the 16 subjects in which advanced credit examinations are given. Please consult the Director of Physical Education if interested in advanced credit examinations.

Sophomore transfer students must complete four of the eight-point physical education requirement. Junior and senior transfer students are *not* subject to the requirement.

The program consists of both individual and team activities with the major emphasis placed on the development of interests which can be carried on in later life. A student who elects individual sports such as golf, tennis, sailing, or squash will receive a strong background in the fundamentals of the sport. Instruction in physical education classes often leads to intercollegiate or intramural participation.

Physical education classes for the year are divided into four quarters, with these activities:

First Quarter:
Archery, bicycling, CPR, ballet (beginning and intermediate), partner dance, tap dance, development, field hockey, touch football, ultimate frisbee, golf, lacrosse, pistol, precision air rifle, rock climbing, rugby, sailing, scuba, sculling, self-designed fitness, swimming (beginning), T'ai Chi, and tennis (beginning and intermediate).

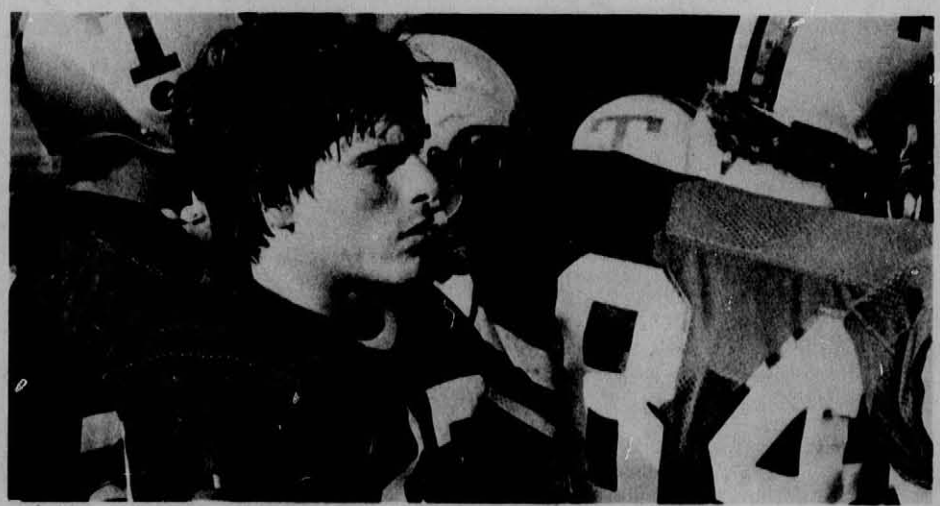


Second Quarter:
Badminton, basketball fundamentals, basketball officiating, CPR, ballet (beginning and intermediate), partner dance, tap dance, development, diving, fencing, hockey, judo, pistol, precision air rifle, Red Cross advanced life saving, self-designed fitness, skating (beginning), squash, swimming (beginning and intermediate), and yoga.

IAP:
Archery, badminton, baseball (hitting), CPR, ballet (beginning), partner dance, fencing, field hockey (indoor), first aid, hockey, box lacrosse, pistol, self-designed fitness, skating (beginning), figure skating, squash, and T'ai Chi.

Third Quarter:
Basketball, CPR, ballet (beginning and intermediate), partner dance, tap dance, development, fencing, figure skating, first aid (part 1), hockey, judo, pistol, rifle: small bore, scuba, self defense, self-designed fitness, skating (beginning), skin diving, squash, swimming (beginning, intermediate, and advanced techniques), volleyball, and Red Cross W.S.I. (part 1).





Wellesley-MIT Exchange Program

Fourth Quarter:
Archery, bicycling, CPR, ballet (beginning and intermediate), partner dance, tap dance, development, first aid (part 2), ultimate frisbee, golf, pistol, rock climbing, sailing, scuba, sculling, self-designed fitness, softball, squash, swimming (beginning), tennis (beginning, advanced beginning, and intermediate), and Red Cross W.S.I. (part 2).

Upon entering MIT each student must submit a record of a medical examination and take a swimming test. Students who fail the swimming test are expected to take beginning swimming. If the medical examination indicates any disability which might limit physical activities, athletic requirements may be modified with consultation with the MIT Medical Department.



The Wellesley-MIT Exchange Program was established to expand the educational opportunities for students of each institution. Here the word "educational" does not apply simply to academics, but also to the social involvement and cultural awareness that can be expanded by cross-registering.

Wellesley is a small, liberal arts college for women located on a 500-acre woodland campus 12 miles west of Boston.

Wellesley College — the faculty, the students, the facilities, the campus — provides a different yet no less challenging environment for learning and living from that of MIT. Whether taking a course that is not offered at MIT, just walking around the vast expanse of trees and grass, or even swimming or sailing at the lake, the experience at Wellesley will be rich and rewarding.

Wellesley and MIT operate free weekday bus service between the two campuses for students who are cross-registered. The ride is about 40 minutes each way, providing time for reading, studying, and thinking before and after classes. Essentially, this means that students will need at least one hour between their Wellesley and MIT classes.

MIT students receive full library privileges at the Wellesley College Library, and may take physical education classes there.

Information and copies of the Wellesley catalogue are available in the Exchange Office at MIT in Room 7-108, (617) 253-1668. The Exchange Office at Wellesley is located in Room 339B, Green Hall, 235-0320 x468 (through the MIT tie line: 187-468).

Registering at MIT for a Wellesley course is like registering for a regular MIT course. Students should put the course name and number on their registration form or correction form in the space marked "Cross Registration at Wellesley." Students must also register at Wellesley during the first two weeks of classes.

Members of the Wellesley faculty serve as exchange coordinators to assist exchange students. Their names, phone extensions, and the departments they represent are available in the Exchange Office at MIT.

To drop a Wellesley course students should fill out a registration correction card and inform both their Wellesley instructor and the Exchange Coordinator at Wellesley.

MIT students receive letter grades for their Wellesley courses unless 1) a course is designated mandatory "credit/non-credit" by Wellesley, 2) they are a freshman under MIT's mandatory "pass/fail" requirement, or 3) they are a junior or senior using one of their two MIT electives for pass/fail.

Grading for Wellesley's credit/non-credit system differs from that of MIT's pass/fail system. At MIT a pass is awarded for work above failing; however, at Wellesley credit is awarded for C-level work or above.

To take a course at Wellesley under the MIT pass/fail option, students must file a Registration Correction Card with the MIT Registrar. Freshmen automatically receive pass/fail from the Registrar, however, they should inform the Wellesley Registrar that their grade should be recorded pass/fail.

Wellesley sends grades to both the student and the MIT Registrar. Grades do not arrive until several weeks after the end of the term. As a result, they cannot be included in the MIT end-of-term grade report but instead are entered on the next grade report.

Students may take Wellesley courses to meet a variety of MIT distribution and concentration requirements. There are, however, some restrictions and special procedures, which are described below.

Generally students cannot substitute Wellesley courses for MIT Science Core courses (Chemistry/Biology, Physics, and Calculus) or Laboratory Requirement courses. They may take Wellesley courses to satisfy Science Distribution Requirements, but need the approval of the Committee on Curricula.

To meet the Distribution portion of the MIT Humanities, Arts, and Social Sciences Requirement, students may take the courses listed in the HASS Distribution section earlier in this chapter. The requirement that students must choose distribution courses from at least three different fields applies to Wellesley courses just as it does to MIT courses.

Wellesley courses may be designated as part of the Concentration in the Humanities, Arts, and Social Sciences at the discretion of the designated advisor in that Field of Concentration. A list of advisors may be obtained from the Exchange Office at MIT or the Office of the Dean of Humanities and Social Science, Room 20D-204, 253-3470. Special concentrations may be arranged through Janet Romaine, Assistant to the Dean of Humanities and Social Science.

Students may use Wellesley courses as unrestricted electives toward fulfilling the Humanities, Arts, and Social Sciences Requirement, but for administrative reasons they must petition to do so. Petitions may be obtained from the Exchange Office at MIT or from Janet Romaine. Students with questions pertaining to the Humanities, Arts, and Social Sciences Requirement should contact Ms. Romaine.

Most examinations are offered on a self-scheduled basis. Complete information on examinations and papers is available during the term in the Exchange Office at MIT.

Students may seek an extension of a deadline for a final paper or examination only in the case of illness or grave emergency. They must apply for an extension within 24 hours of the deadline by contacting the Exchange Coordinator at Wellesley. Students who turn in a final late without an extension will be penalized with a lowered grade.

The following is a list of majors at Wellesley:

Departmental

Anthropology
Art
Astronomy
Biological Sciences
Black Studies
Chemistry
Chinese
Economics
Education
English
French
Geology
German
Greek and Latin
History
Italian
Mathematics
Music
Philosophy
Physics
Political Science
Psychology
Religion
Russian
Sociology
Spanish
Theatre Studies

Interdepartmental

Chinese Studies
Classical Civilization
Classical and Near Eastern Archaeology
Medieval/Renaissance Studies
Molecular Biology
Psychobiology

Individual

American Studies
East Asian Studies
Italian Culture
Language Studies
Theatre Studies
Urban Studies
Women's Studies



Admissions

Freshman Admissions





The majority of undergraduate men and women enter MIT as members of the freshman class, directly following completion of secondary school studies. Most good public, parochial, and independent secondary schools in the United States and equivalent schools in other countries provide suitable preparation for the student who takes full advantage of the opportunities that such schools afford. The efforts of secondary schools to achieve regional accreditation are encouraged by MIT.

The preparatory course in high school should be a broad one. The applicant should be able to read with intelligence and sensitivity and to express ideas clearly in oral and written form. In mathematics, emphasis should be on thorough mastery of fundamental principles, operations, and definitions rather than on covering a wide range of topics.



Each applicant is required to have completed the following specific preparatory subjects; the figures in parentheses represent the usual "unit" rating, a unit being a full year's study in a secondary school subject taken four or five times a week:

English (4)	Plane Geometry (1)
Algebra (2)	Chemistry (1)
Physics (1)	Trigonometry (1/2)

Students who will not have completed all of these subjects by graduation should be prepared to meet the requirement through a summer school program. MIT does not offer a summer program for entering freshmen; therefore, students are expected to make their own arrangements.

The precise content of the mathematics curriculum is not prescribed, but the applicant must, as a minimum, have sufficient preparation for the study of calculus.

In addition to the subjects specifically required, the applicant normally will have completed at least six additional units in secondary school studies. No limitations are imposed in the choice of these elective subjects. In the selection of the entering class, the Committee will be guided by the quality of the applicant's work and by apparent promise on grounds of intellect and character, rather than by choice of electives.

MIT commends the study of history and of foreign language in depth. The choice of languages should be guided by the educational opportunities open to each student, by special interests or cultural ties, and by the nature of his or her probable future work.

Application Procedures

Applicants are encouraged to write during their junior year for information. Candidates in their last year of high school must complete the application process by January 1 of the year of intended entrance. Early action is available with a November 1 deadline. There is a $30 application fee. Notices concerning the admission decision will be mailed in early April.

Personal Conferences (Interview)

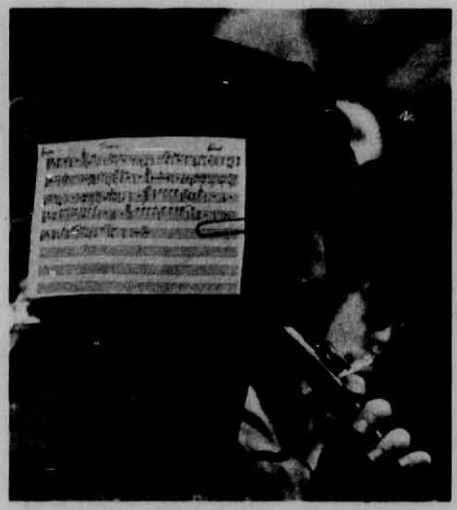
Each applicant for admission to the freshman class is required to have a personal conference with a designated member of the MIT Educational Council near the applicant's home. Council members are MIT graduates who have been selected for their ability to represent MIT and for their interest in young people.

Each applicant will be referred for a conference to a member of the Council. This conference is an essential part of the final application and must take place between May 1 of the junior year and December 15 of the year prior to entrance.

Prospective applicants and their families are welcome at the Admissions Office Monday through Friday between 9 am and 4 pm. Visitors should try to plan their time to include a student-guided tour of the campus, available at 10 am and 2 pm each weekday that the Admissions Office is open. If planning a visit from a distance, please be sure to check on local holidays.

Entrance Examinations

All candidates are required to take the following tests given by the College Board: the Scholastic Aptitude Tests and three one-hour achievement tests in 1) Level I or Level II Mathematics, 2) Physics or Chemistry or Biology, 3) English Composition or one of the History tests. (Test requirements vary for international students. See the section on Entrance Examinations for Foreign Applicants later in this chapter for more details.



The College Board offers these examinations in the principal cities of the United States and abroad. The test dates, locations, and fees for the current year are outlined in an Information Bulletin which may be obtained from most guidance offices or by writing directly to the College Board, Box 592, Princeton, New Jersey 08540. Residents of western North America, Mexico, Australia, Pacific Islands, Japan, and Taiwan should apply to the College Board, Box 1025, Berkeley, California 94701.

Candidates for admission for September 1982 must have completed the SATs and the three achievement tests by the January 1982 testing date. Either the SAT or up to three achievements may be taken on any scheduled test date. Note that the closing dates for registration are usually four to six weeks (five to seven weeks outside the United States) before the test date. The College Board should be requested to send all scores directly to MIT. A student taking physics or chemistry in the junior year should probably take the achievement test in that subject during the spring of that year.



Early Action

MIT requires a complete set of application materials before considering a candidate for admission. A student who takes all the required College Board tests by the November test date and files all of the application material by November 1 of the senior year may request the Committee on Admissions to review the application by mid-December. If the test scores, school grades through the junior year, and other qualifications are so excellent that the applicant will clearly be acceptable later, the Committee will offer admission immediately; if it feels that it should compare the application with those of other candidates, it will hold the application until the usual time in April. A student who seeks early consideration in this way is free to file applications at other colleges and, if offered admission at MIT, is not required to reply to the Institute before the candidates' reply date in early May. This, therefore, is not an "early decision" plan in the usual sense.

Minority Program

The Institute makes its facilities available to qualified students, regardless of cultural background or financial condition. In order to help newly admitted students make a successful transition from high school to the pace and style of MIT, a special summer session is available, called Project Interphase. This program offers subjects in math, science, and the humanities which build on the regular entrance requirements. It is available by invitation at no expense to the student.

Deferred Admissions

Occasionally students wish to take a year off between secondary school and college. In such cases we recommend following normal admissions procedures, as if going directly on to college, and then requesting deferral. If during the "deferred" year students take post-secondary school academic work approximating a full course load, they must reapply as transfer students rather than matriculate as deferred freshmen.

Advanced Placement

MIT has always encouraged students to move ahead academically according to their capabilities. It offers four procedures by which students entering from secondary schools may go directly into a subject at an advanced level: 1) the College Board Advanced Placement Program; 2) International Baccalaureate; 3) college transcript; and 4) Advanced Standing Examination at MIT.

Students who take college-level subjects offered in their schools in cooperation with the College Board Advanced Placement Program should take the appropriate three-hour examinations administered by the Board each year in May and instruct the Board to send the scores to MIT. Degree credit for MIT subjects, and, where appropriate, advanced placement, is given on the basis of a high achievement in the tests (normally a score of four or five). The students are notified of the credit offered before registration so that they may discuss an optimum schedule with their faculty advisor.

In some secondary schools, selected students take college-level subjects at a local college. Such students may submit an official transcript from the college showing subjects taken and grades earned in order to receive MIT credit under the regular college transfer procedures.

MIT does not give credit for high school or other precollege study of foreign languages.



International Undergraduate Admissions

The MIT undergraduate student body includes citizens of other countries. These students normally join the freshman class after completing secondary school at the highest level. Students are encouraged to plan to complete the Higher School Certificate, the General Certificate of Education at the Advanced Level, the Baccalaureate, the Maturite, or the Gymnasium, even though decisions on admission to MIT are made in April, prior to the time when most exams are normally taken.

All citizens of foreign countries, except Canadian citizens and foreign citizens attending secondary schools in the United States, should begin the application process as outlined below.

Application Procedures

Students should write to the Director of Admissions at least a year before they plan to enter MIT for information about application procedures. Included in the response will be the leaflet, "Information for Prospective International Students" and a Request for Application form which should be returned promptly. Final Application materials will be forwarded to those whose Request for Application form is approved. All documents must be completed in English or accompanied by attested translations of the original into English. In order to receive consideration, the Final Application must be completed and returned by January 1, and the required College Board tests (including, if appropriate, the Test of English as a Foreign Language) must be taken by the January test date. All students are urged to register for the tests at least six to eight weeks in advance of the testing date.

Request for Application forms or initial letters of inquiry about admission received after January 1 will be too late for the fall term.

Personal Conferences

Applicants will be asked to arrange a personal conference with a local MIT alumnus, a representative of the Institute for International Education, or the America-Mideast Educational and Training Services (AMIDEAST).

Facility in English

Lectures, laboratory sessions, and written or oral examinations at MIT are conducted in English. All applicants must present evidence of their ability to carry on their studies in English.

Entrance Examinations for Foreign Applicants

If an applicant's schooling has been in English for the past five years, the College Board tests listed in the Entrance Examination section of this chapter are the required entrance examinations. If English has not been the language of instruction for the past five years, the following group of tests may be substituted: the Test of English as a Foreign Language (TOEFL) and the Physics Achievement Test, the Chemistry or Biology Achievement Test, and either the Math Level I or Level II Achievement Tests.

TOEFL is administered by the Educational Testing Service. Students wishing to take the TOEFL must do so no later than the January test date; an earlier test date is preferable. Write directly to the Educational Testing Service, Princeton, New Jersey 08540, USA, for registration material and information about this test.

College Transfer Admissions

Students who have completed two or more terms with high standing at a recognized college, university, engineering school, or junior college and who are entitled to honorable dismissal may be admitted to MIT by transfer. Applications should be submitted by April 1 for entry in September and by November 15 for entry in February. Applications from students in their first year of college will normally be considered only after the college record for the entire year becomes available.

A transfer student's eligibility for admission will be determined by the Committee on Admissions after a review of his or her record. The applicant will be expected in every case to have completed one year's study of secondary school physics and chemistry (or the equivalent at the college level) and mathematics through trigonometry.

Transfer applications may be submitted at not less than one-year intervals. It is not customary to admit as a transfer a student with only one additional year's work needed to complete the degree.

Transfer applicants will be asked to take the College Board tests prescribed in this chapter's section on Entrance Examinations for freshman applicants if they have not already done so. Transfer applicants from foreign countries are admitted only for September.

Foreign transfer students should read carefully the sections on Entrance Examinations and Entrance Examinations for Foreign Applicants in this chapter.

Application Procedures

College students considering transfer to the Institute should file a Preliminary Application for Admission with Advanced Standing on a form obtainable from the Admissions Office. The Director of Admissions will advise the applicant of those parts of the regular entrance requirements which must be fulfilled and will arrange to have the final application materials sent.

The applicant must assure that the following documents are submitted:

1
A completed Application for Admission with Advanced Standing, indicating all subjects that will have been completed at the time of transfer, and a nonreturnable fee of $30.

2
A certified transcript of the college record to date, including a statement of good standing. A certified statement covering subjects subsequently taken should be sent as soon as it is available. Students in their first year in college may wait until the end of the year before sending the first transcript of record.

3
Catalogue pages describing all subjects which will have been completed.

4
Three evaluation reports, including two from faculty instructors and one from the Dean of Students or the applicant's chief faculty advisor. These forms should be sent directly to the Director of Admissions by the endorsers.



5
A report from the secondary school attended. The report should be made on the form provided with the Final Application and should be sent directly from the secondary school to the Director of Admissions.

6
College Board test reports, as appropriate.

As soon as the completed application has been reviewed, the applicant will be informed of the decision. In some cases, action may be deferred until final grades are available.

Applications for Financial Aid

An intention and a wish to apply for financial aid may be shown on the admission application form in space provided for that purpose.

Advanced Credit

Students admitted by transfer may expect to receive credit for subjects of study completed elsewhere that are substantially equivalent to corresponding Institute subjects. A grade above the lowest passing grade is necessary.

A student in another college contemplating later transfer to MIT should plan a program of studies to include as much as possible of the mathematics, physics, and humanities as is included in the typical first two years of MIT.

Applicants admitted with advanced standing in architecture will be placed in the design sequence in accordance with their performance on their first problem.

All remaining questions concerning credits must be settled within two weeks after the opening of the academic year. In these cases, the student should consult the Director of Admissions.

Special Student Admissions

The Institute can accept a limited number of undergraduates who wish to carry on special studies and who are not degree candidates at MIT. The students enroll as Special Students; they enjoy most of the privileges of the regular student but are not eligible for campus housing or financial assistance from MIT. Special Student status is granted for *one term only*, and a new application for this status is required for any successive terms. Admission as a Special Student does not carry any implication for applications filed at a later date. Applicants must present academic credentials of high quality or evidence of professional experience relevant to the proposed program. Admission is subject to available places in the classroom, laboratory, or studio.

The Director of Admissions will supply application forms upon request. There is an application fee of $30 for the first application; it is not required for renewal applications within a two-year period.

Deadlines for filing applications are August 1 for fall term, December 1 for spring term, and May 1 for summer term.



Costs for Undergraduates

Undergraduate student costs for the academic year 1981-82 at MIT will be about $11,700. This includes tuition, comprehensive health care services at the MIT Medical Department,[1] and an estimate for the costs of room and board, books, supplies, and personal expenses. Cost of travel obviously varies significantly and is not included. The cost of books and supplies, clothes, laundry, recreation, and other personal necessities vary widely depending upon interests, tastes, and needs, but typically total about $1,120. There are many kinds of dining and housing arrangements at MIT and the range of student expenses for room and board is broad (but is generally between $2,200 and $3,200 for the academic year). Total costs for most undergraduates during the 1981-82 academic year will be in the range of $8,900 to $11,900 (excluding cost of travel), depending upon specific choices.

The following are the basic **tuition and fees** at MIT for the academic year 1981-82 (which are reviewed and likely to increase each year):

Tuition	$7,400
Hospital and Accident Insurance Policy[2]	168

The tuition for all regular undergraduates in the first and second terms is $3,700 per term. Full tuition in either term of the current year covers the January Independent Activities Period. Tuition rates for the Summer Session are published each year in the *Summer Session Catalogue,* available in March.

Regular undergraduate students who have permission to take only a few subjects are initially charged full tuition. They may then apply to have their tuition charged at the rate of $120 per unit with the approval of the Faculty Advisor and, if not a degree candidate, with the additional approval of the Dean for Student Affairs. In such cases, there is a minimum fee of $720 for subjects and a minimum of $310 for S.B. thesis. Upon recommendation of a department, the Dean for Student Affairs, in the case of an undergraduate student, may set a special tuition rate in unusual circumstances.

Special Students are charged at the rate of $120 per unit taken either for credit or not for credit. This unit fee applies up to a maximum of $3,700 per term and is subject to the following minimum fees:

Members of the MIT Community[3]	$720
Other Special Students	1,080

Cooperative programs offered by MIT provide industrial and research experience through a series of work assignments interwoven with regular study at the Institute. The tuition fees for cooperative programs are as follows:

Aeronautics and Astronautics, Course XVI-B
Mechanical Engineering, Course II-B
Ocean Engineering, Course XIII-C
June-August (15 months), $7,400

Chemical Engineering Practice, Course X-A
September-January or February-June, $3,700

Electrical Science and Engineering or Computer Science and Engineering, Course VI-A
Engineering Internship Program
Materials Science and Engineering, Course III-B
July 1 to June 30, $7,400

In each case, the first $3,700 is due on the date when the first-term tuition is normally due, and the additional $3,700 is due on the date when the second-term tuition is normally due. Upon recommendation of the Department, a special tuition rate for any cooperative program may be set by the Dean in an unusual case.

A student withdrawing before the start of a term is not charged any tuition for that term and any tuition payments previously made for that term will be refunded. Students withdrawing during the first or second term are charged one-twelfth of the stated tuition for the term for each week from the starting date of the term, with a minimum two-week charge. A student is financially obligated to the Institute for the tuition appropriate to the program approved by his or her Faculty Advisor or Graduate Registration Officer at the beginning of the term. Any subsequent reduction in fees is based on the date that cancellation of a subject or withdrawal from the Institute is effected. At that time, any excess payments which the student has made will be refunded.

1
Payment of the tuition fee entitles all regular and special registered students to comprehensive health care services at the MIT Medical Department, including consultation with a wide range of specialists, diagnostic studies, and hospitalization in the MIT Infirmary. Charges are made for routine eye examinations, contact lens services, ear piercing, dental care services, obstetrical care, contraceptive devices, missed appointments, and those surgical procedures and outside diagnostic tests that are generally covered by the student's hospital and accident insurance policy.

2
The MIT Student Insurance covers hospitalization (other than in the MIT Infirmary) due to accidents or illness. The insurance is required for all students, unless they can demonstrate that they have equivalent coverage through another insurance program. A medical insurance plan for a student's spouse and children is also available. The additional cost of insurance coverage for the spouse for outside hospital care is $456. Hospitalization insurance for one or more children may be purchased for $156. A student withdrawing during a term may cancel this insurance and receive a credit, as of the end of the month when cancelled, by filing a request at the Student Insurance Office.

3
Includes Special Students who are full-time employees of the Institute or who are dependents of full-time employees or regular students.

Miscellaneous Fees

Application fee for undergraduate admission	$30
Late registration fee	10
Late degree application	20
Fee for late payments	50

Processing Charges for Late Changes in Registration

A late change in registration, which requires the approval of the appropriate faculty committee, is defined as adding a subject after the fifth week or dropping a subject during the last three weeks of a term. The processing charge for late changes is $20 for one subject or $25 for more than one subject in a petition. There is an additional charge of $20 for a retroactive change after the end of the term.

The miscellaneous fees and processing charges listed above are nonrefundable, unless levied in error.

Payments

All payments are to be made to MIT, Cambridge, Massachusetts 02139, by the time specified in the financial registration instructions issued prior to the opening of each term. A late charge of $50 is assessed for each payment that is not received when due. Registered student status can be withdrawn at any time for non-payment of fees. A student who expects to be a candidate for a degree must make satisfactory financial arrangements for any indebtedness prior to requesting entry of his or her name on the degree list.

To assist students in meeting each term's expenses, various financial aids are available for which the student may be eligible (described in the next section). Also, students and their families might consider the installment plans that are offered. The MIT Parent Loan Plan, for example, was recently developed to help parents pay for four years of college costs over a period of about six and one-half years. MIT provides the basic funds for this monthly installment plan, which offers loans at moderate interest rates to parents whose annual family income is between $25,000 and $75,000. There are also a number of prepayment plans and extended payment plans available through commercial banks, lending institutions, and insurance agencies. Information on these installment programs will be sent in the spring to the parents of newly admitted students. Otherwise, information may be obtained from John Rogers, MIT Parent Loan Plan Office, Box 160, Boston, Massachusetts 02101, (617) 253-3342.

MIT also offers a deferred payment plan to undergraduates on a limited basis. This plan allows for each term's tuition and other payments to be spread over the term in three installments. (An administrative fee of $50 per term will be charged for this service.) The deferred payment program for undergraduates, however, is planned primarily to assist students (and their families) with short-term emergency situations or other special family circumstances. This plan may be modified (or discontinued) over the next several years, as various alternatives, such as the Parent Loan Plan, are developed. Financial registration instructions and billings for tuition and fees will be sent to admitted and continuing undergraduate students prior to the beginning of each term.

Financial Aids

Grants, Loans, and Employment

Students considering MIT are strongly urged to explore all areas of financial assistance, including government scholarship and loan programs. A number of states sponsor scholarship programs for residents, and information concerning eligibility may usually be obtained from secondary school guidance counselors. The Federal Guaranteed Loan Program is administered by individual states. Local banks and lending institutions should be able to answer initial inquiries concerning the availability of loans under this program.

Parents of students considering MIT might also explore the Parent Loan Plan, which is described in the preceding section.

The Student Financial Aid Office provides grants and loans based on the financial need of the individual student, as determined by analysis of a statement of family financial condition. This will be provided by means of the Financial Aid Form of the College Scholarship Service. A copy of the most recent parental Federal tax return is also required in support of aid applications.

The Student Financial Aid Office reviews applications and makes awards from the most suitable Institute grant and loan resources. Applicants need not request aid from a specific fund. Any need which is not met by grant may be offset by long-term loans or employment.

Students are expected to work and/or borrow as the first incremental portion of their aid. Student loan funds allow the student to pay part of the cost of his or her education on long-term credit under favorable financial terms. However, loan fund capital is limited, and MIT student loans are granted only on the basis of demonstrated financial need. Undergraduate loans are provided from several sources, including the National Direct Student Loan (NDSL) Program and the Institute's own Technology Loan Fund.

Jobs are not assigned; rather, students are expected to arrange employment most suitable to their own talents and available time. The Student Employment Office maintains listings of positions to assist students seeking jobs. Employment is usually available on campus in dining facilities, residence halls, offices, libraries, and laboratories. Listings of off-campus positions also are available. Students' earnings from part-time work depend on experience, and, of course, availability of time.

Applications for Financial Aid

Entering Freshmen

Students who wish to be considered for financial aid should complete the appropriate form included with the Application for Admission. Financial aid application materials must be submitted prior to January 1. An application for admission is not prejudiced by an application for aid. The two decisions are entirely separate — need criteria have no bearing on admissions, and admissions criteria have no part in determining qualifications for aid. There is no reason to be deterred from applying concurrently to MIT for admission and aid.

International Students

MIT has small amounts of scholarship and loan funds which are made available to exceptionally well-qualified undergraduate international students who demonstrate financial need. International students who wish to be considered for financial aid should complete and return the appropriate form included with their admissions material by November 1. Because financial aid funds are severely limited, students should seek aid from sources other than MIT. **International students should make all arrangements for their financial obligations to MIT for their entire stay in the United States before leaving their countries.** Further information about the admission of international students is available from the Director of Admissions, Room 3-108, MIT, Cambridge, Massachusetts 02139, USA.

Transfer Students

Transfer applicants who wish to be considered for financial aid may obtain an application form by completing the Request for MIT Financial Aid Application included in the Admissions packet.

Scholarships and Special Loan Funds

Upperclass Students

MIT awards are made on an annual basis, and recipients are required to reapply in January each year for continued assistance in the following year. Upperclass students who have not received prior assistance may also apply at this time. Upperclass financial aid application instructions are available from the Student Financial Aid Office in mid-February; the reapplication process calls for a copy of the most recent parental Federal tax return, and all applicants are expected to apply concurrently for a Federal Pell (Basic) Grant, a State grant where applicable, and for any and all renewable grants received in prior years. Eligibility for MIT undergraduate grant funds will end when the student is eligible to receive an initial degree, or after eight terms, whichever occurs first.

Over the years since its founding, the Institute has received gifts from many benefactors, alumni, and friends, who have recognized student need for assistance toward their costs. The following list presents the names of the scholarships thus established from which student aid is annually drawn. The parenthetical figures at the end of each name state the year the scholarship was established.

Frank W. and Carl S. Adams Memorial Fund (1955)

Alcoa Scholarships (1965 and 1968)

Max I. Alimansky ('28) Memorial Student Scholarship Fund (1973)

Caroline Hadley Allen Fund

Elbert G. Allen ('00) Fund (1969)

Nils Anderson Scholarship (1961)

William P. Anderson, Jr. Fund (1965)

Louie G. Applebee Fund (1942)

Rufus Applegarth, Jr. Scholarship (1963)

W. Cornell Appleton Scholarship Fund (1971)

Association of Iron and Steel Engineers — Madsen Scholarship Fund (1966)

Athan Scholarship (1962)

Elisha Atkins Fund (1894)

Hattie G. Atkins Fund (1962)

Julian M. Avery ('18) Fund (1957)

Jason S. Bailey Fund (1952)

Thomas Wendell Bailey Fund (1914)

Charles Tidd Baker Fund (1922)

Constance and Arthur H. Ballard Memorial Scholarship Fund (1969)

Frederick James Amweg Memorial Fund (1979)

Colonel Daniel Moore Bates ('96) Scholarship Fund (1973)

Lester I. Beals Memorial Scholarship Fund (1976)

Louis D. Beaumont Foundation Scholarships (1973)

John Rice Bell Memorial Scholarship (1961)

Harry Howe Bentley Fund (1979)

Alf K. Berle Memorial Scholarship Fund (1960)

Billings Student Aid Fund (1900)

Ernst Henri Birnbaum Memorial Fund (1964)

Huse Templeton Blanchard ('01) Fund (1946)

Levi Boles Fund (1915)

Jonathan Bourne Fund (1915)

Albert G. Boyden Fund (1931)

Bertram Brewer Scholarships (1952)

Hubert D. Broderic (1965)

A. Raymond Brooks ('17) Scholarship Fund (1973)

A. Lawrence Brown ('13) Fund (1979)

Harriet L. Brown Fund (1932)

Walter Stanley Brown Scholarship Fund (1968)

Bryant Chucking Grinder (1979)

Willard B. Buck Scholarship Fund (1971)

The John S. Buhler ('27) Memorial Scholarship Fund (1973)

Denison K. Bullens Scholarship Fund (1960)

Vannevar Bush Scholarship Fund (1960)

Cabot Corporation Scholarships (1955)

Godfrey L. Cabot Fund (1950)

Thomas D. Cabot Scholarship Fund (1960)

William Putnam Cabot Scholarship Fund (1977)

Joel W. Campbell Scholarship Fund (1967)

William H. Carlisle, Jr. Scholarship Fund (1968)

Mrs. Richard Carson, Sr. Fund (1979)

Mabel Blake Case Fund (1920)

Harry Hardin Catching ('12) Memorial Scholarship Fund (1975)

Nino Tesher Catlin Fund (1926)

Francis Ward Chandler Memorial Fund (1969)

Edward S. Chapin ('98) Scholarship Fund (1967)

James M. Chovak ('57) Memorial Scholarship Fund (1976)

Clapp and Poliak Scholarships (1966)

Lucius Clapp Fund (1905)

Clark Foundation Scholarships (1953)

Edna McConnell Clark Scholarship (1973)

J. Russell ('29) and Dorothy V. Clark Fund (1972)

Thomas L. Clark Memorial Scholarship (1956)

A. V. Clarke Fund (1950)

Class of 1887 Scholarship Fund (1967)

Class of 1895 Memorial Scholarship Fund (1945)

Class of 1906 Scholarship Fund (1967)

Class of 1909 Memorial Fund (1957)

Class of 1910 Scholarship Fund (1967)

Class of 1917 Edwin E. Aldrin, Jr. Scholarship Fund (1972)

Class of 1917 Memorial Scholarship Fund (1980)

Class of 1918 Memorial Scholarship Fund (1971)

Class of 1925 Scholarship Fund (1974)

Class of 1926 Charles Stark Draper Fund (1974)

Class of 1931 Compton Memorial Freshman Scholarship Fund (1956)

Class of 1932 Fund (1951)

Class of 1933 Fund (1958)

Class of 1933 Robert M. Kimball ('33) Memorial Scholarship (1964)

Class of 1934 Compton Fund (1959)

Class of 1935 Memorial Scholarship Fund (1971)
Class of 1936 Scholarship Fund (1971)
Class of 1937 Scholarship Fund (1971)
Class of 1938 Scholarship Fund (1938)
Class of 1939 (1979)
Class of 1950 Scholarship Fund (1974)
Fred L. and Florence L. Coburn Fund (1932)
Coffin Memorial Fund (1929)
Arthur L. Collier Memorial Fund (1977)
W. A. Conant Scholarship Fund (1943)
Albert Conro Scholarship Fund (1943)
The George R. Cooke ('08) Fund (1939)
Charles D. Coryell Memorial Scholarship Fund (1971)
Paul F. Cotter ('57) Fund (1974)
John G. Crane Scholarships (1951)
Allen S. Crocker Memorial Fund (1961)
Lucretia Crocker Fund (1916)
Ernest J. Cronenbold ('03) Scholarship Fund (1974)
Eunice McLellan Cruft Fund (1949)
Allan R. Cullimore Fund (1979)
Ralph E. Curtis Scholarship (1960)
Louis R. Damiano Memorial Scholarship Fund
Isaac W. Danforth Fund (1903)
D'Autremont Scholarship Fund (1979)
Tenney L. Davis Scholarship Fund (1967)
Robert Taylor Dawes ('26) Scholarship Fund (1969)
The Delafield Memorial Fund (1960)
Orville B. Denison Memorial Fund (1960)
Marie G. Dennet Scholarship Fund (1963)
Carl Pullen Dennet Memorial Scholarship Funds (1956 and 1959)
Edward Depoyan ('30) Memorial Fund (1976)
Thomas C. Desmond Scholarship Fund (1960)
John H. Dessauer Scholarship Fund (1973)
Development Fund Scholarships (1950)
Ann White Dickinson Fund (1968)
Frederick N. Dillon, Jr. Scholarship Fund (1968)
Fred C. Dobbs Fund (1960)
Dormitory Fund (1903)
Philip B. Downing Trust
Henry C. Dresser Fund (1965)
Thomas Messinger Drown Scholarships (1928)
Edouard N. Dube, Class of 1921 (1979)
Charles Dyer Scholarship Fund (1968)
Eastman Kodak Company Scholarships (1977)
John A. Easton, Jr. ('36) Scholarship Fund (1980)
The Ederic Foundation (1979)
Daniel W. Edgerly Fund (1964)
Robert B. Zsabel Ehrman Memorial Scholarship Fund (1970)
M. Herbert Eisenhart ('07) Scholarship Fund (1980)
Calvin P. Eldred Memorial Scholarship Fund (1970)
Electrical Regulator Scholarship Fund
Leola M. Farnham Scholarship Fund (1966)
Farnsworth Fund (1889)
Alton J. Farrel, Jr. Scholarship Fund (1967)
Robert S. Faurot ('44) Scholarship Fund (1976)
Francis Edwin Faxon Scholarship Fund (1967)
Joshua B. Feldman ('40) Memorial Scholarship Fund (1976)
Harold W. Fisher Fund (1979)
Charles Lewis Flint Fund (1889)
Sarah S. Forbes Fund (1913)
Clara and F. Joseph Ford Scholarship (1951)
Foundry Educational Foundation Scholarships (1947)
Arthur E. Fowle Fund (1956)
Benjamin Franklin Fund (1956)
Evert W. Freeman Scholarship Fund (1956)
Philip Jacob Friedlander Fund (1945)
Lillian H. Fuller (1979)
William W. Garth ('36) Memorial Scholarship Fund (1975)
Jurgis J. Geguzis Fund (1957)
Norman H. George Fund (1919)
Arthur B. Gilmore Fund (1941)
James R. Glazebrook Fund (1959)
Ethel A. Gleason Memorial Scholarship (1963)
Samuel A. Goldblith ('40) Scholarship Fund (1976)
Lewis Goldstein Memorial Scholarship Fund (1973)
Barnett D. Gordon ('16) Fund (1942)
Haskell ('38) and Ina Gordon Scholarship Fund (1974)
John William Grant Fund (1979)
John H. Gregory Fund (1963)
John A. Grimmons Fund (1952)
Robert G. Gross — Lockheed Aircraft Corporation Scholarships (1963)
Rita Welch Gruber Memorial Scholarship (1961)
Gulf and South America Steamship Company Fund (1953)
William T. Haebler ('22) Memorial Scholarship (1960)
Humphrey M. Haley Scholarship Fund (1958)
Lucia G. Hall Scholarships (1945)
Hall-Mercer Scholarship Fund (1940)
Russell Hamilton ('19) Scholarship Fund (1976)
Claire Morton Prince Hanks Fund (1966)
Katherine Hansen ('53) Memorial Scholarship Fund (1975)
Harrington Scholarship Fund (1961)
James H. Haste Fund (1930)
Charles Hayden Memorial Scholarships (1939)
Delos G. Haynes Scholarship Fund (1970)
Herrick Foundation Scholarship Fund (1976)
Joseph Hewett ('96) Fund (1965)
Bancroft Hill Memorial Fund (1957)
Henry A. Hill Scholarships (1979)
Clifford E. Hoar Scholarship Fund (1972)
Eric Hodgins ('22) Memorial Scholarship Fund (1972)
George Hollingsworth Scholarship (1916)
Loren C. Holm Scholarship Fund (1950)
James T. ('14) and Esther Roen Holmes Scholarship Fund (1974)
John & Sarah W. Hopewell (1980)
Theodore V. Houser Scholarship Fund (1956)
Elias Howe, Jr. Scholarships (1949)
Dr. and Mrs. Chiao-Yue (nee Yeuh-Gin Gung) Hu Scholarship (1970)
Hunt Scholarship Fund (1971)
Samuel P. Hunt Fund (1945)
T. Sterry Hunt Scholarship (1894)
William F. Huntington Fund (1892)
Cuthbert Hurd Scholarship Fund (1968)
Rudolph Hurwich Fund (1979)
Charles L. Ireson Scholarship Fund (1959)
David L. Jewell Fund (1928)
Edward A. Jones Scholarship Fund (1947)
Ralph T. Jope Fund (1979)
Joy Scholarship (1886)
Sarah Maude Kaemmerling Fund (1952)
William R. Kales Scholarship Fund (1953)
Kalker Scholarship Fund (1969)
Walter R. and Nellie J. Kattelle Scholarship Fund (1972)
Mitchell B. Kaufman ('15) Memorial Scholarship Fund (1975)
Richard and Eric T. Keller Memorial Scholarship Fund (1973)
Henry Donald Kemp Fund (1964)
Bo Kwang Kim Scholarship Fund (1957)
Warren J. King ('48) Scholarship Fund (1976)

Malcolm G. Kispert ('44) Memorial Scholarship Fund (1975)

Royce G. Kloeffler Memorial (1979)

Amelia S. Kniesner Scholarship Fund (1944)

Kurrelmeyer Fund (1947)

Forrest Fay Lange Class of 1923 Scholarship Fund (1973)

John Lawrence ('32) Scholarship Fund (1974)

Constance D. Lazear Fund (1979)

William Houston Lazear ('23) Memorial Fund (1976)

George J. Leness Scholarship Fund (1969)

George Albert Lewis (1979)

Teh Ching Li ('37) Memorial Scholarship Fund (1971)

Y. T. Li Fund (1959)

Jacob and Jennie Lichter Fund (1949)

Gustaf Robert Lindberg Fund (1957)

Paul Weeks Litchfield Scholarship (1954)

William Litchfield Scholarship (1910)

Ellis Littmann Fund (1979)

Littman Foundation Scholarship (1960)

Charles E. Locke Memorial Fund (1923)

Richard W. Lodge Fund (1955)

Sheridan A. Logan Fund (1964)

Elisha T. Loring Fund (1890)

George J. Loveley Scholarship Fund (1960)

Percival Lowell Scholarships (1955)

Samuel E. Lunden Leadership Fund (1967)

George P. Lunt ('10) Memorial Scholarship Fund (1974)

Eugene and Margaret McDermott Scholarship Fund (1960)

Frederick F. Mackentepe ('14) Scholarship Fund (1970)

Alice Maclaurin Scholarship (1951)

Madsen Scholarship Fund (1966)

Estus H. Magoon ('14) Student Aid Fund (1975)

Eugene H. Mahoney Fund (1975)

Georgia Lamar Malone Scholarship (1961)

Theodore A. Mangelsdorf Fund (1961)

Francisco Marcucella Fund (1953)

Rupert Anderson Marden Fund (1933)

Martin-Marietta Foundation Scholarship Fund (1954)

Waldo A. Martin Scholarship Fund (1950)

Margaret A. Matthews Fund (1947)

Thomas Mayor Fund (1963)

William P. McMullan (1979)

George J. Mead Scholarships (1951)

Charles E. Merrill Scholarship Fund (1955)

Samuel Mildram Memorial Fund (1970)

Arthur Merkel Miller Fund (1960)

Robert W. Milne Fund (1943)

Joseph R. Minevitch Memorial Scholarship Fund (1957)

Li Ming Scholarship Fund (1969)

James H. Mirrlees Fund (1886)

MIT Alumni Fund National Scholarships (1957)

MIT Boston Stein Club — New England and National Scholarship Funds (1955)

MIT Boston Stein Club — Jerome B. Wiesner Freshman Scholarship Fund (1976)

MIT Club of Atlanta (1979)

MIT Club of Chicago Scholarship Fund (1944)

MIT Club of Mexico (1978)

MIT Club of Rochester Scholarship Fund (1968)

MIT Club of Southern California (1961)

MIT Women's League (1979)

Massachusetts Matching Grants Program (1978)

Morningstar Scholarship (1953)

Fred W. Morrill Scholarship Fund (1941)

Wm. T. Morris Foundation, Inc. (1979)

Maude Phipps Morrissey Fund (1972)

Frederick Taft Moses ('07) Scholarship Fund (1959)

Gertrude B. Newman Scholarship (1952)

Morris M. Newman ('34) (1979)

Niarchos Scholarship (1956)

Nichols Scholarship (1895)

Charles C. Nichols Scholarship (1904)

Hart and Arthur Nichols Scholarship Fund (1966)

William E. Nickerson Scholarship Fund (1949)

Samuel Niedelman ('24) Fund (1976)

Mrs. Samuel Niedelman Fund (1979)

Howard A. Noble ('97) Scholarships (1956)

Lockwood Oliver ('23) Student Aid Fund (1980)

John Felt Osgood Scholarship (1909)

Thomas Anthony Pappas Scholarship Fund (1980)

Louise Parks Knight and Charles F. Parks Memorial Fund (1952)

George L. Parmelee Fund (1921)

Ralph M. Parsons Memorial Scholarships (1980)

Frank E. ('05) and Seba B. Payne Foundation Scholarship Fund (1962)

Langdon Pearse Memorial Scholarship (1958)

Frank Stetson Pecker Fund (1947)

Richard Perkins Fund (1887)

Malcolm Oliver Petri Memorial Fund

St. Elmo Tower Piza Memorial Fund (1962)

Abraham Pletman Scholarship Fund (1975)

Charles H. and Helen Bartlett Pray Fund (1950)

Florence E. Prince Fund (1943)

Procter and Gamble Company Scholarships (1979)

William W. Quarles Memorial Scholarship (1971)

Walter R. Ramsaur Scholarship Fund

George H. Rand Scholarship (1958)

Thomas Adelbert Read Scholarship (1934)

Willis Ward Reeves, Jr. Fund (1945)

Arthur Reid Memorial Scholarship (1966)

Charles A. Richards Fund (1939)

Frederick L. Richards Memorial Fund (1960)

I. D. Richheimer Memorial Scholarship (1961)

John Roach Scholarship Fund (1937)

Karl Robbins Scholarship (1951)

Willard F. Rockwell Scholarship Fund (1961)

Mr. & Mrs. Francis X. Roddin (1979)

Gilbert M. Roddy ('31) Scholarship Fund (1974)

William Barton Rogers Scholarships (1947)

Cornelius Van Stone Roosevelt (1978)

William P. Ryan Memorial Fund (1935)

John P. Schenkl Fund (1922)

George Scher Fund (1949)

Anna and David C. Schilling Scholarship Fund (1970)

William E. Schrafft Charitable Fund

Science Scholarships (1956)

Second Century Scholarship

Paul D. Seghers, Jr. Scholarship (1948)

Robert J. Seid Award (1971)

Louise E. and Theresa Seley Student Aid Fund (1961)

Irving Shaknov Scholarship (1954)

Friends of Jay Tsun Shaw ('46) Scholarship Fund (1974)

Frederick J. Shepard, Jr. Fund (1959)

James and Donald H. Sheridan Scholarships Fund (1961)

Frank Arnold Sherman Scholarship Fund (1947)

Thomas Sherwin Scholarship (1871)

Albert and Harry Smith Fund (1979)

Chester W. Smith ('29) Scholarship Fund (1976)

Daniel J. Smith ('11) (1980)

Frank Langdon Smith Scholarship Fund (1968)

G. H. Miller Smith Fund (1945)

H. Hilliard Smith Fund (1950)

Horace T. Smith Fund (1931)

Society of Naval Architecture and Marine Engineering Scholarships (1957)

Sons and Daughters of New England Puritan Colony Scholarship (1931)

Walter W. and Edna J. Soroka Memorial Student Aid Fund (1971)

Anna Spooner Fund (1939)

Louis E. Stahl ('36) Scholarship Fund (1976)

Standard Oil Company of California Scholarships (1955)

Philip B. Stanley ('06) Memorial Scholarship Fund (1971)

Mrs. Avery Stanton Fund (1979)

Creighton B. Stanwood Scholarship Fund (1974)

Wentworth Stevens Fund (1957)

Julia Stewart Scholarship (1974)

Philip Stockton Fund (1961)

Albert F. Sulzer Scholarship (1955)

Sydney Family Scholarship Fund (1976)

Tau Beta Pi Memorial Scholarship Fund (1947)

Howard F. Taylor Memorial Scholarship Fund (1962)

Technology Club of New York Scholarship Fund (1976)

Lawrence E. Teich ('40) Memorial Scholarship Fund (1966)

Mary Thacher Scholarship (1956)

Richard H. Tingey Memorial Fund (1962)

Samuel E. Tinkham Fund (1924)

Franklin Towle Fund (1979)

Arthur L. Townsend Fund (1960)

W. H. Triplett ('12) Scholarship Fund (1961)

Y. T. Tsai Memorial Scholarship (1955)

James E. Turner ('33) Scholarship Fund (1976)

John L. Turner ('31) Fund (1960)

John Deloss Underwood Memorial Scholarship (1977)

Estate of Maud Underwood (1979)

Susan Upham Fund (1892)

Samson R. Urbino Fund (1927)

Vermont Scholarship (1924)

F. P. von Olker Fund (1962)

Ann White Vose Fund (1896)

Arthur M. Waitt Fund (1925)

Grant Walker Fund (1943)

Muriel Alvord Ward Fund (1960)

Warren Benevolent Fund (1961)

Henry Arthur Waterman Scholarship Fund (1969)

John J. Watson Memorial Fund (1963)

James Watt Scholarship (1942)

Edwin S. Webster ('88) Foundation (1974)

Herman E. and Mary E. Weihmiller Scholarships (1979)

Louis Weissbein Fund (1915)

William J. ('48) and Barbara Weisz Scholarship Fund (1976)

Frances Erving Weston Fund (1912)

Samuel Martin Weston Fund (1912)

Archer E. Wheeler Scholarship Fund (1957)

Ray Hill White Memorial Fund (1956)

Amasa J. Whiting Fund (1927)

George Carlyle Whiting (1979)

Granger Whitney Fund (1957)

Harold O. Whitney Scholarship Fund (1968)

Thomas H. Wiggin ('95) Fund (1965)

Elizabeth Babcock Wilmann Fund (1935)

Wilson Scholarship (1953)

Gilbert Williams Winslow ('37) Memorial Fund (1967)

Howard I. Wood Scholarship Fund (1969)

Augusta Wolff Scholarship Fund (1975)

Morrill Wyman ('15) Fund (1923)

Conrad Henry Young Scholarships (1957)

William R. Zimmerman ('46) Scholarship Fund (1980)

The following loan funds have been established for special purposes at the Institute. Except where stated, these loan funds are administered under terms similar to those governing the Technology Loan Fund, and no separate application need be made.

Walter Phelps Bliss Memorial Fund

Boston Stein Club Freshman Loan Fund (1953)

Boston Stein Club Freshman Loan Fund (1968)

Anna J. and Francesco Casaretta Loan Fund (1966)

Francis W. Chandler Loan Fund (1927)

Ruth Hornblower Churchill Memorial Loan Fund (1958)

Class of 1917 Loan Fund (1937)

Class of 1963 Loan Fund (1963)

Thomas F. and Lida Niles Connors Loan Fund (1962)

Daunis Family Fund (1971)

Carl P. Dennett Loan Fund (1956)

George Freydberg Fund (1972)

Ethel I. Fryer Scholarship Loan Fund (1951)

Nathan R. George Loan Fund (1943)

John A. Grimmons Loan Fund (1963)

Gerald L. Hartstein Memorial Loan Fund (1963)

John A. Herlihy Loan Fund (1962)

Jerome Hunsaker Loan Fund (1970)

Roscoe Hupper Loan Fund (1955)

Rebecca R. Joslin Loan Fund (1924-36)

Klock-Overton-Mills-Roberts-Longyear Loan Fund (1961)

Lamson-Virgin Loan Fund (1946)

Dr. Max Levine Loan Fund

Harry J. and Iolia R. Lohbiller Loan Fund (1962)

MIT Incentive Loan Fund (1971)

Anthony P. Mathesius Loan Fund (1970)

George H. May Loan Fund (1914)

Helen and Leo Mayer Loan Fund (1967)

George J. Mead Loan Fund (1951)

Arthur T. Nelson, Jr. Memorial Loan Fund (1962)

Pemrose Loan Fund

Michael Joseph Pollock Loan Fund (1962)

Ellen H. Richards Loan Fund (1964)

M. H. Rogers Loan Fund (1945)

Lillie C. Smith Fund (1965)

Gertrude W. Swartz Memorial Student Loan Fund (1971)

Technology Matrons Loan Fund (1960)

Robert Kelley Thulman Loan Fund (1963)

Timbie Memorial Fund (1954)

F. B. Tough Fund (1924)

United States Steel Corporation (1978)

Frank P. Wakefield Loan Fund (1955)

Prizes and Awards

To encourage and recognize high achievement by students at MIT, a number of prizes have been established by individuals and organizations. In general, these awards are made each year by the Office of the Dean for Student Affairs or by the departments or organizations concerned.

Alpha Chi Sigma Prizes (1965)

American Institute of Chemists Awards (1957)

Association of MIT Alumnae Award (1958)

Avery Allen Ashdown Award

Baton Society Awards (1960)

Robert A. Boit Prizes (1921)

Karl Taylor Compton Prizes (1951)

The Frederick Gardner Fassett, Jr. Award

The Goodwin Medal

Albert G. Hill Prize

Ellen King Prize (1950)

Military Prizes

Outstanding Freshman Award

Phi Lambda Upsilon Award in Freshman Chemistry

Phi Lambda Upsilon Sophomore Award

Jeffrey L. Pressman Award

Scott Paper Foundation Leadership Award

William L. Stewart, Jr. Awards (1964)

Stratton Prizes (1930)

The Harry S. Truman Scholarship

The Laya and Jerome B. Wiesner Awards (1979)

Aeronautics and Astronautics

Luis de Florez Awards (1960)

James Means Memorial Prize (1925)

Henry Webb Salisbury Memorial Award (1941)

Architecture and Planning

Alpha Rho Chi Medal (1932)

Athletics

In addition to varsity letters and freshman numerals in 22 intercollegiate sports, a number of awards are given to undergraduates by student organizations for outstanding contributions to intramural and intercollegiate athletic activities.

Class of 1948 Award

Admiral Edward L. Cochrane Award

Eastern College Athletic Conference Merit Medal

Biology

John L. Asinari Awards

Chemical Engineering

Robert T. Haslam Cup (1959)

Hunneman Prize (1927)

Civil Engineering

A.S.C.E. Student Chapter Scholarship

Tucker-Voss Award (1953)

Richard Lee Russel Prize (1967)

Earth and Planetary Sciences

Christopher Goetze Memorial Prize

Electrical Engineering and Computer Science

Morris J. Levin Award

Supervised Investors' Services, Inc. Awards (1957)

Carlton E. Tucker Awards for Excellence in Teaching (1962)

David T. Schultz Award (1969)

Management

The Brooks Prize in Management

Editorship of the Sloan Management Review

Sloan School of Management Senior Prize

Materials Science and Engineering

Metallurgy and Materials Prize (1963)

American Metal Climax Foundation Prize (1969)

Mechanical Engineering

American Society of Mechanical Engineers Student Paper Awards

Luis de Florez Awards (1957)

Silent Hoist and Crane Company Materials Handling Award (1950)

El Wellech — Corning Glass Works Award

Engineering Projects Laboratory — Showcase Awards

Meteorology

The Carl-Gustav Rossby Award in Meteorology

Ocean Engineering

American Bureau of Shipping Prize, Naval Architecture and Marine Engineering (1924)

American Bureau of Shipping Prize, Ocean Engineering (1973)

Brand Award (1957)

Naval Ship Systems Command Award (1970)

Undergraduate Research Opportunities Program

Clapp and Poliak Engineering Design Awards (1973)

Class of 1970 Research Awards (1972)

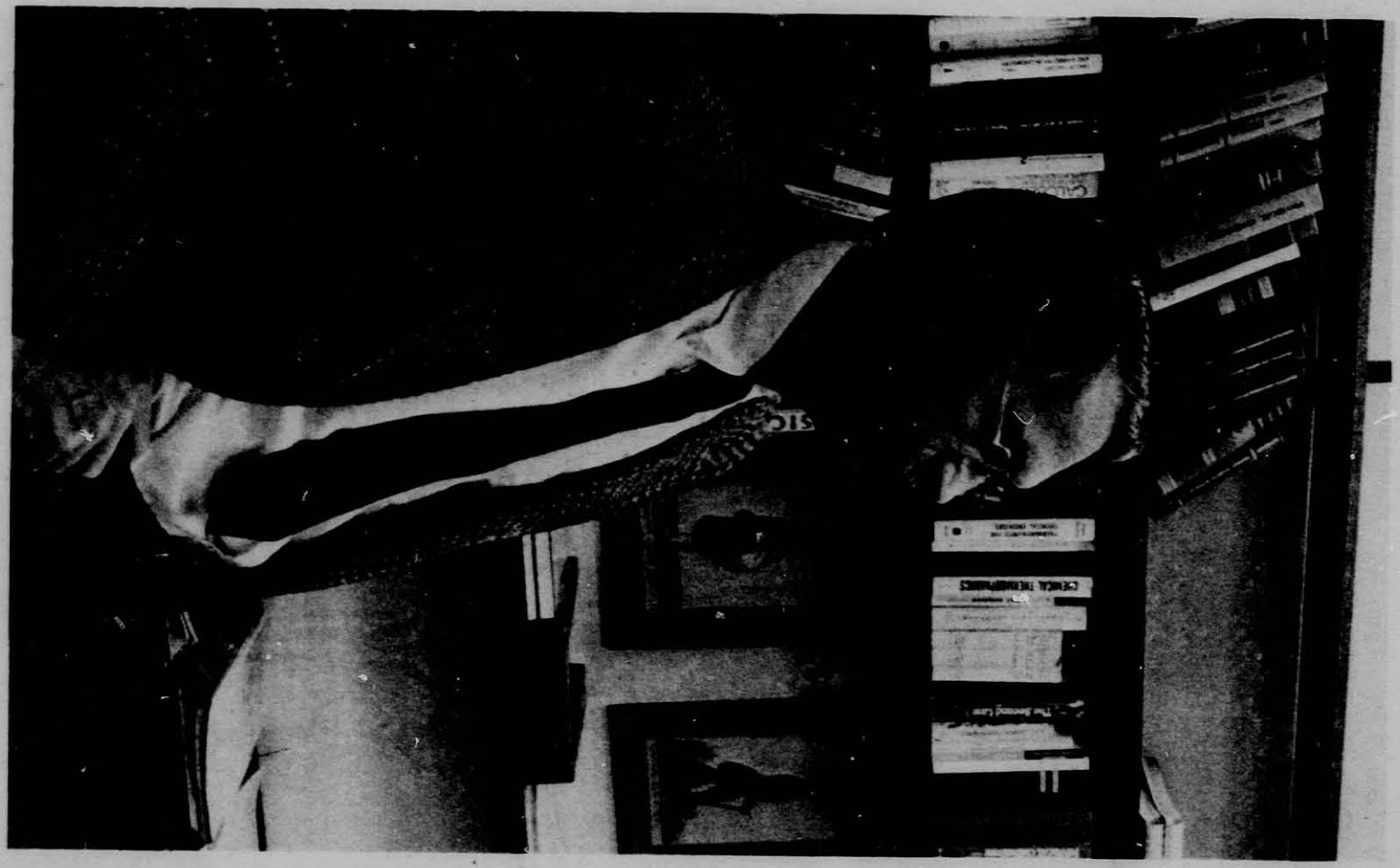
Eloranta Summer Fellowships Program (1969)

Mining and Mineral Resources Research Institute Awards (1979)

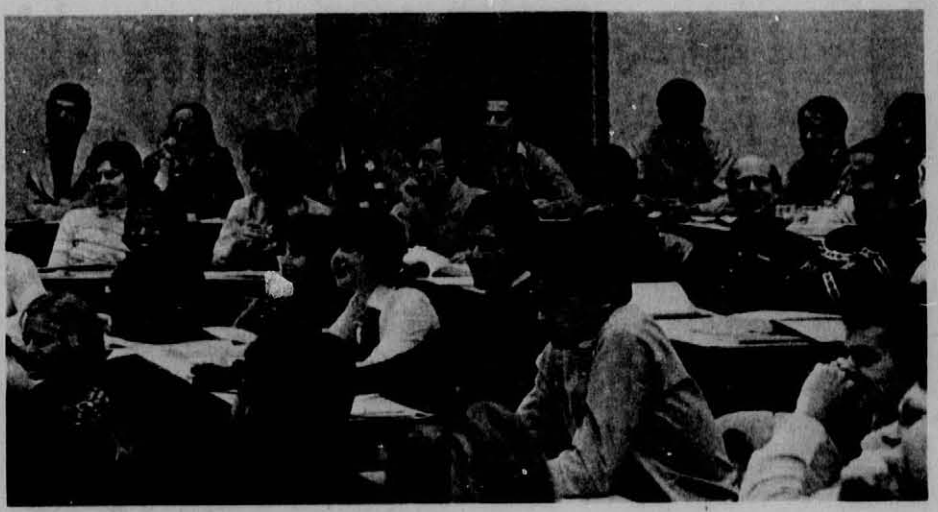
Sea Grant Research Awards (1981)

Sigma Xi Research Awards (1972)

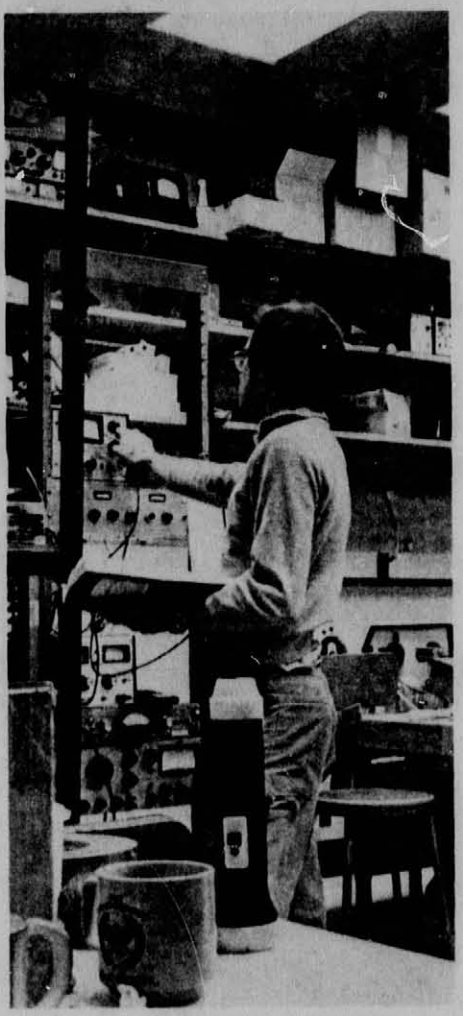
Uniroyal Research Awards (1972)











Graduate Education at MIT

Resources for Graduate Study

For almost a century the MIT Graduate School has provided an ideal environment for advanced study by faculty and students working together to extend the boundaries of knowledge. While the Institute has traditionally been a leader nationally in engineering graduate education, in more recent years its doctoral programs in mathematics and the physical and life sciences have attained national prominence. In addition, graduate programs in economics and social sciences, architecture, urban studies, and management have broadened the spectrum of graduate education.

The most important factor in the effectiveness of the graduate programs at MIT is the quality of the faculty. MIT is proud of its nationally and internationally recognized faculty of scholars and academic leaders who are also effective teachers and research collaborators.

The broad scope and high quality of its graduate education have made MIT a leader in the international sector. About a third of its graduate students come from foreign nations. In recent years an increasing number of minority students have participated profitably in academic work at all levels. Although it has always welcomed women graduate students, it is within the last decade that an increasing number of women have found MIT to be an excellent place in which to pursue study toward a graduate degree. This broad representation of students from widely different backgrounds has contributed greatly to the enrichment of student life on the campus and to the excellence of the Graduate School.

Graduate students are appointed as teaching assistants which is an integral part of their graduate education. These as well as positions as research assistants offer the student professional experiences.

Graduate education at MIT places special emphasis on the relevance of science and technology to the complex problems of society. Such problems take an interdisciplinary approach which may involve expertise in several different departments.



Extensive resources for graduate study have developed naturally at MIT from a long tradition of emphasis on contributions to new knowledge. The wealth and diversity of teaching and research resources are described in this catalogue in the departmental sections. Graduate students may participate in all of the Institute's wide-ranging research activities.

Although most graduate students find their interests served by programs available within a single department, many elect to work in interdisciplinary fields which may reach into two or more departments and involve interdisciplinary work in any of MIT's laboratories. The scope of many interdisciplinary programs and facilities is described in Chapter V, Interdepartmental Study and Research.

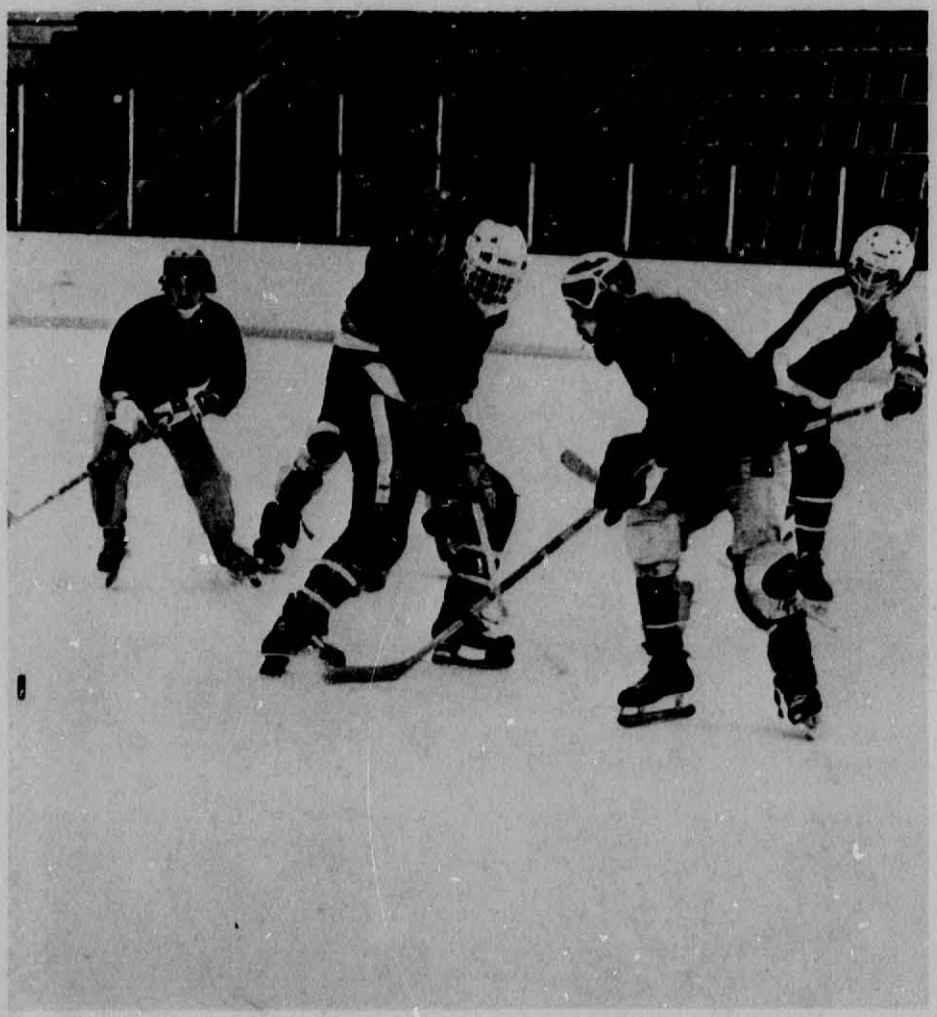
The MIT Libraries provide a major resource for graduate study. Comprehensive collections are available in fields in which MIT concentrates its teaching and research efforts. Through participation in the Boston Library Consortium, graduate students, faculty members, and research staff have quick access to extensive research collections outside the Institute.



Another resource for graduate study is the cross-registration programs, with Harvard University (including the Medical School), Wellesley College, and the Woods Hole Oceanographic Institution. Limited study opportunities are also available at Brandeis University, Tufts University, and Boston University. Details are given later in this chapter.

Graduate students are encouraged to use MIT's extensive athletic facilities. A number of teams composed of undergraduates and graduate students participate in intercollegiate competitions, as well as the intramural athletic program.

The cultural and social life and recreational facilities of the MIT campus are shared alike by undergraduate and graduate students. Concerts and dramatic performances are frequently given by Institute groups and professional performers. Leaders in many professional areas give lectures and seminars on the campus, which are open to all members of the Institute community. Greater Boston is an outstanding cultural and intellectual center, where students may take advantage of the exceptional opportunities available.



Organization of the Graduate School

The administration of the Graduate School rests with the President, the Provost of the Institute, the Dean and Associate Deans of the Graduate School; and the Committee on Graduate School Policy, whose members include, among others, a faculty member from each department offering graduate degrees and two representatives from the Graduate Student Council. The Institute has a single faculty which is responsible for both undergraduate and graduate instruction.

Each department exercises a large measure of autonomy for its graduate programs, under general guidelines established for the Institute as a whole. Each department has a departmental committee on graduate students, including one or more Graduate Registration Officers, to administer department graduate procedures. The membership of the Committee on Graduate School Policy is listed with that of other faculty committees in Chapter VIII of this catalogue.

More detailed information about the organization, rules, regulations, and procedures of the Graduate School is given in the *Graduate School Manual*. Copies are available from the Graduate School Office and from departmental graduate offices.

General Requirements for Graduate Degrees

Graduate students may pursue work leading to any of the following degrees: Doctor of Philosophy, Ph.D.; Doctor of Science, Sc.D.; Engineer's degrees; Master of Science, S.M.; Master of Architecture, M.Arch.; and Master in City Planning, M.C.P.

The major fields for graduate study are listed below. Graduate programs are described in individual department statements in Chapter VI. These statements should be consulted for more specific information.

Each graduate student is officially enrolled in one department or Course. The programs are not limited, however, to subjects offered in a single department. Subjects and research programs may be chosen from several departments, with the approval of the faculty advisor to ensure that the overall program is integrated and well balanced with respect to a major field of study.

A student who expects to come to MIT for an advanced degree after earning an undergraduate degree elsewhere should give careful attention to undergraduate prerequisites for the advanced work which he or she intends to undertake as outlined by each department in Chapter VI. For advice on such subjects, a student should consult the department in which he or she wishes to enroll.

MIT degrees are "residence" degrees in the sense that a major portion of the work for which each is awarded must be done on campus in association with the faculty, other graduate students, and the Institute community. This environment includes access to libraries, to educational opportunities offered by other disciplines, and also to recreational, cultural, religious, and athletic opportunities. The amount of time required to attain any one degree varies.

Degrees are awarded by the Corporation of the Institute upon the recommendation of the faculty. Favorable faculty action is based upon approval by the Committee on Graduate School Policy on recommendations from the appropriate departmental committees on graduate students.

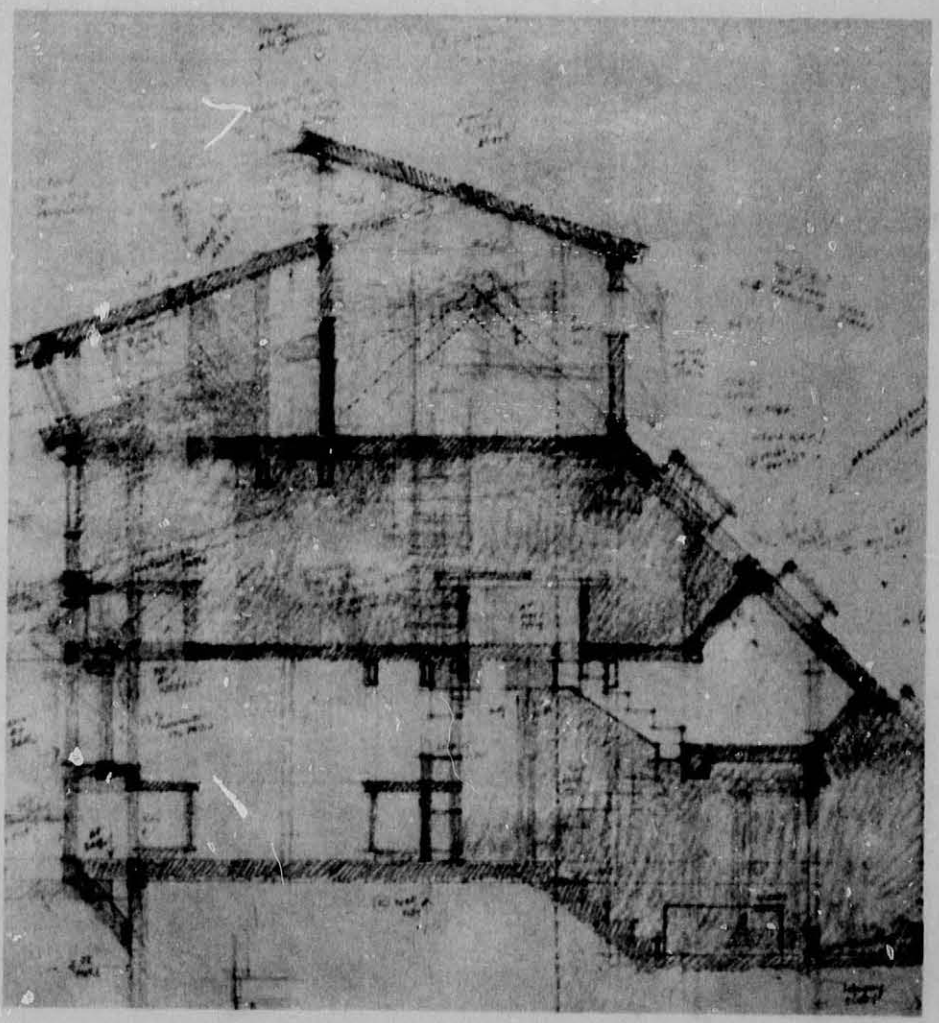
School of Architecture and Planning

Architecture, Course IV
Architectural Design (M.Arch.)
Architecture Studies (S.M.)
Architecture, Art, and Environmental Studies (Ph.D.)
Visual Studies (S.M.)

Urban Studies and Planning, Course XI
Urban and regional planning
Urban and regional studies

School of Engineering

Aeronautics and Astronautics, Course XVI
Aeroacoustics
Aerodynamics
Aeroelasticity
Aerospace systems
Aircraft propulsion
Astrodynamics
Biomedical engineering*
Computer systems
Dynamic energy conversion
Estimation and control
Flight transportation
Fluid mechanics



Gas dynamics
Gas turbines
Gas turbine structures
Navigation and control systems
Instrumentation*
Management of technology*
Materials engineering*
Physics of fluids
Plasma physics
Space propulsion
Structural dynamics
Structures technology
Technology and policy*
Vehicle design

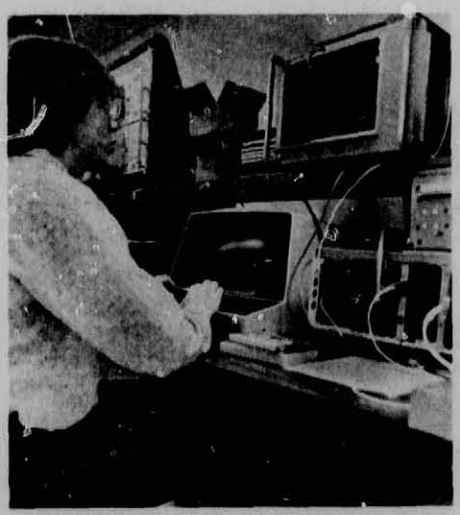
Chemical Engineering, Course X
Applied chemistry
Biochemical engineering
Biomedical engineering*
Catalysis and reactor engineering
Chemical engineering systems
Engineering operations
Environmental engineering*
Fuel engineering
Management of technology*
Materials
Materials engineering*
Polymers and plastics
Technology and policy*

Chemical Engineering Practice, Course X-A

Joint Program with the Woods Hole Oceanographic Institution, Course X-W
Oceanographic engineering

Civil Engineering, Course I
Applied earth science
Building systems
Civil engineering
Civil engineering systems
Coastal engineering
Construction engineering and management
Earthquake engineering
Environmental engineering*
Geotechnical engineering
Geotechnology
Hydrodynamics
Hydrodynamics and coastal engineering
Management of technology*
Materials
Materials engineering*
Operations research*
Project management
Soil mechanics
Structural engineering
Structural mechanics
Structures
Technology and policy*
Transportation*
Transportation systems
Urban engineering
Urban systems
Water resources

Joint Program with the Woods Hole Oceanographic Institution, Course I-W
Oceanographic engineering



Electrical Engineering and Computer Science, Course VI
Electrical engineering
Electrical science
Artificial intelligence
Bioelectrical engineering
Biomedical engineering*
Communications
Computer science
Control engineering
Electric power systems
Electromagnetics
Electronics
Energy systems
Operations research*
Quantum electronics
Solid state electronics
System engineering
Systems science
Technology and policy

Joint Program with the Woods Hole Oceanographic Institution, Course VI-W
Oceanographic Engineering

Materials Science and Engineering, Course III
Ceramics
Management of technology*
Materials engineering
Materials science
Metallurgy
Polymers
Technology and policy*

Joint Program with the Woods Hole Oceanographic Institution, Course III-W
Oceanographic engineering

Mechanical Engineering, Course II
Acoustics and vibration
Applied mechanics
Automatic control
Biomedical engineering*
Combustion
Computational mechanics and finite element analysis
Computation and microprocessor applications
Computer-aided design/manufacturing
Continuum mechanics
Cryogenics
Desalination
Design
Dynamics

*Approved Interdepartmental Program

Ecosystems
Energy conversion and conservation
*Environmental engineering**
Fibers and polymers
Fluid mechanics
Heat transfer
Internal and external combustion engines
Management of technology*
Man-machine systems
Manufacturing
Materials and materials processing
Mechanical engineering
Mining and resource engineering
Polymers and polymer processing
Stress analysis
Technology and policy*
Thermodynamics
Transportation*
Tribology; friction, lubrication and wear

Joint Program with the Woods Hole Oceanographic Institution, Course II-W
Oceanographic engineering

Ocean Engineering, Course XIII
Acoustics
Applied mechanics
Coastal zone utilization
Environmental engineering*
Fluid mechanics
Hydrodynamics
Management of technology*
Marine data systems engineering
Marine engineering
Marine resource development
Marine transportation
Naval engineering
Ocean engineering
Ocean engineering and law
Ocean systems management
Operations research*
Sea floor engineering
Ship propulsion
Ship systems
Structural mechanics
Technology and policy*

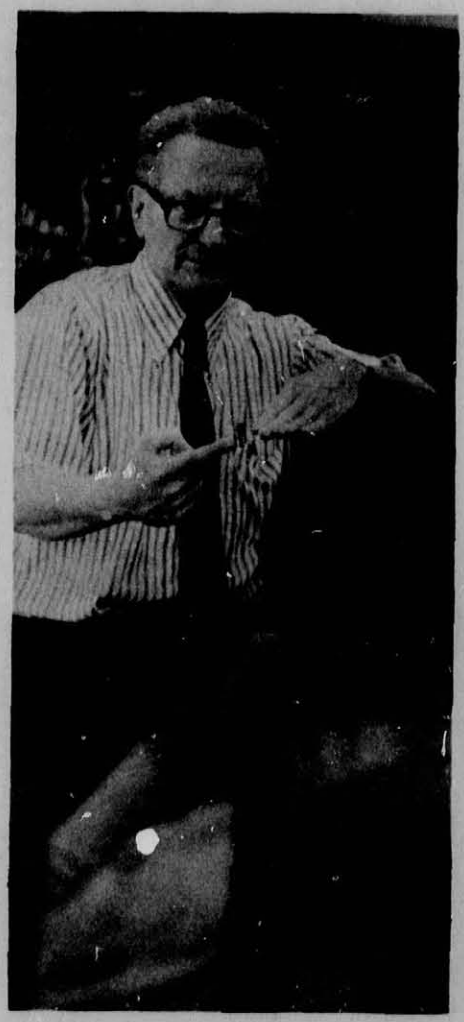
Joint Program with the Woods Hole Oceanographic Institution, Course XIII-W
Oceanographic engineering

*Approved Interdepartmental Program

Naval Construction and Engineering (USN and USCG), Course XIII-A

Ocean Systems Management Course XIII-B

Nuclear Engineering, Course XXII
Applied plasma physics
Applied radiation physics
Energy technology
Fusion reactor engineering
Management of technology*
Nuclear fuel management
Nuclear materials engineering
Nuclear reactor engineering
Nuclear reactor physics
Technology and policy*



School of Humanities and Social Science

Economics, Course XIV

Linguistics and Philosophy, Course XXIV
Linguistics
Philosophy
Linguistics and Philosophy

Political Science, Course XVII

Psychology, Course IX
Cognitive psychology
Developmental psychology
Experimental psychology
Neuroanatomy
Neurophysiology
Physiological psychology
Psycholinguistics
Sensory perception

Sloan School of Management

Management, Course XV
Management of technology (S.M.)*
Operations research*



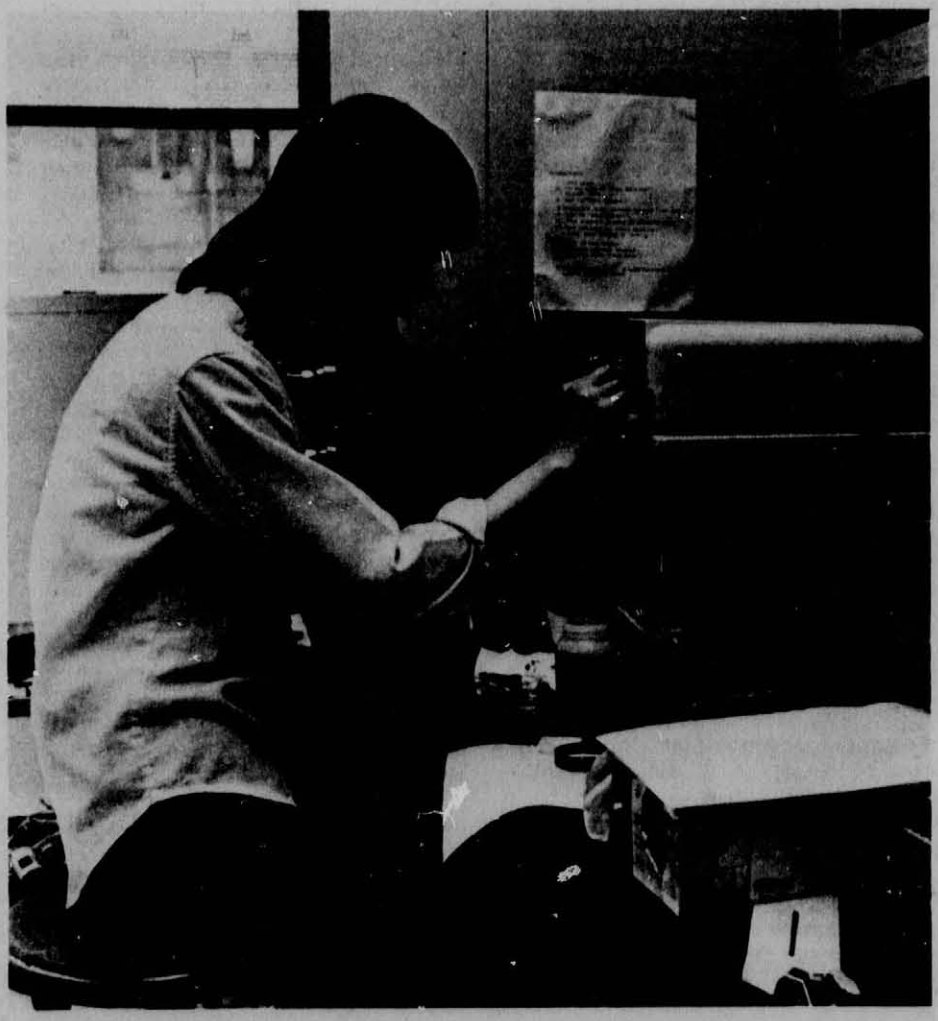
School of Science

Biology, Course VII
Biochemistry
Biophysics
Cell and developmental biology
Immunology
Microbiology
Physiology

Joint Program with the Woods Hole Oceanographic Institution, Course VII-W
Biological oceanography

Chemistry, Course V
Analytical chemistry
Biological chemistry
Biophysical chemistry
Chemical physics
Inorganic chemistry
Organic chemistry
Physical chemistry

Earth and Planetary Sciences, Course XII
Geochemistry
Geology (classical geology, theoretical geology)
Geophysics
Oceanography
Planetary sciences



Joint Program with the Woods Hole Oceanographic Institution, Course XII-W
Oceanography

Interdisciplinary Science Program, Course XXV (S.M. only, but no new applicants after academic year 1980-81)
Animal cell science
Environmental chemistry
Science communication
Science education

Mathematics, Course XVIII

Meteorology and Physical Oceanography, Course XIX
Meteorology
Oceanography
Physical oceanography (Ph.D.)

Joint Program with the Woods Hole Oceanographic Institution, Course XIX-W
Oceanography

Nutrition and Food Science, Course XX
Biochemical engineering
Food engineering
Food science and technology
Human and clinical nutrition
International nutrition planning
Neural and endocrine regulation
Nutritional biochemistry and metabolism
Toxicology

Physics, Course VIII

Harvard-MIT Division of Health Sciences and Technology

Biomedical sciences
Medical engineering
Medical physics

*Approved Interdepartmental Program

Master's Degrees

Master of Science With and Without Specification

For the degree of Master of Science, the student must have completed satisfactorily a program of study of at least 66 units, of which 42 units shall be "A" subjects, and a thesis, both acceptable to the department in which he or she is enrolled. If 34 units of "A" subjects and the thesis are in a single field, as determined by a departmental committee on graduate students, the degree will be recommended with specification of the field in which the student has thus specialized; otherwise, the degree will be recommended without specification.

The choice of field of specialization must be approved by the committee on graduate students of the department in which the student is enrolled. Approval of the entire program must be obtained from this committee and from the student's faculty advisor. A special interdepartmental committee, approved by the Dean of the Graduate School, may be appointed to supervise a program in an interdepartmental field.

The satisfactory completion of the Master's degree requires the student to be in residence for a minimum of one regular academic term (not the summer session). Every degree candidate working on a thesis must register for thesis in all periods during which his or her thesis research or writing is actually in progress and during the term his or her name appears on the degree list. The same high standard of academic performance in a program approved by a departmental committee on graduate students is required for either degree.

Master of Architecture

The graduate degree of Master of Architecture is awarded upon the satisfactory completion of a program of study of at least 164 subject units approved by the Department of Architecture, of which 96 units must be in "A" subjects, and the completion of a thesis acceptable to the Department of Architecture The candidate must also have been in residence for a minimum of four regular academic terms. A student who enters without previous experience in a department of architecture may take as long as eight academic terms to complete the degree.

Master in City Planning

For the degree of Master in City Planning, the student must have completed satisfactorily a minimum of 120 units of which at least 42 units must be "A" subjects. The student must also have completed a thesis acceptable to the Department of Urban Studies and Planning, and have been in residence for a minimum of two regular academic terms.

Simultaneous Registration for Two Master's Degrees

Single thesis. This degree plan is intended for qualified graduate students who seek academic recognition in two professional fields which, although distinct, have a substantial interdisciplinary connection. The interdisciplinarity is implemented both by a balanced choice of academic subjects, made with the advice of each of two departments, and by selection of the thesis topic.

To satisfy the minimum requirements for the program, the student must complete (in addition to thesis units) at least 132 subject units of which 66 units are unique to each department. At least 42 of each group of 66 units must be graduate "A" subjects. In those instances where, for a single regular Master's degree or program, a department has established unit requirements in excess of the foregoing minima, the departmental requirements prevail. Such excess of units in one department may not be applied to the program in the other department.

Students pursuing a Master in City Planning in addition to a second Master's degree must have both programs approved in the usual way, but the subject units for the M.C.P. can be lowered at the discretion of the Department of Urban Studies and Planning.

Participation in this degree plan is limited to students who are already registered in one department and who meet the admissions criteria of the second department. At least two regular terms prior to completion of the program, the student must submit to each department a statement of educational objectives along with a detailed program plan that includes a description of the proposed thesis topic. The total program must meet with the approval of each department and a petition approved by the Dean of the Graduate School describing the program must be filed with the Registrar.

The thesis research must be done under the supervision of an approved member of one of the two participating departments with the other department providing a thesis reader. The thesis must be of superior quality. The single thesis cannot be used to satisfy the thesis requirements of any additional graduate degree programs.

In special cases, the Standing Committee of an approved Interdisciplinary Program may act in lieu of one of the two participating departments.

Two theses. Occasionally an individual, already admitted to the Graduate School, may wish to pursue simultaneously two distinct Master's programs, fulfilling the thesis requirement with a separate thesis for each degree program. In such cases, the usual unit requirements for each program apply separately. Registration for two degrees is contingent upon approval by the second department of a request for admission. Such a request is initiated by a petition approved by the department in which the student is currently enrolled.

Simultaneous Award of Bachelor's and Master's Degrees

An undergraduate student of the Institute who is enrolled as a candidate for the Bachelor's degree may be admitted by a department as a candidate for the Master's degree. Students must register as graduate students for at least one regular academic term (not summer session) to be recommended for the simultaneous award of the Bachelor's and Master's degrees. The thesis submitted for the Master's degree may also be accepted by the department in fulfillment of the undergraduate thesis requirement, if any. A student wishing to pursue this type of academic program must apply for graduate admission in the usual way, as well as file a petition with the Registrar which has been approved by the student's undergraduate Faculty Advisor and the Graduate Registration Officer of the appropriate department.

Engineer's Degrees

The program for an Engineer's degree requires more advanced and broader competence in engineering and science subjects than for the Master's degree, but with less emphasis on original research than a doctoral program. In general, the Engineer's degree requires two academic years beyond an undergraduate degree.

The following Engineer's degrees are awarded: Chemical Engineer (Chem.E.); Civil Engineer (C.E.); Electrical Engineer (E.E.); Engineer in Aeronautics and Astronautics (E.A.A.); Environmental Engineer (Env.E.); Materials Engineer (Mat.E.); Mechanical Engineer (Mech.E.); Metallurgical Engineer (Met.E.); Nuclear Engineer (Nucl.E.); Ocean Engineer (Ocean E.).

Satisfactory completion of a program of advanced study and research approved by the appropriate department or interdepartmental committee of the School of Engineering is required. The minimum program consists of at least 162 subject units (exclusive of thesis units) and the completion of an acceptable thesis. The candidate must also have been in residence for a minimum of two regular academic terms. Registration is required of every degree candidate working on a thesis in all periods during which the thesis research or writing is actually in progress and during the term his or her name appears on the degree list. A department may accept a Master's thesis of superior quality for the Engineer's degree only if the student intends to use that document to fulfill the requirements of a single Master's degree.

Doctoral Degrees

MIT offers the degrees of Doctor of Science and Doctor of Philosophy, interchangeably, in the engineering and science departments (except biology) and in the fields of medical engineering and medical physics. The degree of Doctor of Philosophy is awarded in architecture, biology, economics, linguistics, management, philosophy, political science, psychology, and urban studies and planning. These degrees certify creditable completion of an approved program of advanced study in addition to a research dissertation of high quality based on original research.

The two Institute requirements for a doctorate are: 1) completion of a program of advanced study, including a general examination; and 2) completion and oral defense of a thesis on original research.

The program of advanced study and research may be selected in any field approved by the department in which the student is enrolled. The thesis is in this same field but the program often includes subject areas reaching into several departments. If the field requires substantial participation by two or more departments, an interdepartmental faculty committee, approved by the Dean of the Graduate School, should be appointed to supervise the student's program.

Each doctoral candidate has a general examination in his or her field at such time and in such manner as the departmental or interdepartmental committee approves. This examination consists of both oral and written parts.

Cross Registration at Other Institutions

Interdepartmental Degree Programs

Many recent developments in the physical and social sciences and engineering reflect interdisciplinary trends. Thus a number of graduate students desire doctoral programs in fields whose boundaries overlap two or more departments or Schools. In certain areas, such as biomedical engineering, economics and urban studies, environmental engineering, instrumentation, management of technology, medical engineering and medical physics, operations research, technology and policy, and transportation, special continuing committees provide guidance. In other fields, interdepartmental doctoral programs are administered by ad hoc committees appointed for each student and approved by the Dean of the Graduate School.

Minor Program

Although there is no Institute requirement of a minor for the Doctoral degree, certain departments require that candidates take a number of subjects outside their major field.

Language Proficiency

There is no Institute language requirement; however, several departments require that a candidate be able to read or speak one or two foreign languages with intermediate competence. Typically, a student may satisfy the requirement in one of three ways: 1) by fulfilling the requirement before entrance by passing one or more intermediate or advanced subjects with a grade of C or better; 2) through examination by the Foreign Languages and Literatures Section of the Department of Humanities; 3) by taking a two-term subject in a language or languages offered by the Foreign Languages and Literatures Section of the Department of Humanities. Depending on student demand, the Section offers a choice of two-term language subjects, stressing the ability to read or to speak, in French, German, Russian, or Spanish.

For the purpose of the second alternative, the Section gives written and oral examinations in French, German, Russian, and Spanish once each term. Written and oral examinations in other approved languages are arranged individually upon request.

Thesis

The doctoral thesis usually requires at least one full-time academic year of research, while most doctoral research efforts require a substantially longer time. Each doctoral candidate is required to register for thesis in all periods during which work is actually in progress.

The investigation must be carried out under the supervision of an MIT faculty member or senior staff member approved by the department. Work already accomplished elsewhere which has not been approved by a department cannot be accepted in fulfillment of the thesis requirement.

An oral examination on the thesis and its field will be held after the thesis has been submitted and evaluated by the examiners.

Non-Resident Doctoral Thesis Research Status

While doctoral thesis research is ordinarily carried out while the student is in residence at the Institute, on some occasions it may be essential or desirable that the student be absent from the campus during a period of his or her thesis research. Permission to become a non-resident doctoral candidate must be sought from the Dean of the Graduate School at least one month prior to the opening of the term during which the student wishes to register in this category. Consult the *Graduate School Manual* for additional information on non-resident status.

Harvard University

A regular, full-time graduate student at MIT may, by permission, enroll to take subjects (exclusive of thesis) at Harvard without paying additional tuition, provided that this exchange enrollment does not exceed one-half of his or her total registration for the term. Included in the above category are MIT full-time Special Graduate Students. This cooperative arrangement is not applicable to the summer session.

Requests for registration under this cooperative arrangement should be confined to subjects which are not offered at the student's own institution. If there is an apparent duplication of a requested subject in the two schools, acceptable reasons for the request must be presented. Students will not be allowed to attend classes in which additional registrants put an undue load on the instructors. The procedures to be followed are given in the *Graduate School Manual.*

Wellesley College

Graduate students are eligible to participate in the Wellesley-MIT Exchange Program. Details about the program may be obtained in the Wellesley-MIT Exchange Program office.

Woods Hole Oceanographic Institution

Information regarding the programs in Oceanography may be obtained from the Department of Earth and Planetary Sciences or from the Department of Meteorology and Physical Oceanography at MIT. The Departments of Chemical Engineering, Civil Engineering, Electrical Engineering and Computer Science, Materials Science and Engineering, Mechanical Engineering, and Ocean Engineering at MIT can provide information about the program in Oceanographic Engineering, and the Departments of Biology and Nutrition and Food Science can provide information regarding the program in Biological Oceanography.

Graduate Registration and Academic Performance

Boston University

An arrangement for cross-registration purposes has been made between the MIT Departments of Economics and Political Science and the African Studies Program of Boston University. Details of the procedures to be followed are similar to those for Harvard-MIT cross-registration.

Brandeis University

A cooperative arrangement also exists between the MIT Department of Urban Studies and Planning and the Florence Heller Graduate School for Advanced Studies in Social Welfare at Brandeis University. Cross-registration is restricted to one or two subjects per term in the areas of social welfare at Brandeis and urban studies at MIT.

Tufts University

A cross-registration agreement exists between the MIT Department of Nutrition and Food Science and the School of Dental Medicine at Tufts University. The program is restricted to specific graduate subjects at each institution.

Complete information on registration procedures may be found in the "MIT Registration Material" packet which is available to students in December and May in the Building 10 Lobby. Additional details may be found in the *Guide for Undergraduates and Faculty Counselors* and the *Graduate School Manual.*

Definition of Student Status

Once admitted (or readmitted) to MIT, a person becomes an MIT student at the start of the term for which he or she was admitted. Student status is retained until graduation, unless the student withdraws, is required to withdraw, or fails to complete registration in a given term. For the fall and spring terms, completion of the five steps listed below is necessary for continuing student status during that term: 1) registration material issued by the Registrar has been completed and returned, 2) fees have been paid to the Cashier's Office, or, the student has made satisfactory arrangements with the Student Accounts Office for payment, 3) the faculty counselor or registration officer has signed the student's registration form and this form has been received by the Registrar's Office, 4) an ID validation sticker has been picked up, and 5) all graduate students also must have submitted the MIT Graduate School Need Analysis form or the Graduate and Professional Schools Financial Assistance Service form to the Student Financial Aid Office.



Registration

Each student is required to complete registration forms and present them to the Registrar before the opening of each term specified in registration instructions. First-term registration is available during the summer to newly entering students and should be picked up at the Registrar's Office (E19-335) upon arrival at MIT. Registration material for continuing students is available in May and can be picked up in the Building 10 Lobby for two days, after which it is available in the Registrar's Office. Second-term registration materials are available late in the first term in the Building 10 Lobby for two days and then in the Registrar's Office. An individual who has not completed registration procedures by the start of the sixth week of the term will be considered withdrawn and will be charged a prorated tuition for this period.

Every student is assigned to a faculty member of his or her department who serves as the student's Registration Officer. Each student's program must be approved by this individual, and changes may be made only with the Registration Officer's approval.

Subject Credits and Designations

The credit hours (units) for each subject indicate the number of hours spent each week in class and laboratory, plus the estimated time the average student spends each week in outside preparation. Each subject is listed with three credit numbers, showing in sequence the units allotted to: class; laboratory, design, or field work; and preparation. The total unit credit for a subject is obtained by adding together all the units shown.

In the list of subject descriptions, the year classification is indicated as "U" for an undergraduate subject and "G" for a subject offered primarily for graduate students. The "A" designation following the name of a subject indicates that it is an approved subject for a graduate degree and is offered primarily for graduate students.

Final Examinations

Final examinations are held at the end of each term; the schedule is issued about a month before the examination period. Each student is held responsible for obtaining an examination schedule at the Information Center, for reporting any conflicts in examinations before the time limit given on the schedule, and for attending the final examinations required in the subjects for which he or she is registered.

No member of the instructing staff can excuse a student from a scheduled final examination. Absence from any final examination is equivalent to a failing grade except on presentation of adequate evidence of sickness or other valid reason for the absence. The Dean of the Graduate School must be consulted for approval in order for a student whose term work has been satisfactory to take a postponed examination on the subject. The instructor may, if the evidence warrants, issue a final grade without requiring a postponed final examination.

Grade Reports and Transcripts

Grade reports are issued by the Registrar at the end of each term and summer session to all registered students. Students may order transcripts of their academic record at the Registrar's Office, Room E19-335, upon presentation of a receipt from the Cashier's Office, Room 10-180, or the Student Loan Office, Room E19-225, at a cost of $2 per copy.

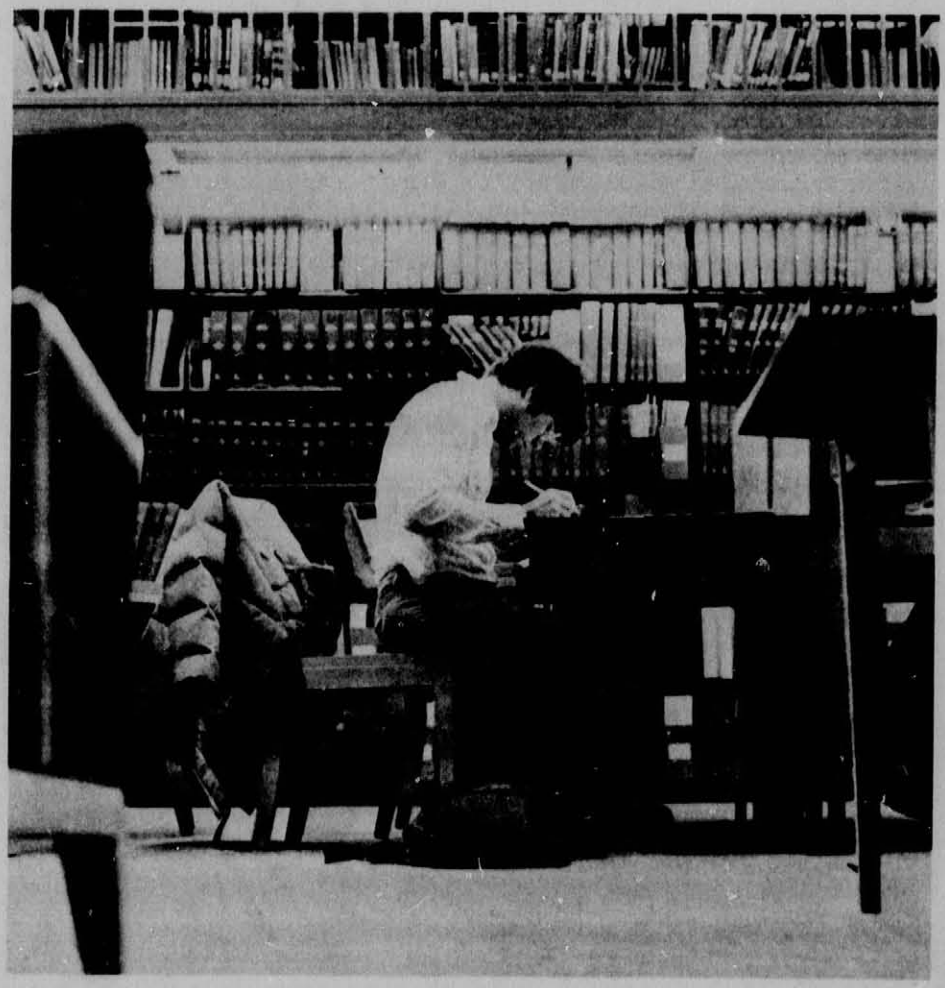
Detailed descriptions of the grades and notations used at MIT are given in the section entitled Undergraduate Registration and Academic Performance in Chapter III of this catalogue. Grades and notations used at MIT in both undergraduate and graduate subjects are the same.

Graduate Academic Standards

It is the responsibility of the Committee on Graduate School Policy (CGSP) to monitor minimum academic standards for graduate students and special graduate students in accordance with the Rules and Regulations of the faculty. The CGSP reviews the academic records of all graduate students at the end of each term (including the summer session), and students with cumulative ratings of 3.5 to 4.0 are given particular attention. Consideration is given not only to low grades, but to other factors affecting a student's performance in meeting the requirements for the degree program in which he or she is enrolled.

Recommendations for action by the CGSP are made by departmental graduate committees. Unless extenuating circumstances are found, students who are not making satisfactory progress towards a degree may be denied permission to continue or may be warned that without substantial improvement in the following term they may be refused further registration in the Graduate School.

More detailed information concerning procedures followed by CGSP may be found in the *Graduate School Manual.* It is also important for students to be informed of individual department requirements and expectations concerning academic performance.



Admissions

Regular Graduate Admissions

A Regular Graduate Student is an applicant who has been admitted to the Institute and is registered for a program of advanced study and research leading to any of the post-baccalaureate degrees offered by MIT. A student registered in a program of study leading to the simultaneous award of the degrees of Bachelor of Science and Master of Science must apply to the Graduate School and be registered as a graduate student for at least one academic term (not the summer session) of his or her program of study.

To be admitted as a Regular Graduate Student, an applicant must have received a bachelor's degree or its equivalent from a college, university, or technical school of acceptable standing. Applicants are evaluated by the department in which they propose to register, on the basis of their prior performance and professional promise. These are evidenced by academic records, letters of evaluation from individuals familiar with the applicant's capabilities, and any other pertinent data furnished by the applicants. While high academic achievement does not guarantee admission, such achievement, or other persuasive evidence of professional promise, is expected.

The engineering departments normally require students seeking a Doctoral degree to qualify first for a Master's degree.

Undergraduate Requirements for Advanced Degrees

In addition to preparation in the specific field of interest, most departments require significant work in mathematics and the physical sciences, but some require as little as a year each of college-level mathematics and physical science. Requirements of individual departments are given in Chapter VI of this catalogue. Students with minor deficiencies in preparation may be admitted to the Graduate School; however, deficiencies in prerequisite, or general or professional subjects must be made up before the student may proceed with graduate work dependent on them.





Application Procedures

Students normally enter the Graduate School in September. However, in several departments suitable programs can be arranged for students entering in June or February. Prospective applicants should check with individual departments about their dates for admission.

Students wishing to enter in June or September should apply on the prescribed forms by January 15; candidates for admission in February should apply by November 1. However, applications submitted later may be considered if vacancies still exist. Candidates for admission who are also applicants for financial aid should observe the same deadlines.

Applicants attending colleges or universities on the semester system should apply before the end of the fall semester for admission in June or September, submitting a transcript of fall grades as soon as it is available.

Applications for admission (except to the Sloan School of Management and the Departments of Chemistry, Urban Studies and Planning, and Physics) should usually be requested from and submitted to the Director of Admissions, Room 3-103, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139. A $30 application fee must accompany the application form. Payment should be by check or money order, payable to the Admissions Office, MIT. The fee is not required of a student who applies for readmission as a candidate for the same degree or for a higher graduate degree in the same department after a lapse of less than two years. Applications for readmission after an absence of five years or more must be approved by the Dean of the Graduate School.

Notification about admission for September is sent as soon as action is taken (usually before April 1); for February applicants, notification usually is sent as

soon as the application is complete. Admission of a student who is in the final year of work toward a bachelor's degree is conditionally approved until subsequent evidence is provided that the degree has been awarded.

Inquiries about specific requirements for admission and subsequent provision of evidence should be addressed to the chairman of the appropriate departmental committee on graduate students.

Graduate Record Examinations (GRE)

Applicants for admission to graduate study in the Departments of Biology, Earth and Planetary Sciences, Economics, Political Science, Mathematics, Physics, Psychology, the Joint Program in Oceanography and Oceanographic Engineering with the Woods Hole Oceanographic Institution, and the Medical Engineering/Medical Physics program in the Division of Health Sciences and Technology are required to submit scores in the Aptitude Test and in the appropriate Advanced Test of the Graduate Record Examination.

The Department of Chemical Engineering and the interdepartmental program in Operations Research require GRE aptitude scores and one Advanced Test score corresponding to the undergraduate major.

The Department of Ocean Engineering highly recommends for all applicants and requires of all international students GRE scores including one Advanced Test. The Department of Biology will accept test scores resulting from the GRE Advanced Test in either chemistry, physics, or biology. The Department of Psychology requires the Aptitude Test for Verbal and Quantitative Ability, as well as the Analytic Score. Advanced tests of the GRE are recommended but not required.

The Department of Meteorology and Physical Oceanography requires the GRE Aptitude Test only. The Department of Electrical Engineering and Computer Science does not require these examinations and makes no recommendation regarding them. In the Department of Urban Studies and Planning, the GRE is required for Ph.D. applicants; it is not required for MCP applicants. All other departments recommend but do not require the submission of such scores. The Sloan School of Management requires applicant scores on the Graduate Management Admissions Test (an aptitude test) only.

Applicants are urged to consult with appropriate departments to confirm test requirements and recommendations. For a test application, write to the Graduate Record Examination, Educational Testing Service, Box 955, Princeton, New Jersey 08540.

International Graduate Admissions

Graduate student applicants who are citizens of countries other than the United States must have received a bachelor's degree or its equivalent from a college, university, or technical institute. The academic record and all credentials must indicate the ability of the candidate to complete an approved program of study and research. Applicants are evaluated by the academic departments. Admission is granted on a competitive basis. Competence in written and spoken English is expected. Students whose native language is not English and whose schooling has not been predominantly in English, must take the Test of English as a Foreign Language (TOEFL). This test is mentioned in the section on International Undergraduate Admission in Chapter III of this catalogue.

The Final Application for Admission from International Students may be obtained from the Director of Admissions, Room 3-103, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139.

Applicants must submit complete application materials to the Director of Admissions.

Please refer to the previous section concerning individual departmental requirements for the Graduate Record Examinations.





Special Graduate Students

A Special Graduate Student is one whose intended program of study is essentially graduate in nature but who is not a candidate for a degree. Normally such a student will have received a bachelor's degree. All applications are made through the Admissions Office. Applications for the specific subjects desired will be evaluated by the Graduate Committee of the department(s). Admission is valid for only one term; a student must seek readmission each term to continue at the Institute. Those applying for Special Graduate Student status for the first time must pay a $30 application fee. To be allowed to continue as a Special Graduate Student, academic performance satisfactory to the Committee on Graduate School Policy must be maintained.

The deadlines for filing Special Student applications are May 1 for the summer term, August 1 for the fall term, and January 1 for the spring term.

Citizens of countries other than the United States whose native language has not been predominantly English must submit the Test of English as a Foreign Language (TOEFL) as noted in the section on International Graduate Admissions.



Admission as a Special Graduate Student does not imply any commitment on the part of the Graduate School toward an individual's admissibility to Regular Graduate Student status (degree candidate). If a Special Graduate Student is subsequently admitted as a degree candidate, subjects completed may be used in partial fulfillment of requirements for an advanced degree. The department will determine what subjects are acceptable. Registration as a Special Graduate Student does not count toward minimum residency requirements for an advanced degree.

Correspondence concerning admission as a Special Graduate Student should be addressed to the Director of Admissions, Room 3-103, from whom application material and "Information for Special Students" may be obtained.

Graduate Student Status for Research Staff Members

In view of their full-time responsibilities on assigned research and their corresponding salary scales, staff members of the Office of Sponsored Programs or the Charles Stark Draper Laboratory may not be full-time Regular Graduate Students, but may, under certain conditions be granted the status of Special Graduate Student. However, an OSP appointee or an employee of the Lincoln Laboratory or the Draper Laboratory who desires to work for an advanced degree must be admitted as a Regular Graduate Student and complete the residency and other requirements of the degree program to which the individual has been accepted. This individual may not continue to hold a research staff appointment.

Any OSP appointee or an employee of the Lincoln Laboratory or the Draper Laboratory may, by written permission from the director of the division (or his or her designate), apply for admission as a Special Graduate Student for enrollment in one subject only per term (but not thesis), either as a listener or for academic credit. Acceptance for such enrollment will be granted if, in the opinion of the instructor, the individual is qualified to undertake the subject and if section size permits. For this type of enrollment, the student will be assigned to an appropriate Registration Officer and will pay, whether as a student or listener, the fee established at the Special Student rate.

Other Employment

A graduate student may not interrupt an academic program to accept employment on the academic, administrative, or research staff or as an hourly employee at MIT, the Lincoln Laboratory, or the Draper Laboratory either during the academic year or the summer, unless the approval of the department head and of the appropriate academic Dean has been obtained and unless the work as an employee is unrelated to the student's thesis research. A thesis release form indicating such approval must be submitted to the appropriate Personnel Officer to effect such employment. A graduate student may not include in his or her thesis any material based in whole or in part upon work done while holding an academic or research staff appointment.

Costs for Graduate Students

The following are the basic tuition and fees at MIT for the academic year 1981-82 (which are reviewed and likely to increase each year):

Tuition[1]	$7,400
Hospital and Accident Insurance Policy[2]	168

The tuition for all regular graduate students, including graduate student staff, in the first and second terms is $3,700 per term. Full tuition in either term of the current year covers the January Independent Activities Period. The minimum term tuition charge for registration for doctoral thesis upon readmission as a resident student is $5,550, if not registered during preceding regular term. The tuition for all regular graduate students including fellows, trainees, and academic staff in the 1981 Summer Session was $2,470. Special tuition rates apply to other students in the Summer Session. These are published each year in the *Summer Session Catalogue*, available in March.

Special Students (except in the Sloan School of Management) are charged at the rate of $120 per unit taken either for credit or not for credit. This unit fee applies up to a maximum of $3,700 per term and is subject to the following minimum fees:

Members of the MIT Community[3]	$720
Other Special Students	1,080

Any resident graduate student making progress toward a degree is expected to register and is considered a full-time student. If a graduate student requires only part of a term to complete the thesis, initially, full tuition for the term is charged, and adjustments to tuition are made at a later date. If the student was registered for thesis as a resident student in the immediately preceding term, regular or summer, tuition for thesis will be adjusted after acceptance by the department of the completed document on the basis of a charge of $310 per week from the starting date of the term, with a minimum of $310 for the Master's or Engineer's degree and $620 for the Doctor's degree. If the immediately preceding term was the summer term and if the graduate student was not registered for thesis in that summer term, but was registered for thesis in residence in the previous second term, the minimum tuition for thesis is $1,850. A student who continues to hold a fellowship, traineeship, or graduate staff appointment for the remainder of the term after delivery of the thesis continues to be regarded as a full-time student and the tuition will not be adjusted. In unusual circumstances, the Dean of the Graduate School may set special tuition rates for graduate students.

Doctoral thesis research is ordinarily carried out while the student is in residence at the Institute. However, on some occasions, it may be essential or desirable that the student be absent from the campus during a period of his or her thesis research. Permission to become a non-resident doctoral candidate must be sought from the Dean of the Graduate School **at least** one month prior to the opening of the term during which the student wishes to register in this category. Prior to submission, the request must be approved by the student's thesis supervisor and by the representative to the Committee on Graduate School Policy from the student's department of registration. Students who are permitted to undertake non-resident thesis research must register as Non-Resident Doctoral Candidates and pay tuition equal to approximately 15 percent of the regular full tuition ($555 per term for 1981-82). Following completion of the non-resident period, the student must return to resident status for completion and presentation of the doctoral thesis. If the student requires only part of this first term back in residence to complete the thesis, the tuition will be adjusted subject to a minimum of one-half of regular tuition. Please consult the *Graduate School Manual* for additional information on non-resident status.

Cooperative programs offered by MIT provide industrial and research experience through a series of work assignments interwoven with regular study at the Institute. The tuition fees for cooperative programs are as follows:

Aeronautics and Astronautics, Course XVI-B
Mechanical Engineering, Course II-B
Ocean Engineering, Course XIII-C
June-August (15 months), $7,400

Chemical Engineering Practice, Course X-A
September-January or February-June, $3,700

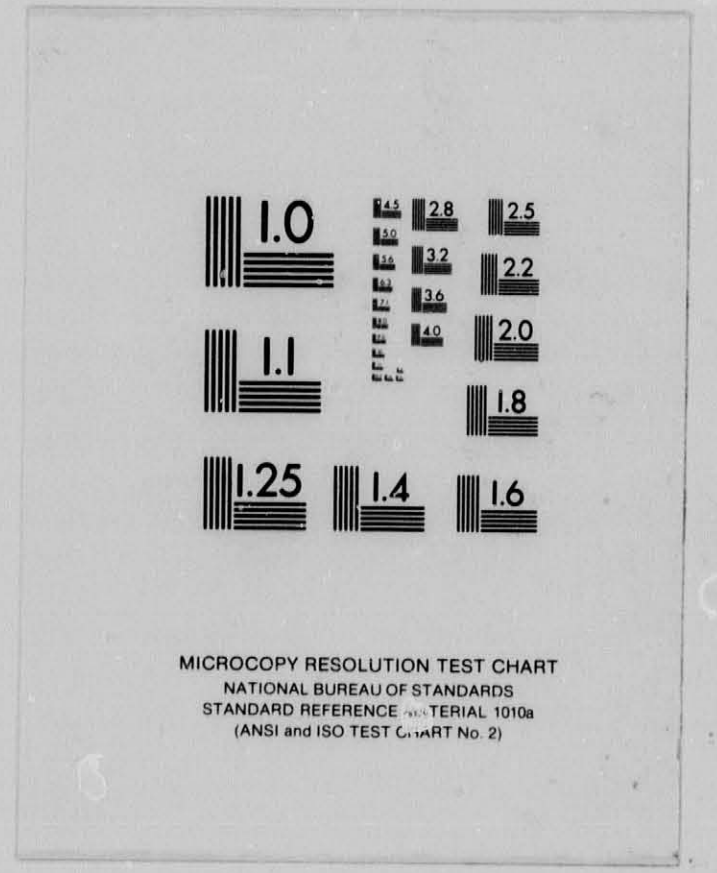
Electrical Science and Engineering or Computer Science and Engineering, Course VI-A
Engineering Internship Program
Materials Science and Engineering, Course III-B
July 1 to June 30, $7,400

In each case, the first $3,700 is due on the date when the first-term tuition is normally due, and the additional $3,700 is due on the date when the second-term tuition is normally due. Upon recommendation of the Department, a special tuition rate for any cooperative program may be set by the Dean in an unusual case.

1
Payment of this fee entitles all regular and special registered students to comprehensive health care services at the MIT Medical Department, including consultation with a wide range of specialists, diagnostic studies, and hospitalization in the MIT Infirmary. Charges are made for routine eye examinations, contact lens services, ear piercing, dental care services, obstetrical care, contraceptive devices, missed appointments, and surgical procedures and outside diagnostic tests that are generally covered by the student's hospital and accident insurance policy.

2
The MIT Student Insurance covers hospitalization (other than in the MIT Infirmary) due to accidents or illness. The insurance is required for all students, unless they can demonstrate that they have equivalent coverage through another insurance program. A medical insurance plan for a student's spouse and children is also available. The additional cost of insurance coverage for the spouse for outside hospital care is $456. Hospitalization insurance for one or more children may be purchased for $156. A student withdrawing during a term may cancel this insurance and receive a credit, as of the end of the month when cancelled, by filing a request at the Student Insurance Office.

3
Includes Special Students who are full-time employees of the Institute or who are dependents of full-time employees or regular students.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Special graduate students in the Sloan School of Management may take no more than two subjects per term. Except for employees of the Institute or their children, the tuition fee is $215 per unit of registration, with a minimum charge of $1,935. There is a maximum charge of $5,720 per term for full-time special graduate students enrolled in the program. Students interested in the Accelerated Program of Graduate Study in Management should consult the Sloan School of Management with regard to fees.

There is a professional activities fee of $100 per regular term in the Master's Degree Program in the Sloan School.

A student withdrawing before the start of a term is not charged any tuition for that term and any tuition payments previously made for that term will be refunded. Students withdrawing during the first or second term are charged one-twelfth of the stated tuition for the term for each week from the starting date of the term, with a minimum two-week charge. A student is financially obligated to the Institute for the tuition appropriate to the program approved by his or her Faculty Advisor or Graduate Registration Officer at the first of the term. Any subsequent reduction in fees is based on the date that cancellation of a subject or withdrawal from the Institute is effected. At that time, any excess payments which the student has made will be refunded.

Graduate Living Costs

Living expenses for graduate students vary widely depending on such factors as marital status, availability of resources, interests, and tastes. Monthly living expenses for single graduate students generally range from about $650 to $900. This includes cost estimates for housing, food, medical insurance and fees, books, and other personal expenses. It does not include tuition. Campus housing for graduate students is limited and less than half of the graduate student population can be accommodated in Institute housing. On-campus dining opportunities are available to graduate students.

Miscellaneous Fees

Application fee for graduate admission	$30
Late registration fee	10
Fee for late payments	50
Fee for doctoral degree language exam (given at an unscheduled time)	30
Fee for late filing of degree application	20
Fee for late thesis title change	20
Library Processing Fees	
Doctoral Theses	24
All other theses for advanced degrees	17

Processing Charges for Late Changes in Registration

A late change in registration, which requires the approval of the appropriate faculty committee, is defined as adding a subject after the fifth week or dropping a subject during the last three weeks of a term. The processing charge for late changes is $20 for one subject or $25 for more than one subject in a petition. There is an additional charge of $20 for a retroactive change after the end of the term.

The miscellaneous fees and processing charges listed above are nonrefundable, unless levied in error.

Payments

All payments are to be made to MIT, Cambridge, Massachusetts 02139, by the time specified in the financial registration instructions issued prior to the opening of each term. A late charge of $50 is assessed for each payment that is not received when due. Registered student status can be withdrawn at any time for non-payment of fees. A student who expects to be a candidate for a degree must make satisfactory financial arrangements for any indebtedness prior to requesting entry of his or her name on the degree list.

A graduate student may arrange with the Student Accounts Office to defer payments over the term. (An administrative fee of $50 will be charged for this service.) The deferred payment plan is currently being reviewed and may be modified (or discontinued) over the next several years as various alternatives are developed. Financial registration instructions and billings for tuition and fees will be sent to admitted and continuing graduate students prior to the beginning of each term.

Students and their families might consider the Parent Loan Plan, recently developed to help parents of MIT students pay for educational expenses at MIT over an extended period of time. This monthly installment plan offers loans at moderate interest rates to parents (US citizens) whose annual family income is between $25,000 and $75,000. Further information may be obtained from John Rogers, MIT Parent Loan Plan Office, Box 160, Boston, Massachusetts 02101, (617) 253-3342.

Financial Aids

Fellowships, Traineeships, and Scholarships

MIT makes available financial support to graduate students from a variety of sources and in several different forms — fellowships, scholarships, traineeships, teaching and research assistantships, the Federal College Work-Study Program, and the Technology Loan Fund. Many forms of support are granted solely on the basis of merit while others are granted on the basis of financial need or a combination of merit and need.

Neither every department nor the Institute itself has the financial resources to provide support for all deserving students. Thus, it is important that prospective students explore all sources of aid available outside MIT to find means of financing their graduate programs.

Upon admission to an MIT graduate program, all students are required to complete the MIT Graduate School Need Analysis form as a part of the registration process. Although MIT does not require completion of the Graduate and Professional Schools Financial Aid Service (GAPSFAS) form, students may submit the GAPSFAS form in lieu of the MIT Graduate Student Need Analysis form. To do so, they must designate on the GAPSFAS form that a copy should be sent to MIT.

Information on fellowships and other financial aid resources is available from departments and the Graduate School Office, Room 3-136. Information on loans and the College Work-Study Program is available form the Student Financial Aid Office, Room 5-119.

A fellowship or traineeship is an award to a graduate student which covers tuition, partially or fully, and provides, in addition, a stipend to help defray living expenses. In the context of the Graduate School, a scholarship is an award which fully or partially covers tuition only. Most awards are made on the basis of academic promise and in some instances financial need to students who are enrolled in a graduate degree program. Under Section 117 of the US Internal Revenue Code of 1954, such awards, held by degree candidates, are not usually subject to income tax.

The Institute receives funds from individual donors and corporations which provide for the support of fellowships and scholarships each year. In addition, government agencies and foundations offer fellowships and other grants which they award either directly to outstanding students for use at institutions of their choice or, in a few cases, to MIT for award to its students. Fellowships available under these national programs are summarized in the following section.

Applicants to the Graduate School who seek financial support from any of the fellowships, traineeships, or scholarships administered by MIT, including those granted by national agencies and foundations for award by the Institute, should check the appropriate items on the regular Application for Admission to the Graduate School. Applicants will be considered for awards for which they are eligible after they have been accepted into a graduate program. Currently enrolled graduate students who seek financial support should consult with the appropriate departmental office.

Applications for fellowship aid for the academic year, beginning in June or September, must be filed by January 15. Applications for fellowship aid filed after this date are considered only if funds are available. Final action on applications is taken on the recommendation of departments to the Graduate School at the end of March, after the announcement of awards to applicants by the national agencies and foundations under their national competitive programs. A student who wins such a fellowship is not usually considered further for an award by MIT.

In accordance with a resolution of the Council of Graduate Schools in the United States, endorsed by most graduate schools in the US, a student has until April 15 to accept or decline an offer. If a student does not reply to an offer by this date, it may be canceled.

Every student holding a fellowship, traineeship, or scholarship for graduate study at the Institute must register as a full-time graduate student for the period of the award. If a student withdraws from the Institute before tenure expires, the award must be relinquished, and the student will be required to refund any sum already paid as the Dean of the Graduate School deems appropriate.

Teaching and Research Assistantships

MIT employs about 450 graduate students each year as part-time or full-time instructors or teaching assistants to assist the faculty in grading undergraduate quizzes, instructing in the classroom and laboratory, and conducting tutorials. The rate of compensation for such students is determined by the Dean of the School according to the circumstances of the appointment.

The departments regard seriously the benefits of a teaching assistantship as a preparation for a career in university teaching, and the Institute offers a prize each year — the Goodwin Medal — for conspicuously effective teaching by a graduate student.

The units for which an instructor or teaching assistant may register as a student are determined by the department in the light of the student's assistantship duties, program of study, and compensation.

Appointments to teaching assistantships are made upon recommendation of the head of a department. A student who wishes to be considered for a teaching appointment should write to the department. Only full-time graduate students who are candidates for advanced MIT degrees may be appointed.

Each year about 1,200 graduate students at MIT hold appointments as research assistants. The principal duty of a research assistant is to contribute to a program of departmental or interdepartmental research.

Most students welcome the opportunity to participate as junior colleagues of the faculty in an ongoing research project which frequently influences their choice of thesis topic. Appointments to research assistantships are made by the department head to full-time students who are candidates for advanced MIT degrees.

The units for which a research assistant may register are determined by the department in the light of duties and program of study. Research assistants are compensated on the basis of time devoted to their research. In all cases they must pay full tuition.

Loan Funds

MIT administers the Technology Loan Fund under which financial assistance is available to graduate students. However, loan capital is limited and MIT student loans are granted only after the student has explored all sources of aid including employment opportunities and the Guaranteed Student Loan program from banks and other lending institutions. Eligibility for MIT loans is based on need as determined by the Student Financial Aid Office, and is a function of student expenses and resources (including assets). Standard budgets have been developed for single students and married students with or without dependents and are rigorously applied. Loans not covered by the Guaranteed Student Loan program require a co-signer.

Graduate students who do not possess US citizenship or a permanent resident visa are not eligible for state or federally guaranteed loans, nor are they eligible for MIT loans during the first year of residence. Thus, students who are citizens of other countries must be prepared to meet their expenses for the first year at MIT without recourse to loans from the Institute, and without expectation that in subsequent years loans may be available.

Special Students (individuals who are not admitted to a graduate degree program) may apply to MIT for loan funds but with no commitment to provide assistance. State Guaranteed Loans may be approved when the student is enrolled for 24 or more units.

Specific information on eligibility for loan funds is available from the Student Financial Aid Office, Room 5-119.

Other Employment Opportunities

The Federally funded College Work-Study Program provides some on-campus employment for eligible graduate students. To qualify for Work-Study employment, a student must be a United States citizen or permanent resident, a full-time resident degree candidate, and must demonstrate financial need. For further information on the College Work-Study Program or other on-campus job opportunities, students may contact the Student Financial Aid Office, Room 5-119.

Special Graduate Students are not eligible for MIT scholarships, fellowships, or grants or for employment funded under the College Work-Study Program.

Graduate Residents

Graduate resident positions in undergraduate Institute Houses and independent living groups (including fraternities) provide room and board. Applications for a resident position from students who have completed at least one graduate year at MIT or new students who have been MIT undergraduates may be made to the Dean for Student Affairs.

Scholarships and Fellowships for Graduate Students

National Fellowships for Graduate Study

American Association of University Women
Council for Opportunity in Graduate Management Education
Graduate Fellowships Program (formerly Ford Foundation)
Hertz Foundation
National Fellowships Fund
National Science Foundation

See Graduate School Office for details of these and other programs.

Aid for Foreign Study

Churchill Scholarship Program
German Academic Exchange Service (DAAD)
Institute of International Education (Fulbright)
Luce Scholars Program
Marshall Scholarships
Rhodes Scholarships

Numerous other fellowships exist for graduate and postdoctoral study abroad. For an inclusive listing of international fellowships consult the International Students' Office, Room 5-112, 253-3795. All of the above scholarships have early fall deadlines.

Aid for Study in Various Fields

The following individuals and organizations have made gifts to MIT to assist graduate students in need of financial aid. These awards are administered by the Graduate School Office or the individual departments (as indicated). Allocations are made in the same manner as other scholarship and fellowship awards and individual applications are usually not necessary.

Edward Austin
John F. Blackie Memorial
William Sumner Bolles
Helen Collamore
Alfred W. French
Ida M. Green
Frank M. Greenlaw
Holland Hamilton Fellowship
Whitaker Health Sciences Fund
IBM
John A. Lyons
MTS Systems Corporation Fellowship
National Distillers and Chemical Corporation
NPW Fellowship in Energy
Potter-Seltzer
Rockwell International
Henry Bromfield Rogers
Henry Saltonstall
James Savage
Susan H. Swett
Gerard Swope
Frank Hall Thorp
Thomas Upham
Jonathan Whitney
Xerox, Inc.
Hugh Hampton Young Memorial Fund

Aeronautics and Astronautics

Donald W. Douglas
Richard C. Du Pont
Lester D. Gardner

Architecture

The Aga Khan Fellowship for Islamic Architecture
Avalon Foundation
Francis Ward Chandler Memorial Fund
W. Danforth Compton Memorial
William Emerson Fund
William and Frances Emerson
Edith M. Hobbs
Samuel A. Marx
Floyd Naramore Architectural Memorial Fund
Willard B. Perkins

Chemical Engineering

Amoco Foundation
Chevron (Standard Oil Company of California)
Edwin R. Gilliland
Halcon International, Inc.
Kennecott Copper Corporation
Arthur D. Little
Michelin
Nestle Company
Owens-Corning Fiberglass Corporation
Stauffer Chemical Company

Chemistry

Lewis Paul Chapin
Dow Chemical Company
Eastman Kodak Company
Halcon International, Inc.
Arthur D. Little
Forris Jewett Moore Memorial
James Flack Norris
Polaroid Foundation, Inc.
Uniroyal Foundation

Civil Engineering

W. H. Mills Construction Industry Fellowship

Earth and Planetary Sciences

Chevron (Standard Oil Company of California)

Economics

Clarence J. Hicks Memorial
Joseph N. Scanlon Memorial
Graduate Economics Alumni Fellowship

Electrical Engineering and Computer Science

General Electric Foundation
GenRad Foundation
Grass Instrument Company
Schlumberger Foundation
Vinton-Hayes Fellowships in Communication

Management

Sloan School of Management — A number of fellowships and scholarships for students seeking the doctor's degree.

Materials Science and Engineering

Allegheny-Ludlum Industries, Inc.
American Metal Climax Foundation
ASARCO Foundation
International Nickel Company, Inc.
Michelin
MTS Systems Corporation
Owens-Illinois, Inc.

Mechanical Engineering

Allied Chemical Corporation Fellowship
Ashland Oil Foundation, Incorporated, Foundation
Cummins Engine Foundation
Wilfred Lewis
MTS Systems Corporation
Polaroid Foundation Fellowship
Procter & Gamble Company
Weyerhauser Company Foundation Fellowship

Nuclear Engineering

Babcock and Wilcox Fellowship
Sherman R. Knapp Fellowship in Nuclear Power Engineering
Theos J. Thompson Memorial Fellowship
General Electric Foundation

Nutrition and Food Science

Bernard E. Proctor Memorial
Stauffer Chemical Company
Bethesda Research Laboratories, Inc.

Ocean Engineering

Gulf and South American Steamship Company
Society of Naval Architects and Marine Engineers

Physics

Karl Taylor Compton Fellowships

Special Loan Funds

The following funds have been established for special purposes at the Institute. Except where stated, these loan funds are administered under terms similar to those governing the Technology Loan Fund, and no separate application need be made.

Walter Phelps Bliss Memorial Fund

Anna J. and Francesco Casaretta Loan Fund (1966)

Francis W. Chandler Loan Fund (1927)

Ruth Hornblower Churchill Memorial Loan Fund (1958)

Class of 1917 Loan Fund (1937)

Daunis Family Fund (1971)

George Freydberg Fund (1972)

Ethel I. Fryer Scholarship Loan Fund (1951)

Jerome C. Hunsaker Loan Fund (1970)

Rebecca R. Joslin Loan Fund (1924-36)

M. H. Rogers Loan Fund (1945)

Lillie C. Smith Fund (1965)

Gertrude W. Swartz Memorial Student Loan Fund (1971)

Technology Matrons Loan Fund (1960)

Robert Kelley Thulman Loan Fund (1963)

Timbie Memorial Fund (1954)

F. B. Tough Fund (1924)

Frank P. Wakefield Loan Fund (1955)

Prizes and Awards

To encourage and recognize high achievement by students at MIT, a number of prizes have been established by individuals and organizations. In general, these awards are made each year by the Office of the Dean for Student Affairs, the Dean of the Graduate School, or by the departments or organizations concerned.

American Institute of Chemists Award (1957)
Avery Allen Ashdown Award
Karl Taylor Compton Prizes (1951)
The Goodwin Medal
Military Prizes
Scott Paper Foundation Leadership Award
Irwin Sizer Award
William L. Stewart, Jr., Awards (1964)
Stratton Prizes (1930)
The Laya and Jerome B. Wiesner Awards (1979)

Aeronautics and Astronautics

Luis de Florez Awards (1960)
James Mean Memorial Prize (1925)
Henry Webb Salisbury Memorial Award (1941)

Architecture

Student Medal of the American Institute of Architects (1914)

Civil Engineering

Tucker-Voss Award (1953)
Richard Lee Russel Prize (1967)
Steinberg Prize (1977)

Earth and Planetary Sciences

Christopher Goetze Prizes

Electrical Engineering and Computer Science

Department of EECS Teaching Awards
Supervised Investors' Services, Inc., Awards (1957)
Carlton E. Tucker Award for Excellence in Teaching (1962)
David T. Schultz Award (1969)

Management

The Brooks Prize in Management
Editorship of the Sloan Management Review
Thomas M. Hill Prize in Management

Materials Science and Engineering

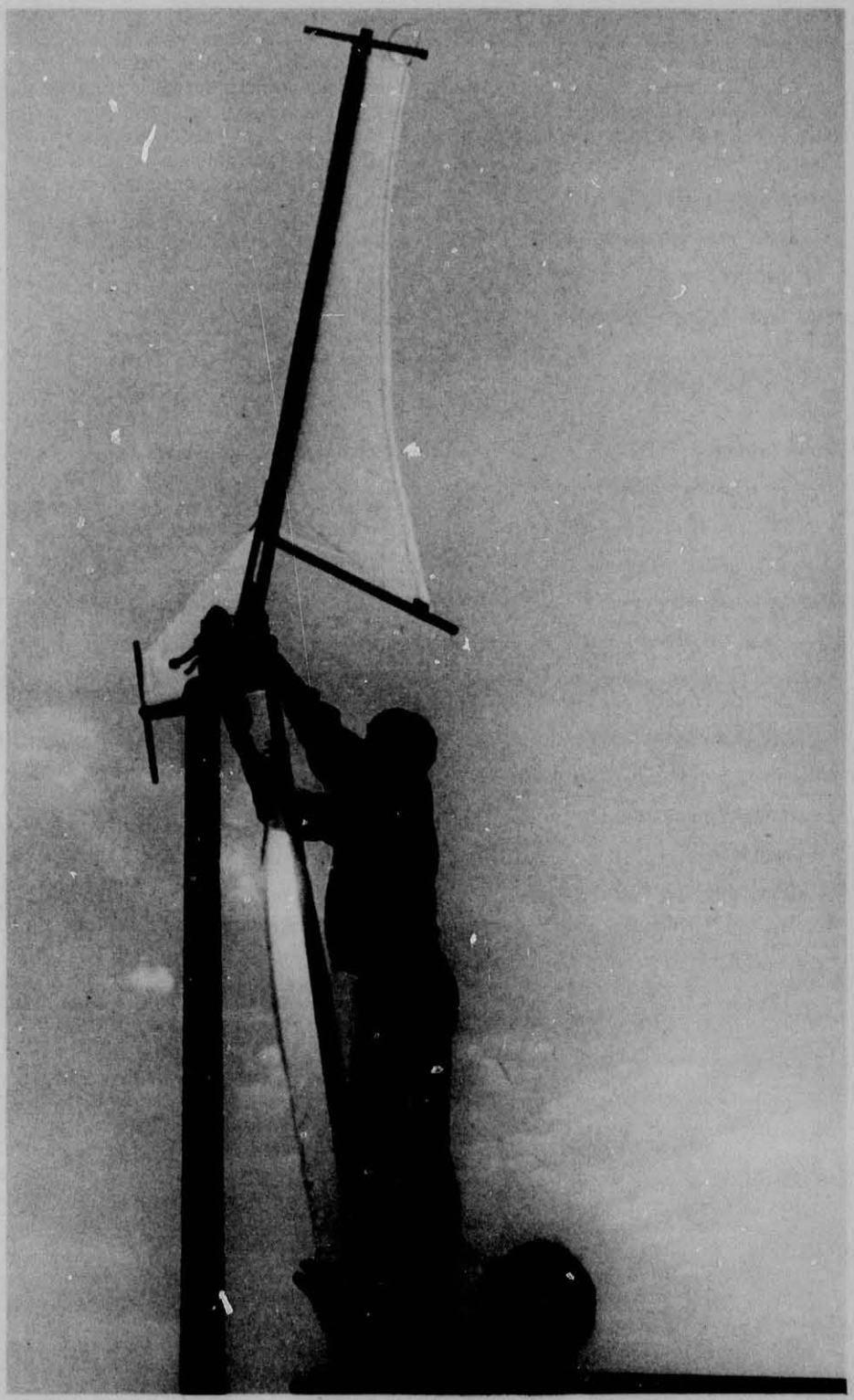
American Metal Climax Foundation Prize (1969)
Falih N. Darmara Materials Achievement Award
Foundry Educational Foundation Scholarship
John Wulff Award for Excellence in Teaching

Mechanical Engineering

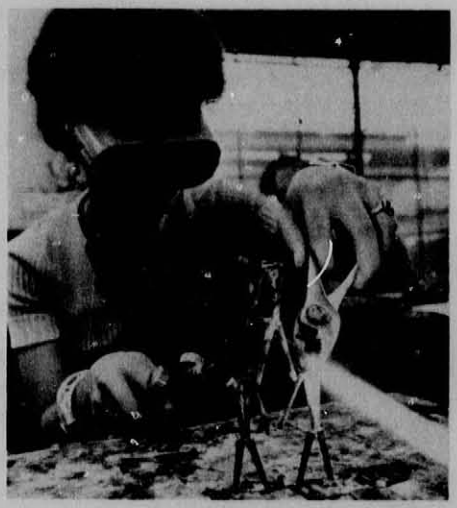
Luis de Florez Awards (1957)
Silent Hoist and Crane Company Materials Handling Award (1950)

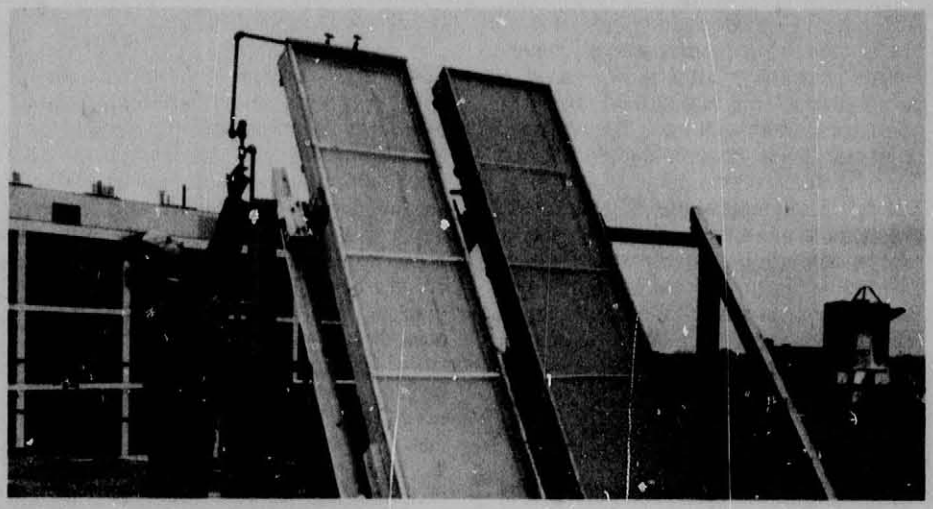
Meteorology and Physical Oceanography

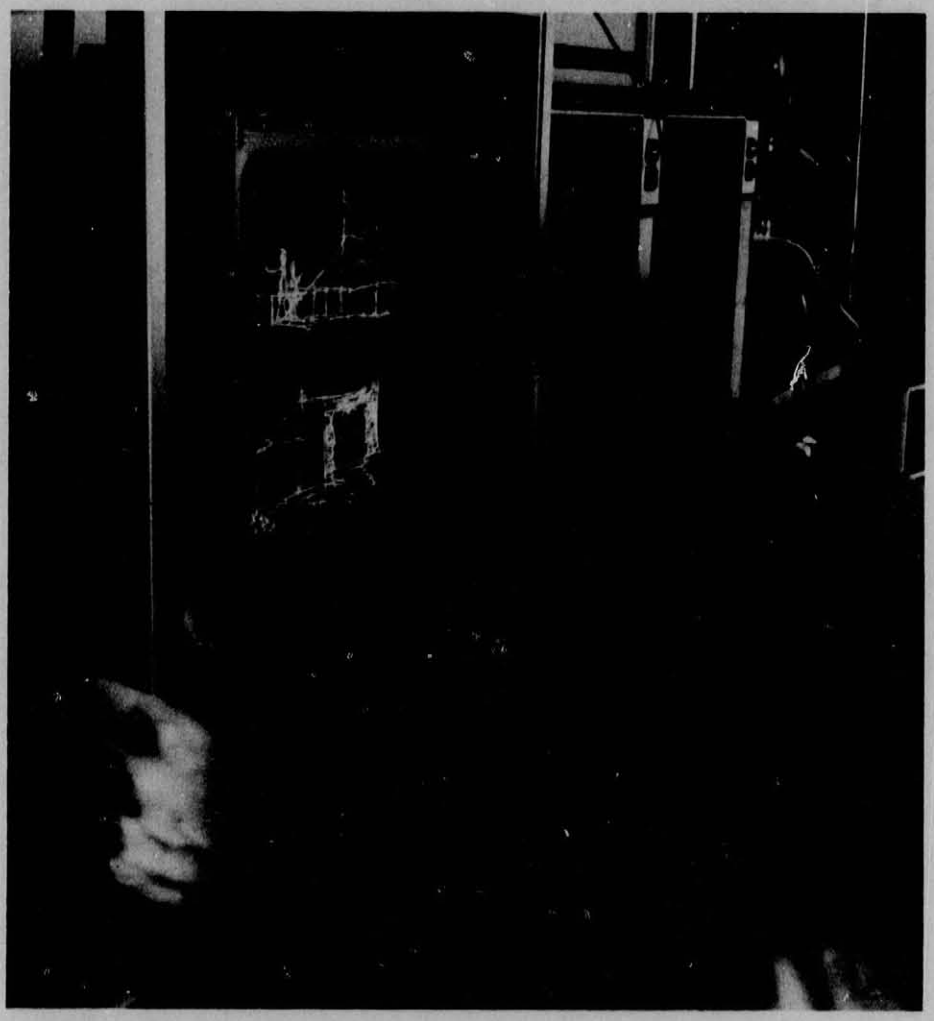
The Carl-Gustav Rossby Award in Meteorology



V Interdepartmental Study and Research







Interdepartmental Study and Research

Advances in knowledge and concern with the functioning of modern society have led researchers to become interested in complex problems that can no longer be adequately dealt with from the vantage point of a single academic department. There is thus an increasing tendency at MIT for faculty and students from different fields to work together in a variety of groups, laboratories, centers, and programs that cut across departmental or School lines. Some of these opportunities lead to degrees, or form the basis for a "minor" program; many can be explored through the interdepartmental organizations and research facilities listed in this chapter.

Undergraduate Opportunities

Some of these interdepartmental educational programs lead to the S.B.; the title of a degree-granting program is followed by **(S.B.)**. These, and the other interdepartmental programs for undergraduates outlined in this chapter include:

Archaeology and Ancient Technology
Astronomy and Astrophysics
Biomedical Engineering
Concourse Program for First-Year Students
Energy Study and Research
Environmental Studies
Experimental Study Group
Interdisciplinary Research Opportunities
Interdisciplinary Science Degree Program
Joint Degree Programs in Humanities and Engineering and Humanities and Science
Law-Related Studies
Mineral Resource Studies
Science, Technology, and Society
Special Interdisciplinary Programs in Humanities
Study and Research in Education
Undergraduate Seminars
Unspecified Degree Programs

Graduate Opportunities

Some of these interdepartmental educational programs have been formally approved as degree-granting programs by the Committee on Graduate School Policy. Each of these programs has a standing faculty committee which administers the program, and each grants named degrees in the field of study. In this chapter, the title of such a degree-granting program is followed by the advanced degree(s) it offers; i.e., **(S.M.), (Ph.D.),** etc. Other study or research opportunities described here **may** be fields of study which lead to advanced degrees, but these programs are administered on a more ad hoc basis than the programs described above. The interdepartmental programs for graduate students outlined in this chapter include:

Acoustics
Biomedical Engineering
Cognitive Science
Communications Policy
Economics and Urban Studies
Energy Study and Research
Environmental Studies
Joint Program in the Management of Technology
Law-Related Studies
Mineral Resources Engineering and Management
Oceanography and Oceanographic Engineering
Operations Research
Polymeric Materials
Power Engineering
Science, Technology, and Society
Statistics
Study and Research in Education
Technology Adaptation Program
Technology and Policy
Transportation

Interdepartmental Organizations and Research Facilities

The Institute's major interdepartmental organizations and research facilities, most of which offer undergraduates and graduate students opportunities for interdepartmental research, are:

Artificial Intelligence Laboratory
Bates Linear Accelerator
Bitter National Magnet Laboratory
Cell Culture Center
Center for Advanced Engineering Study
Center for Advanced Visual Studies
Center for Cancer Research
Center for Cognitive Science
Center for Computational Research in Economics and Management Science
Center for Health Effects of Fossil Fuels Utilization
Center for Information Systems Research
Center for International Studies
Center for Materials Research in Archaeology and Ethnology
Center for Materials Science and Engineering
Center for Policy Alternatives
Center for Space Research
Center for Transportation Studies
Clinical Research Center
Division for Study and Research in Education (with faculty list)
Electric Power Systems Engineering Laboratory
Energy Laboratory
George Russell Harrison Spectroscopy Laboratory
Innovation Center
International Food and Nutrition Program
Laboratory for Computer Science
Laboratory for Information and Decision Systems
Laboratory for Manufacturing and Productivity
Laboratory for Nuclear Science
Laboratory of Architecture and Planning
Lincoln Laboratory
Materials Processing Center
Mining and Minerals Resources Research Institute
Neurosciences Research Program
Nuclear Reactor Laboratory
Operations Research Center
Plasma Fusion Center
Research Laboratory of Electronics
Sea Grant College Program
Statistics Center
Technology Adaptation Program
Wallace Astrophysical Observatory
Wallace Geophysical Observatory

Other Opportunities

Undergraduate Interdepartmental Opportunities

Archaeology and Ancient Technology

Through a combination of archaeological fieldwork, laboratory studies, and subjects, this program attempts to improve the understanding of how pre-modern people adapted their material environment to their needs. We also study how culture, interacting with the physical properties of materials, produced technological systems which, in turn, helped to shape the cultures themselves. The point of departure of the program is the laboratory study of specific technologies (for the moment mainly metallurgical and ceramic), as those technologies are manifest in archaeological objects, including attempts at reproducing certain techniques using the same materials and processes that were used in antiquity. The archaeological fieldwork is aimed at examining the same technologies studied within the laboratory in their own original ecological and cultural settings with the goal of elucidating not only the technology itself, but how it interacted with the human and physical landscape in which it was practiced. The subjects, given in the Department of Humanities (in the Anthropology/Archaeology Program) and in the Department of Materials Science and Engineering, focus on different ancient societies and different ancient technologies; they also look at the ethnographic record of the use of materials and techniques in the production of art and material culture in general.

This area of study combines the scientific examination and experiments of the materials laboratory, the scientific excavation of archaeological sites, the aesthetic feel of the technology and appreciation of its products, and the historical and anthropological study of the contexts of the technologies in specific places and times.

The specific projects currently under study in the Laboratory for Research on Archaeological Materials and in the field include examination of pre-Columbian metalworking in the Andes and a study of the ancient copper industry of the island of Cyprus. Interested students should contact Professor Heather Lechtman, Room 16-401, MIT, Cambridge, Massachusetts 02139, (617) 253-2172 or Professor Arthur Steinberg, Room 14N-308, 253-6956.

Astronomy and Astrophysics

A broad variety of research and study in astronomy and astrophysics is carried out under the astrophysics program, an interdisciplinary group whose interests span planetary, X-ray, radio, and infrared astronomy. The academic programs are administered by the Departments of Physics, Earth and Planetary Sciences, Mathematics, Electrical Engineering and Computer Science, and Chemistry. A description of the subjects, research facilities, and academic requirements is given under Astronomy and Astrophysics, which is included in the School of Science section. Further information may be obtained by contacting Professor Bernard Burke, Room 26-335, MIT, Cambridge, Massachusetts 02139, (617) 253-2572.

Biomedical Engineering

An area of study which is of increasing interest to undergraduate and graduate students alike lies at the interface between the engineering and life and health sciences. Investigations on such varied topics as biomaterials, biological control systems, and mechanisms of sensory perception, to name only a few, involve faculty and students from most of the engineering departments. Much of this research is carried out in interdepartmental laboratories in collaboration with workers from medical centers in the Boston area. The undergraduate wishing to explore this developing area has ample opportunity within his or her regular departmental major through elective subjects, special laboratory projects, and the senior thesis. These studies should be of special interest to students who are enrolled in a premedical curriculum. The Committee on Biomedical Engineering serves as an advisory body which can assist students in setting up interdepartmental programs. Further information may be obtained from Professor L. R. Young, Room 37-207, MIT, Cambridge, Massachusetts, 02139, (617) 253-7805.

Concourse Program for First-Year Students

For freshmen who wish to have a more interdisciplinary approach to first-year studies, the Concourse Program offers team-taught curricula which use and emphasize the comparison and interrelationship of ideas and techniques from the sciences, engineering, social sciences and humanities, and which explore the possibilities (and limits) of integrated thought in these areas. Ideas and techniques are viewed in various unifying contexts, both thematic and historical. The Program covers, and provides credit for, the Institute Requirements of the first year (Chemistry/Biology, Physics, Mathematics, and Humanities, Arts, and Social Sciences). Further information may be obtained from the Concourse Office, Room 20C-224, MIT, Cambridge, Massachusetts 02139, (617) 253-3200.

Energy Study and Research

Undergraduate programs in most departments at MIT, including all those in the School of Engineering, prepare students for careers in the energy field that can be entered immediately upon graduation. Such programs include not only the basic sciences, but also the applied sciences, such as fluid and solid mechanics, heat, controls, chemical processes, economics, and materials. Specialized subjects lead more directly towards careers, as in exploration for and production of uranium and fossil fuels; development of alternative energy sources such as solar, wind, and geothermal; petroleum refining; manufacture of synthetic fuels; conventional and nuclear generation of electric power; energy conservation in buildings, transportation, and manufacturing; and energy policy. In addition, all undergraduate engineering programs provide preparation for graduate work in the field of energy.

Many opportunities exist for undergraduates to work on energy-related research projects offered by the centers, laboratories, and academic departments. This research can be done for thesis or other academic credit or for pay under the Undergraduate Research Opportunities Program. Further information, including lists of advisors, programs, subjects, and research topics related to energy are available through the Office of the Dean of Engineering, Room 1-206, MIT, Cambridge, Massachusetts 02139.

Environmental Studies

Environmental studies for undergraduates at MIT are available through a variety of departments and laboratories. Both the technical and the policy aspects of environmental studies are explored in subjects offered by the Departments of Civil Engineering, Mechanical Engineering, Ocean Engineering, Chemical Engineering, Earth and Planetary Sciences, and Urban Studies and Planning, and the Program in Science, Technology, and Society. The subjects can be grouped into air and water quality; pollution control; water, ocean, and energy resource management; public policy and planning for the environment; and the impacts of technology on the environment. In addition, many departments offer other educational and research opportunities in specific areas of the environment closely related to their own disciplines.

Undergraduates whose interests span more than one discipline may arrange a coordinated program of interdisciplinary environmental study by entering one of the unspecified degree programs sponsored by many of the departments. Undergraduate students who have a disciplinary commitment but desire a coherent minor program of environmental study may do so through use of the unrestricted electives available to them. Further information, lists of departmental advisors, and subjects offered on environmental issues are available through the Office of the Provost, Room 3-234, MIT, Cambridge, Massachusetts, 02139.

Experimental Study Group (ESG)

The Experimental Study Group is open to any freshman interested in participating in a self-directed study program within a small, individualized learning community. ESG provides the opportunity for freshmen to explore and receive credit for their own academic interests (including standard freshman subjects) without many of the constraints on time, subject material, and learning methods that the regular curriculum imposes. The teaching staff is drawn primarily from the Departments of Physics, Mathematics, Chemistry, and the School of Humanities and Social Science, and includes graduate students, instructors, and professors. The informal learning process for freshmen is strongly supported by the innovative and extensive use of undergraduate tutors.

Once students join ESG, they decide on a course of studies with the assistance of ESG advisors with whom they meet regularly throughout the term. Different styles of learning chosen by students in the past have included independent study, tutorials, self-paced materials, and small seminars and study groups. Freshmen are able to take one or two courses in the regular curriculum along with their studies in ESG. As sophomores, they can take up to half of their courses in ESG. Some students stay on to become tutors to the new freshmen or to participate in various community activities. In ESG, staff members, freshmen, upperclassmen, and alumni all share in a process of personal and intellectual growth. Throughout the program's 12 years of existence, the emphasis on personal interaction has made ESG a unique part of MIT.

Further information is available from the Experimental Study Group, Room 24-612, MIT, Cambridge, Massachusetts 02139, (617) 253-7786.

Interdisciplinary Research Opportunities

The Undergraduate Research Opportunities Program (UROP) provides undergraduates the opportunity to participate with MIT faculty and staff members in a wide range of research activities both on and off campus. Students may participate in ongoing research, or find a faculty sponsor for a self-originated project. The first several pages of the *Student Research Opportunities Directory*, published each year, give details on how to get started. Students are urged to read this before they embark on a project. Information on some current projects is posted on the UROP bulletin board in the main corridor of the Institute, and in the UROP Office, Room 20B-141. New listings are announced each week in *Tech Talk*. Further information may be obtained by contacting the staff at the UROP Office, (617) 253-5049.

Students interested in research also may contact various laboratories and centers directly. For information about the many organizations and facilities which provide opportunities in interdisciplinary research, see the descriptions under Research Opportunities in Interdepartmental Laboratories, Centers, and Programs in the *Directory* and in this chapter.

Interdisciplinary Science Degree Program (S.B.)

In addition to the S.B. degree programs offered by the Departments of Biology, Chemistry, Earth and Planetary Sciences, Mathematics, and Physics, the Interdisciplinary Science Program is sponsored by the School of Science. The program leads to a degree of Bachelor of Science without designation of field, and is intended to provide special opportunities for students interested in interdisciplinary fields such as astronomy, meteorology, oceanography, environmental sciences, medical science, nutrition and food science, or in programs which differ significantly from established departmental offerings. Each student is able to arrange the curriculum in consultation with the faculty advisor, subject to the

approval of a faculty committee. This committee, which includes representatives from all departments of the School of Science, will also help students to find suitable advisors.

Further details of the program, including a listing of curriculum requirements for this degree, are given at the end of the School of Science section of this catalogue. The faculty member in charge of this program is Professor John M. Buchanan; Room 6-219, (617) 253-5723.

Joint Degree Programs in Humanities and Engineering and Humanities and Science, Option 2 (S.B.)

These two programs are designed for students with an active interest in the relationship between humanistic and scientific/technical knowledge. The major is centered on a rigorous system of reading seminars and required subjects in relational studies. In addition, each student assembles a group of elective subjects which provides substantial experience in both humanities and science/technology, not necessarily restricted to a single discipline on either side.

More detailed descriptions of these programs, including outlined courses of study, are included in the Department of Humanities description in this catalogue.

Further information may be obtained by contacting Professor Travis R. Merritt, Room 14N-305, MIT, Cambridge, Massachusetts 02139, (617) 253-4447; Professor Louis L. Bucciarelli, Room 20D-210, 253-4061; or the Course XXI Office, Room 14N-305, 253-4446.

Law-Related Studies

Students who want to acquire knowledge of the legal aspects of their field while still undergraduates, find out more about the legal profession, or learn about our legal heritage, structure, and processes as a part of a general education, may do so through a wide range of undergraduate or graduate subjects, seminars, and fieldwork opportunities. Among the over 30 law-centered subjects in 10 departments are syllabi covering the American legal structure, the judicial process, constitutional history, and legal aspects of planning, management, environmental affairs, and various fields of engineering, including an Introduction to Law and Technology.

In recent years, a substantial number of MIT undergraduates from nearly every department have gone on to law school. The technically oriented undergraduate training serves students well in law school, and the combination appears to fill an important societal need as our technological world becomes progressively more regulated. In addition to the above subjects, there is a series of open seminars, held several times a year, designed to acquaint students with what lawyers actually do. Field research and work opportunities offer other means for testing an interest in the law. Last year an estimated 90 undergraduates worked off campus in law-related research or other activities, including a summer Urban Legal Studies Program.

The Office of Preprofessional Advising and Education, Room 10–186, (617)253-4158, and members of the Pre-law Advisory Council provide guidance and information for students interested in going to law school. They and the Coordinator of Law-Related Studies also have additional information regarding the Law-Related Studies Program at MIT.

Mineral Resource Studies

Study of many aspects of mineral resources is possible through a variety of programs and laboratories. Related activities may be found in the Departments of Materials Science and Engineering, Chemical, Civil, Mechanical, and Ocean Engineering, Earth and Planetary Sciences, Economics, Political Science, and the Sloan School of Management. Departments offer educational and research (UROP) opportunities in the fields which are related to their own disciplines. A student's interest often can be met through a minor program with the use of available electives.

Information on department advisors and special programs of study, and on issues of importance relating to mineral resources, is available at the Mining and Minerals Resources Research Institute, Room 4-140, MIT, Cambridge, Massachusetts 02139.

Science, Technology, and Society

The Program in Science, Technology, and Society focuses on the ways in which scientific, technological, and social factors interact to shape modern life. It traces the impact of scientific ideas and technological practices on society and culture and examines the role of social, political, and cultural considerations in shaping developments in science and technology. The Program's aim is to provide students with a better understanding of the human ramifications of science and engineering and to help them think more realistically and creatively about intellectual, moral, and social issues related to scientific and technological change.

The Program, which is the developmental phase of a prospective College of Science, Technology, and Society, draws its faculty from the social and natural sciences, engineering, and the humanities. The STS curriculum is organized around five general areas of inquiry: 1) the history of science; 2) the history of technology; 3) contemporary issues in science, technology, and society; 4) science, technology, and the organization of industrial society; and 5) cultural dimensions of science and technology. Subject offerings examine such topics as the influence of ethical and political values on the work of scientists and engineers; the ways in which scientific concepts and ideas have contributed to the development of modern Western culture; how technological changes have altered the character of human work and affected the relationships people form with machines; and what constraints and areas of choice are created by the technologies of advanced industrial societies.

All STS undergraduate subjects can be counted toward the Institute Requirement in the Humanities, Arts, and Social Sciences; several Distribution subjects are offered, and Science, Technology, and Society can be chosen as a Field of Concentration. Although at present there is no undergraduate major in Science, Technology, and Society, special versions of the Humanities and Engineering and Humanities and Science majors in Course XXI are available for students who wish to integrate rigorous study in science or engineering with a systematic understanding of an area of humanistic knowledge.

A more detailed description of the Program is given in the School of Humanities and Social Science section of this catalogue. Further information may be obtained from the Director's office, Room E51-113, MIT, Cambridge, Massachusetts 02139, (617) 253-4062.

Special Interdisciplinary Programs in Humanities

The School of Humanities and Social Science offers a number of special subjects and programs of an interdisciplinary nature. Descriptions of the various interdisciplinary programs can be found under the Department of Humanities in this catalogue.

Study and Research in Education

The Division for Study and Research in Education focuses on fundamental questions about human learning. Major themes are individual learning, institutional learning, and educational technology. Issues which underlie these major themes are: how does the learner construct a mental representation affected by the learning context (which might be technological), and how do these constructions affect what is learned. This approach to learning stresses the interrelationship of content and context and raises even more fundamental questions about the relationship between language, thought and action.

The Division offers several elective subjects for undergraduate and graduate credit. As far as possible, students enrolled in each of these subjects will be involved in practical as well as theoretical work.

The Division for Study and Research in Education does not offer an undergraduate major in education. However, subjects offered in the Division (and many other subjects treating a wide variety of topics in education and offered in a number of MIT departments) are available as electives for undergraduates interested in educational issues. Students especially interested in secondary school teaching should also see *A Handbook for Students Interested in a Career in Education*, prepared by the Committee on Preprofessional Advising and Education and available in Room 10-186. Further information may be obtained from the Education Division Administrative Officer, Marion Wasserman, Room 20C-126A, MIT, Cambridge, Massachusetts 02139, (617) 253-7362.

Undergraduate Seminars

The Undergraduate Seminar Program offers an opportunity for students to interact with faculty members in small, informal class settings. Seminars vary tremendously both in style and topic, some being oriented around small, informal class discussions while others may bring in speakers, go out on field trips, or involve extensive laboratory projects. Many of the topics are interdisciplinary, some being taught jointly by members of several departments; some others are topics of interest to faculty outside of their department's usual scope, so it is helpful to look through all of the offerings for topics that may be of interest.

For more details about the program, including titles and descriptions of seminars, see the *Undergraduate Seminar Booklet* issued twice yearly. This publication is available from the Undergraduate Seminar Office, Room 7-105, MIT, Cambridge, Massachusetts 02139, (617) 253-3621.

Unspecified Degree Programs (S.B.)

In a number of departments it is possible to take a less intensive "major," leading to a degree which does not specify a professional field. For such a degree without specification, the student registers in the normal way in the department chosen. Given the added flexibility of an unspecified degree program and with appropriate advice from the home department and from other departments, a student can find in such a program a valuable opportunity for interdepartmental study.

Graduate Interdepartmental Opportunities

Acoustics

Acoustical study and research activities are carried out at MIT within the Departments of Mechanical Engineering, Ocean Engineering, Electrical Engineering and Computer Science, Aeronautics and Astronautics, and Architecture.

In the main, the acoustical work within each department is in support of the "main-line" activities within the department such as communications, machine design, propulsion and guidance, and structural design. Most acoustical studies are interdepartmental in the sense that the subjects of instruction have few prerequisites and can be readily taken by students from any department. It is possible to set up more specialized interdepartmental programs of study and research in acoustics. One mechanism is the unspecified Master's degree in Engineering or Interdisciplinary Science. Another possibility is to enter the doctoral program of one of the departments and to establish a special faculty committee with representatives of the appropriate departments for the program. The degree received may be departmental, or designate a specialty in acoustics.

Acoustics subjects fall generally within three categories. The first of these consists of basic subjects at both undergraduate and graduate levels. Beginning acoustics subjects are taught within the Departments of Electrical Engineering and Computer Science, Mechanical Engineering, and Architecture. A second group of subjects is in support of the various research activities in acoustics. These include subjects in speech communication, neural physiology and perception of speech, sound vibration and wave propagation, aerodynamic noise, and medical ultrasonics. A third set of subjects are in the "professional practice" category, and include noise control, architectural acoustics, and sonar applications. A complete listing of these subjects is contained in the brochure *Acoustics at MIT.*

Students wishing further information regarding interdepartmental programs in acoustics should contact Professor Richard H. Lyon, Department of Mechanical Engineering, Room 3-366, MIT, Cambridge, Massachusetts 02139, (617) 253-2214.

Biomedical Engineering (Ph.D., Sc.D.)

The interdepartmental program in Biomedical Engineering focuses on engineering, the physical sciences, and mathematics as they relate to human biology and medicine; it leads to a doctoral degree. These curricula are aimed at developing biomedical engineers who can function well in both the fields of engineering and life sciences, as, for example, bioengineers concerned with control systems, and with instrumentation for life support mechanisms; biomaterials scientists interested in developing materials for artificial organs and prosthetic devices; experts in fluid flow who are seeking a deeper understanding of how the cardiovascular system functions; and systems engineers interested in designing automated laboratories, model emergency rooms, operating rooms, and patient facilities that utilize the advantages afforded by modern science and technology.

A guide to Biomedical Engineering and Physics at MIT and Harvard describes both educational programs and research activities. Copies are available from Professor L. R. Young, Room 37-207, MIT, Cambridge, Massachusetts 02139, (617) 253-7805.

Cognitive Science

Research and training in cognitive science are pursued within and across departments at MIT through the Center for Cognitive Science. Subjects appropriate for training in cognitive science are offered in Electrical Engineering and Computer Science, Linguistics and Philosophy, and Psychology, and also in the Division for Study and Research in Education. No formal interdisciplinary degree program is offered at present. Graduate students who wish to have information or guidance about available resources across departments should consult members of the Committee on Graduate Studies in the Cognitive Sciences. Its members are: Professors Jonathan Allen, Electrical Engineering and Computer Science, Room 36-575, (617) 253-2509; Sylvain Bromberger, Linguistics and Philosophy, Philosophy Section, Room 20D-105, 253-2645; S. Jay Keyser, Linguistics and Philosophy, Linguistics Section, Room 20D-105, 253-4141; Mary C. Potter, Psychology, Room E10-032, 253-5526; and Daniel Osherson, (Chairman), Psychology, Room 20C-103, 253-7367.

Communications Policy

Rapid technological change and the critical importance of communications to society have combined in recent years to generate intense concern with policy making in this area. This interdisciplinary field which draws on engineering, economics, policy analysis, legal studies, management, political science, and the sociology of communications effects is an area of active study and research at MIT. There is at present no formal degree program in communications policy. Students enroll in the degree program of the department most closely associated with their intellectual interests and professional plans. In recent years these have included the Departments of Electrical Engineering and Computer Science, Political Science, Economics, the Sloan School of Management, and the School of Architecture and Planning.

The Research Program on Communications Policy is a collaborative effort between the Center for International Studies, the Center for Policy Alternatives, the Center for Advanced Engineering Study, the Laboratory for Information and Decision Systems, and the Laboratory for Computer Science. Program faculty are available to advise interested students in the design of their course of study, to put them in touch with ongoing research activity at the Institute, and to help with professional placement. Recent dissertations and faculty research associated with the program have included

studies of the politics of spectrum allocation, policy making in the French television system, satellite communications, the social impact of the telephone, telecommunications facilities in rural Egypt, and Federal regulation of cable television.

The Program publishes an interdisciplinary course list, organizes seminars on special topics usually involving participants from government and industry as well as the Institute, and publishes an annual report describing recent and upcoming research and teaching activities concerned with communications policy. For further information contact Professor Ithiel de Sola Pool, Director, Research Program on Communications Policy, Room E53-401, MIT, Cambridge, Massachusetts 02139, (617) 253-3124.

Economics and Urban Studies (Ph.D.)

A Ph.D. is offered jointly by the Departments of Economics and Urban Studies and Planning at MIT. The Joint Program recognizes the interrelationship between the analytical aspects of policy questions and research opportunities in economics, and the institutional and policy orientation of urban studies. It has been recognized that both research and active intervention into urban problems benefit from the broadening of perspectives and institutional sophistication and the deepening of analytic penetration that a coordinated exposure to the two disciplines offers. This approach thus opens up a wider variety of career challenges than is available to specialists of either field alone. Students desiring to enter the Program must be admitted to both departments and then explicitly to the Joint Program. The Program is administered by a standing interdepartmental committee. Further information may be obtained from Professor Jerome Rothenberg, Room E52-355, MIT, Cambridge, Massachusetts 02139, (617) 253-2674, or from Professor William C. Wheaton, Room 10-403, 253-1723.

Energy Study and Research

All of the Schools at MIT traditionally have had graduate programs that prepare students for careers in the energy field. These programs have received increased emphasis in recent years and there are many opportunities for students interested in all aspects of energy science, engineering, management, and policy. While the Energy Laboratory provides a focus for energy research at the Institute, a great deal of energy-related work is also under way in other centers and laboratories, and in the academic departments.

Students interested in graduate work in the energy field should first gain admission to the academic department whose program best matches their background and interests. An individualized program of advanced study and research can be arranged by a balance of fundamental subjects and interdisciplinary subjects that deal with diverse aspects of energy supply, utilization, and policy, and by selection of an appropriate thesis topic. Energy advisors have been appointed in each department to provide information on elective subjects, degree programs, and research opportunities. A brochure containing further information and the list of advisors is available from the Office of the Dean of Engineering, Room 1-206, MIT, Cambridge, Massachusetts 02139.

Environmental Studies

Environmental studies for graduate students at MIT are available through a variety of departmental and interdepartmental subjects and laboratories. Through its several departments, the School of Engineering sponsors the degree of Environmental Engineer. The Energy Laboratory, an interdisciplinary, mission-oriented laboratory, supports research on environmental issues which cross academic departments and Schools. The Program in Technology and Policy promotes careers in the development and implementation of policies for the productive use and control of technology. Major research with opportunities for graduate study in environmental policy and impact assessment is undertaken by the Laboratory of Architecture and Planning and the School of Architecture and Planning. There also are opportunities in the environmental area under the auspices of the joint programs of MIT and the Woods Hole Oceanographic Institution.

Many departments offer educational and research opportunities in those aspects of the environment which are closely related to their own disciplinary interests. Graduate students may also arrange special programs with the help of their advisors, and they may pursue interdepartmental programs leading to advanced degrees under the auspices of the Dean of the Graduate School. The courses of study available at MIT include: air and water quality; pollution control; water, energy, and ocean resource management; public policy and planning for the environment; and the impacts of technology on the environment. See environmental listings under individual departments for more specific information.

Information concerning environmental education and research activities at MIT is centered in the Office of the Provost, which works with faculty members and appropriate centers and laboratories. Further information and lists of departmental advisors are available through this office, Room 3-234, MIT, Cambridge, Massachusetts 02139.

Joint Program in the Management of Technology (S.M.)

The Joint Program in the Management of Technology is a new, 12-month Master's Program, offered jointly by the School of Engineering and the Sloan School of Management, focusing on management principles for technical people in a technical environment. It is designed for scientists and engineers who, for the near future, plan to remain on the technical side of the organization rather than to move into general management positions, yet who are on a career path requiring increasing managerial responsibilities for technical activities. The rigorous, 12-month curriculum, developed and

taught by faculty from both Schools, leads to a Master of Science in the Management of Technology and covers three elements that integrate readily toward overall Program objectives:

1
Underlying core subjects in management principles and analytic methods;

2
In-depth studies on management of technical programs and organizations;

3
A thesis relating to the management of technical programs and organizations.

Enrollment in the Joint Program in the Management of Technology is for the term beginning in June. Minimum requirements for application include an undergraduate degree in science or engineering and at least five years' work experience in industry or government in a technical capacity. In addition, all applicants should have completed formal courses in differential and integral calculus and in macro- and microeconomic theory prior to enrollment. Applicants must first be accepted by the Admissions Committee of the Joint Program, and are then admitted to MIT through either the Sloan School or through one of the participating Engineering School departments: Aeronautics and Astronautics, Civil Engineering, Materials Science and Engineering, Mechanical Engineering, Nuclear Engineering, or Ocean Engineering.

Director of the Joint Program is Edward B. Roberts, David Sarnoff Professor of the Management of Technology; Deputy Director is J. Herbert Hollomon, Japan Steel Industry Professor of Engineering and Director of the Center for Policy Alternatives.

Detailed information on application requirements and procedures and a complete description of Program objectives and curriculum are available from the Program Manager, Jane M. Morse, Room E52-533, MIT, 50 Memorial Drive, Cambridge, Massachusetts 02139, (617) 253-3733.

Law-Related Studies

MIT graduate students with interests in the legal or public policy aspects of their field can find a number of subjects, research projects, and people at MIT concerned with law. There are subjects in the American legal structure and the judicial process, graduate seminars, and associated research in the legal aspects of the environment, urban planning, ocean resources, planning for legal institutions, construction, transportation, industrial safety, and computer science fields. In some areas, work is undertaken collaboratively with law schools in the area. In addition to several lawyers on the teaching staffs of five different departments, there are lawyers on the administrative staff with experience in a variety of fields which they are willing to share with students.

Mineral Resources Engineering and Management (S.M. Eng., Ph.D.)

The MREM program provides formal educational opportunities to students with interests in the mineral resources field, ranging from mining and processing to resource allocation and policy setting. The combination of academic subjects and research from the entire Institute makes it possible to offer programs in several areas of concentration, through which students are able to pursue a variety of careers in the mineral resources field. The MREM program is a part of the Mining and Mineral Resources Research Institute at MIT, which coordinates activities in the mineral resources field. Studies in the MREM program can lead to the Engineer, Ph.D., or Master of Science corresponding to the department of registration.

The MREM program consists of four subprograms in exploration, extraction, processing, and resource management. The exploration subprogram exposes students to the geological, technical, and decision theoretical aspects of exploration. The student thus will become familiar with the important levels of planning and performing mineral exploration. The extraction subprogram provides a background for design of surface or underground mines, selection and development of mining machinery, management of large projects, and resolution of environmental problems. The processing subprogram deepens the student's physical and chemical education and, based thereupon, leads to the analysis and design of industrial processes including their managerial and environmental aspects. The resource management subprogram encompasses the widest range of all the subprograms. Appropriate aspects of systems engineering, economics, and public policy are covered, as well as problems of substitution and of related resources (water, energy). Depending on the student's inclination, the emphasis of the resource management subprogram can be placed on engineering, management, or public policy. The resource management subprogram also provides the framework for an MREM general overview, which is aimed at students desiring a broader education. Such students would take resource management subjects and selected subjects from the other three subprograms.

In studying for the Master of Science, a student usually will take at least 75 percent of the required credit units from one of the subprograms and the remaining credit units from one of the other subprograms. Engineer and Ph.D. students usually will concentrate at least half of their credit units in one of the subprograms and take the remaining credit units from at least two of the other subprograms. Research projects that are suitable for thesis work are conducted in most of the participating departments.

Students desiring to pursue their studies in the MREM program should apply for admission to graduate studies in the department best suited to their interests. This can be in the department in which most of the subjects will be taken, the department in which the thesis research will be conducted, or the department corresponding to the student's prior education. Students will be awarded the graduate degree in this department.

The participating departments are: Civil Engineering, Mechanical Engineering,

Materials Science and Engineering, Chemical Engineering, Urban Studies and Planning, Earth and Planetary Sciences, Ocean Engineering, Economics, Management, and Political Science.

A prospectus containing detailed information on the MREM program, including listings of academic subjects in each of the subprograms, possible research areas, and the MREM faculty contacts in each of the participating departments, may be obtained from Professor Herbert H. Einstein, Room 1-330, MIT, Cambridge, Massachusetts 02139, (617) 253-3598.

Oceanography and Oceanographic Engineering (Eng., Ph.D., Sc.D.)

MIT and the Woods Hole Oceanographic Institution (WHOI) on Cape Cod offer joint programs of graduate study and research for students with special interests in biological oceanography, chemical oceanography, marine geology, marine geophysics, oceanographic engineering, and physical oceanography. These graduate programs are administered by committees drawn from the faculty and staff of both institutions. Students accepted to the Joint Program have access to the extensive intellectual and physical resources available for advanced study at both WHOI and MIT.

The Joint Program involves several departments at MIT — Biology, Earth and Planetary Sciences, and Meteorology and Physical Oceanography in the School of Science and Chemical Engineering, Civil Engineering, Electrical Engineering and Computer Science, Materials Science and Engineering, Mechanical Engineering, and Ocean Engineering in the School of Engineering. Details concerning entrance requirements, examinations, financial aid, etc. may be found in the descriptions of each individual department and the description following the School of Engineering and the School of Science sections of this catalogue. Information on the overall Joint Program may be obtained from the Dean of Graduate Studies, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts 02543, or from the Joint Program Office, Room 54-912, MIT, Cambridge, Massachusetts 02139.

The Department of Earth and Planetary Sciences and the Department of Meteorology and Physical Oceanography offer programs with the Woods Hole Oceanographic Institution in **chemical oceanography, marine geology, marine geophysics,** and **physical oceanography.** The programs are coordinated by either department and may involve research in other departments at MIT, such as Chemistry. The programs all lead to the Doctor of Philosophy or the Doctor of Science.

Programs in **biological oceanography** are offered jointly with the Woods Hole Oceanographic Institution and lead to the Doctor of Philosophy or Doctor of Science. The programs are coordinated by the Department of Biology and may involve research at WHOI, or other departments at MIT such as Nutrition and Food Science. Program requirements are tailored to individual needs and include preparation in basic areas of biology and marine ecology.

The Departments of Chemical Engineering, Civil Engineering, Electrical Engineering and Computer Science, Materials Science and Engineering, Mechanical Engineering, and Ocean Engineering offer joint programs in **oceanographic engineering** with WHOI. These programs lead to the Engineer, the Doctor of Philosophy, or the Doctor of Science. Students interested in oceanographic engineering, oceanography-related engineering problems, engineering in the ocean, or the control of the ocean and its resources can be served by the Joint Program in Oceanographic Engineering.

Operations Research (S.M., Ph.D.)

The Operations Research Center, established in 1953, provides educational and research opportunities for students and faculty interested in the interdepartmental field of operations research. Varied programs leading to the master's and doctoral degrees with emphasis on either applied or theoretical areas are available. Students usually take a core of basic subjects which provide sound understanding of operations research methodology. This allows considerable flexibility to continue into theoretical research or to begin any of a variety of applications. Current areas of active theoretical research include mathematical programming, decision analysis, and stochastic systems. Areas of application include both industrial and public problems. Industrial applications include production and distribution systems and marketing. Public systems applications encompass health services, police operations, housing, energy, and transportation. In most applications emphasis is laid on the successful integration of field data and measurements with mathematical models and computers to assist managerial decision making.

The doctoral program in operations research provides a strong background in the theoretical foundations of operations research and the techniques used to develop and analyze mathematical models of complex systems arising in economic, social, and physical contexts.

Entering students wishing to concentrate specifically in operations research at the doctoral level may apply directly to the interdepartmental doctoral program. This can be done by inserting the phrase "Operations Research — Interdepartmental Program" at all places in the admissions materials which require filling in "Department of____ ." The assignment of a formal department of registration for these students is arranged by the Operations Research Center, and the supervision and administration of the entire doctoral program is provided by an interdepartmental committee on operations research.

Doctoral candidates wishing to enter a specific department, either because they wish to combine substantial content in some specific field with their operations research study or because they are uncertain as to their interests at the time of application, should apply to the academic department of their choice. These students may wish to pursue graduate pro-

grams within their departments while taking subjects related to operations research and engaging in research which uses methods of the field. Or, during the first or second year of their graduate program, they may decide to apply for admission to the interdepartmental doctoral program in operations research. Subsequent steps to the attainment of the doctoral degree are the same as for people entering directly.

The master's program in operations research prepares students for professional work in a broad variety of public and private institutions. A person takes a core of basic theoretical materials and adds specialized subjects to suit particular educational objectives. Individuals wishing to specialize specifically in operations research should insert "Operations Research — Interdepartmental Program" at appropriate places in the admissions materials as described above. Students seeking a departmental master's degree with relatively less emphasis on operations research should apply to the department of their choice.

The Operations Research Center is particularly interested in minority and women applicants. The Center offers research and teaching assistantships in most of the fields in which the Center is active. Further information on financial assistance and on admissions procedures in general may be obtained by writing directly to the Operations Research Center, Room 24-215, MIT, Cambridge, Massachusetts 02139, or by calling (617) 253-3601.

Polymeric Materials

Polymeric materials span a remarkable range of structures and properties, presenting a diversity of challenges and opportunities for several interacting disciplines. Considering both the fundamentals and technology involved, polymer science and engineering is now one of the most rapidly expanding areas in the field of materials. Polymers can exist in various combinations of amorphous and crystalline states, leading to properties that may be described as rubbery or glassy, strong or weak, tough or brittle. They also exhibit unique rheological behavior which permits the processing into many forms, including fibers, films, and composite materials.

Interdepartmental graduate degree programs focusing on polymeric materials are available to students enrolled in polymer-related departments. For example, a student may register in the Department of Civil Engineering, Mechanical Engineering, Materials Science and Engineering, or Chemical Engineering, and have his or her program of classwork and research specially arranged in consultation with an ad hoc interdepartmental committee chosen for the purpose. This procedure allows for a high degree of flexibility, depending on the candidate's central interests.

In addition to the core subjects in the program, students may concentrate in one or more areas related to polymers, such as synthesis, processing, characterization, structure-property relationships, surface phenomena, biopolymers, fiber technology, and composites.

More specific information concerning interdepartmental study and research on polymeric materials may be obtained from Professor F. J. McGarry, Departments of Civil Engineering and Materials Science and Engineering, Room 8-209, MIT, Cambridge, Massachusetts 02139, (617) 253-7172; Professor A. S. Argon, Department of Mechanical Engineering, Room 1-306, 253-2217; Professor D. R. Uhlmann, Department of Materials Science and Engineering, Room 13-4005, 253-6895; or Professor E. W. Merrill, Department of Chemical Engineering, Room 66-562, 253-4593.

Power Engineering

Academic and research programs in power engineering exist on an interdepartmental basis in the Departments of Aeronautics and Astronautics, Electrical Engineering and Computer Science, Mechanical Engineering, Ocean Engineering, and Nuclear Engineering. These programs cover a diversity of energy-related issues.

Research in power systems is carried on by individual professors in various departments as well as at the Gas Turbine Laboratory, Electric Power Systems Engineering Laboratory, Sloan Automotive Laboratory, Energy Laboratory, Engineering Projects Laboratory, Heat Transfer Laboratory, Cryogenics Laboratory, and at the Nuclear Reactor.

A student enrolled in any department may construct from among various subject offerings and research activities an academic program and thesis research which he or she wishes to pursue. In addition to subjects treating specific topics in power engineering, many other related subjects are available on such topics as thermodynamics, fluid mechanics, heat transfer, control theory, materials, stress analysis, vibrations, cryogenics, and combustion.

Research assistantships are available for graduate students, and some part-time employment is available for undergraduates. For further information on the programs and on financial support, the Graduate Registration Officer of one of the participating departments should be contacted.

Science, Technology, and Society

The Program in Science, Technology, and Society focuses on the ways in which scientific, technological, and social factors interact to shape modern life. It traces the impact of scientific ideas and technological practices on society and culture and examines the role of social, political, and cultural considerations in shaping developments in science and technology. The Program's aim is to provide students with a better understanding of the human ramifications of science and engineering and to help them think more realistically and creatively about intellectual, moral, and social issues related to scientific and technological change.

The Program, which is the developmental phase of a prospective College of Science, Technology, and Society, draws its faculty from the social and natural sciences, engineering, and the humanities. The STS curriculum is organized around five general areas of inquiry: 1) the history of science; 2) the history of technology; 3) contemporary issues in science, technology, and society; 4) science, technology, and the organization of industrial society; and 5) cultural dimensions of science and technology. Subject offerings examine such topics as the influence of ethical and political values on the work of scientists and engineers; the ways in which scientific concepts and ideas have contributed to the development of modern Western culture; how technological changes have altered the character of human work and affected the relationships people form with machines; and what constraints and areas of choice are created by the technologies of advanced industrial societies.

STS offers several graduate-level subjects jointly with other MIT departments, but does not yet have a formal graduate program. Graduate students who wish to pursue questions concerning interactions among science, technology, and society are encouraged to consult with STS faculty members about the variety of arrangements which can be made to meet their needs and interests. Students can participate in research and reading seminars, become involved in faculty research projects, and, with departmental permission, structure a special field of study or minor in STS as part of their degree program. Individually tailored interdepartmental degree programs also can be arranged.

A more detailed description of the Program is given in the School of Humanities and Social Science section of this catalogue. Further information may be obtained from the Director's office, Room E51-113, MIT, Cambridge, Massachusetts 02139, (617) 253-4062.

Statistics

Research and training in statistics are pursued within and across departments at MIT and through the Statistics Center. Subjects in statistics are offered primarily in Mathematics, Management, and Economics.

Current areas of active theoretical research include sequential analysis, robust regression, log-linear models, time-series analysis, detection of influential data, cluster analysis, information retrieval, and statistical computing and graphics. Areas of application include nuclear reactor safety, energy demand models, toxicology, environmental statistics, fingerprint analysis, weather prediction, clinical trials, reliability of econometric models, and the analysis of actuarial data.

Varied programs leading to interdepartmental master's and doctoral degrees with emphasis in either applied or theoretical areas are available.

Further information may be obtained by contacting the Statistics Center, Room E40-140, MIT, Cambridge, Massachusetts 02139.

Study and Research in Education (Ph.D.)

The Interdisciplinary Ph.D. program offered by the Division for Study and Research in Education, jointly with MIT's other academic departments, is open to graduate students interested in research and professional careers in fields related to education. (Currently, graduate students in the Division have joint programs with the Departments of Electrical Engineering and Computer Science, Management, Mathematics, Psychology, and Urban Studies and Planning.)

Through the Interdisciplinary Ph.D. Program the Education Division encourages new developments in education research by students who wish to take substantial initiative and responsibility for shaping their programs of study and research. Insightful research in education requires a combination of skills from many disciplines; professionals need competence in the subject matter to be taught (architecture, chemistry, history, mathematics, physics, etc.), knowledge about the nature of thinking, and insight regarding the nature of educational settings. Underlying questions are: how does the learner construct a mental representation of what is to be learned, how is this representation affected by the learning context, and how do these constructions affect what is learned? The Division's approach to education research stresses the interrelationship of content and context, and raises even more fundamental questions about the relationship between language, thought and action.

The training of education researchers and practitioners requires combinations of theoretical and practical work, and the development in the individual of new syntheses of fields which are appropriate to his or her specialty.

For admission to the Interdisciplinary Ph.D. program, applicants must be qualified for admission according to the regular criteria of the MIT academic department to which they jointly apply and acceptable to the Education Division's Admissions Committee.

The Committee is interested in the student's overall academic record, professionally related experience, and intended course of study. The Committee looks for indication that the student's proposed course of study can be pursued adequately at MIT and for evidence that a particular candidate will be able to design and follow an effective strategy of inquiry. For these reasons, the Admissions Committee reads with great care the personal statement of the applicant. This statement should be a thorough and detailed

discussion of the applicant's experience, thinking, and professional objectives; and as specifically as possible, his or her chief academic interests.

The MIT Graduate School application material, together with a statement of interest in the program and career objectives, should be submitted to the Admissions Office, Room 3-108, MIT, Cambridge, Massachusetts 02139. Application for financial aid should accompany the admissions application. Following concurrent department and program acceptance, applicants will be notified before April 1 of admission to the program for the subsequent year.

Following established procedure for interdepartmental graduate programs, the Dean of the Graduate School will appoint a faculty committee to supervise all aspects of the Ph.D. program for each student. This committee will include representatives from the student's department of registration and the DSRE. Each student is expected to present a thesis in education or interdisciplinary research. The Ph.D. will be awarded through the student's department on recommendation of his or her faculty.

Further information may be obtained by contacting the Dean of the Graduate School, Room 3-134, or the Education Division Administrative Officer, Marion Wasserman, Room 20C-126A, (617) 253-7362.

Technology Adaptation Program

The Technology Adaptation Program (TAP) provides educational and research opportunities for Master's candidates who are interested in the transfer and adaptation of the technologies of their own areas of specialization to the needs of developing countries.

Students who elect this program submit a proposed program for approval to the TAP Policy Committee. This program includes the subjects required for the chosen area of concentration, and at least one subject which deals with management techniques of special importance to developing countries; at least one graduate subject in economics which includes material related to the needs of developing countries; at least one subject in the social sciences area which deals with the structures required to support the application of technologies in developing countries; and at least one graduate subject in an engineering area related to the transfer, adaptation, and/or development of new technologies for developing countries.

Students' proposed thesis topics also require approval of the TAP Policy Committee, as well as of the departments in which the students are registered.

Students interested in working on TAP projects who cannot fulfill all the requirements of the program may be accepted for participation provided they submit a statement with the program proposal which describes the circumstances which, from their point of view, make the deviation justifiable. Each case is judged on its own merits.

Students who elect this program should note that depending upon the number of subjects required for their area of specialization, the total units required for graduation may be higher than the 66 units minimum required by the Institute.

Students may receive financial support in the form of research assistantships associated with current TAP research projects.

A list of these projects and/or further information about the program may be obtained by contacting the TAP Administrative Office, Room 39-525, MIT, Cambridge, Massachusetts 02139, (617) 253-7227.

Technology and Policy (S.M.)

The Program in Technology and Policy is an educational program that promotes careers in the development and implementation of policies for the productive use and control of technology. It is unique in the opportunities it affords students for pursuing their own educational program from a strong basis in engineering and science.

Broadly speaking, the Program educates "engineers with a difference," that is, persons with strong technical foundations and competence in dealing with policy issues.

Challenging jobs are open to men and women who combine a base in technology with skills in identifying, analyzing, and implementing policy issues. Former Technology and Policy students now fill important positions in private industry, Federal, state, and local government, and in independent consulting. Many are also working on the problems of developing areas.

Students may study problems of interest in any of the fields of technology. These cover a wide range, reflecting the concerns of faculty and staff at MIT. The following issues now under investigation suggest some possibilities:

— How should pollution by toxic chemicals be controlled? When is it technically efficient to intervene in the cycle of use, and what legal or economic restraints are effective?

— How can energy consumption be reduced through materials recycling, and how would this policy be implemented? What are the technical, economic, and political trade-offs of different strategies?

— What kind of international arrangements might lead toward a sound development of marine resources in petroleum and minerals?

— What are the effects of government research and development policies on industrial innovation?

The Program leads to a Master of Science in Technology and Policy from which graduates may enter directly into public or private practice. Alternatively, they may elect to continue graduate or professional study at MIT or elsewhere.

The Program provides a supportive context for its students, and encourages close interaction. The size of the Program helps — about 30 students enter each year. We anticipate and operate on the expectation that all new students are highly qualified and will do well in their courses at MIT. We encourage collegial and cooperative relationships, not competitive ones.

The Program develops proficiency in policy analysis and implementation for technological problems. This requires 1) an advanced competence in a specific technological area of the student's choice, 2) skills in policy analysis, 3) an understanding of the context of policy issues, and 4) project and thesis work in bringing the above together.

Students either take or demonstrate competence (on the basis of prior courses or experience) in 1) a concentration of advanced subjects in a chosen field of technology, 2) intermediate subjects in systems analysis and economics, and 3) subjects in law and political processes. Academic credit is routinely granted for comparable studies elsewhere.

Individual curricula are developed by students in consultation with their faculty advisors. Students are encouraged to take full advantage of the wide range of subjects available at MIT in arranging programs of study appropriate to their aspirations and interests. To provide a common base of development for all participants in the Program, students are generally expected to enroll in the following subjects: TPP 21J/1.146J/2.192J/3.56J/13.62J Engineering Systems Analysis; TPP 11 and TPP 12 Project Proseminar in Technology and Policy; TPP 13J Engineering Policy Thesis Seminar; 14.120 Microeconomic Theory or 15.012 Applied Micro and Macroeconomics; 17.220J/TPP 22J The Policy-Making Process.

The Proseminar and thesis are especially important aspects of the student's program. The Proseminar helps students confront policy issues as they really are: very complex and difficult, often ill-defined, and full of conflicting values. It is the element that distinguishes this Program from just a set of subjects. It provides the common ground where students meet to discuss issues of technology and policy.

The thesis is a major effort by the student to do a serious analysis in his or her field of interest. Theses frequently are published by MIT as reports or professional papers. They represent the equivalent of two or three subjects and are often done over the summer.

Students in the Program can proceed to doctoral studies through either departmental or interdepartmental arrangements.

Students with prior interests and capabilities in technology and policy are expected to complete the degree program in one calendar year. Other students may have to extend for an additional semester.

All applicants are encouraged to apply for fellowships that may be available to them, for example through the National Science Foundation, professional societies, or other organizations. Information on aid from governmental agencies, as well as private foundations, may be found in *The Grants Register* available in most public or university libraries. Experience indicates that the kind of student admissable to graduate school at MIT has a good chance of receiving a fellowship.

Students can obtain professional, part-time jobs as research assistants on MIT projects that match their areas of specialization. Many students regularly work in either the Center for Policy Alternatives or the Energy Laboratory, both at MIT. These are best arranged once the student has become acquainted with current activities and has developed basic expertise in technology and policy. In exceptional cases, these jobs may be arranged before the student arrives at MIT.

Applicants should have a strong basis in technology. Applications will be reviewed by the interdepartmental steering committee of the Program and by MIT departments corresponding to their particular interests. This process starts January 30, and candidates will be notified as rapidly as possible.

After admission, each student is required to take a writing exam to evaluate the student's writing skills. If additional skills are needed, the student is required to take a course in technical writing.

The Steering Committee for the Program consists of Nicholas Ashford, Associate Professor, School of Engineering and Assistant Director, Center for Policy Alternatives; Joel Clark, Associate Professor of Materials Systems; Richard de Neufville, Professor of Civil Engineering and Chairman of the Technology and Policy Program; Ted Greenwood, Associate Professor of Political Science; Judith Tegger Kildow, Associate Professor of Ocean Policy, Department of Ocean Engineering; Jeffrey Meldman, Associate Professor of Management Science; David Noble, Assistant Professor of History of Technology, Program in Science, Technology, and Society; Amedeo Odoni, Professor of Aeronautics and Astronautics; Jack Ruina, Professor of Electrical Engineering; Thomas Sheridan, Professor of Engineering and Applied Psychology, Department of Mechanical Engineering; Marvin Sirbu, Jr., Lecturer in Mechanical Engineering and Principal Research Associate, Center for Policy Alternatives; Lawrence Susskind, Associate Professor and Head, Department of Urban Studies and Planning; Martha Weinberg, Associate Professor of Political Science; David Wood, Associate Director, Energy Laboratory and Senior Lecturer, Sloan School of Management.

Further information may be obtained by contacting Professor Richard de Neufville, Room 1-138, MIT, Cambridge, Massachusetts 02139, (617) 253-7694.

Transportation (S.M.)

The Center for Transportation Studies promotes cooperation in interdepartmental and intermodal matters, facilitates innovative research in transportation, and provides a focal point for educational programs within the Institute. Graduate programs leading to the master's and doctoral degrees and professional training are available through the departments associated with the Center.

An interdisciplinary degree, the Master of Science in Transportation, is offered by graduate departments in cooperation with the Center. This degree is designed to prepare students either for careers in transportation or for additional graduate work. Students with a variety of backgrounds such as engineering, social sciences, management, architecture, urban studies, and operations research are encouraged to participate in the program. An entering student should have a background in economics, calculus, and probability.

The degree requirements include the satisfactory completion of at least 72 units and the presentation of an acceptable thesis. The program establishes the basic methodological framework for analyzing transportation problems and offers a number of areas of concentration. It consists of the following three components.

1) Core subjects — 33 units
2) Program area — 18 units
3) Electives — 21 units

A specified core ensures breadth and a common frame of reference for all students in the program. The core includes one required subject which establishes the basic concepts used in the analysis of transportation systems. In addition each student must take at least three of the following five core subjects: Applied Microeconomics, Transportation Institutional Analysis and Policy, Transportation Management, Transportation Performance and Technology, and Transportation Demand and Activity Analysis.

The remainder of the program builds upon a series of program areas, each of which may be considered to be a professional interest group with which a student can associate. Typical examples of program areas are: air, ocean, urban, or freight transportation; transportation and developing countries; transportation, land use and regional development; transportation systems analysis; transportation policy and institutional analysis; transportation technology; transportation logistics and carrier management; and transportation, energy and the environment.

Each student must take at least two related subjects, which constitute a program area. The research associated with the Master's thesis usually requires one to two terms to complete, so students should generally expect to take three to four terms to complete the program. Some exceptional students can complete the program in less time.

Students who have been admitted to study for the Master of City Planning or the Master of Science in Transportation are invited to propose programs for joint work in the two fields leading to a dual degree, Master of Science in Transportation (S.M.T.) and Master of City Planning (M.C.P.). This would take the form of an application for admission to the second degree. Applications must be made prior to the student's final academic year in the first degree program and are considered during the spring admission process. Normally, students are expected to meet the core requirements of both degrees, but may submit a joint thesis and count some subjects completed for one degree towards the other, thus decreasing the overall time required for the two degrees.

A minimum number of units will be set for each student (on an individual basis) within the range 160 to 180 units plus thesis. The number would be determined by: 1) relevance of the student's prior degree to these degrees; 2) relevance of prior work experience; 3) complementarity between the two degree programs in the case of each student.

The Center for Transportation Studies attempts to provide financial assistance, in the form of research and teaching assistantships, in most of the fields in which the Center is active.

Students interested in coming to MIT for transportation studies should write to: Center for Transportation Studies, Room 1-123, MIT, Cambridge, Massachusetts 02139. For each admitted student an appropriate department of registration will be selected based on the individual's background and area of specialization.

Interdepartmental Organizations and Research Facilities

Artificial Intelligence Laboratory

The primary goal of the Artificial Intelligence Laboratory is to understand how computers can be made to exhibit intelligence. Two corollary goals are to make computers more useful and to understand certain aspects of human intelligence. Current research includes work on computer vision and manipulation, intelligent personal assistants, English-language understanding, learning and automatic debugging, common-sense reasoning, expert engineering problem solving, manufacturing productivity, computer architecture, human development, and human education.

Computer Vision and Robotics. Studies in computer vision and the problem of enabling a computer to manipulate its world involve a range of topics from special-purpose schemes for use in practical automation applications, to highly speculative and experimental systems aimed at understanding biological systems. Central problems are the formulation of representations, and the exploitation of natural constraints.

Engineering Problem Solving. Engineers design, analyze, debug, and explain complex engineered systems using reasoning that is relatively deep. Understanding this reasoning requires the ability to deal with such notions as causality and the interaction of constraints. Applications apply particularly to very large-scale integrated circuit design and programming.

Learning and Natural Language. Progress in representation enables progress in learning. Recent work has concentrated on theories explaining how new situations can be analyzed in terms of remembered case studies and on ideas that enable the rules of natural language syntax to be inferred from examples. Applications include information retrieval and intelligent support systems, both oriented toward supplying decision makers with usable computer expertise.

Computing Concepts. Sophisticated ideas for representing knowledge are a major research theme. Accomplishments include the creation of the LISP Machine for symbolic computing, the design of systems for parallel problem solving, and the invention of frame systems.

Further information is available from Professor Patrick H. Winston, Director, Artificial Intelligence Laboratory, Room NE 43-816, MIT, Cambridge, Massachusetts 02139, (617) 253-6218.

Bates Linear Accelerator

During the past few decades, the study of the nucleus and its components has necessitated equipments of size that require them to be available essentially as national facilities and to a wide community of investigators. The William H. Bates Linear Electron Accelerator, funded by the Energy Resources Development Agency for use by MIT research staff (principally in the Laboratory for Nuclear Science and the Department of Physics), is available for use through a formal user's organization to eligible researchers in the New England area and nationwide.

The laboratory supports a broad program of research in electromagnetic interactions with nuclei. Facilities are available for high precision-high resolution electron scattering and photoreactions including pion production. A project is in progress which will raise the present 380 MeV beam energy of the accelerator to 725 MeV by early 1982. A polarized electron source is also under development which will make possible studies of parity violation in electron scattering and spin effects in nuclear reactions. The technique presently being employed to increase the accelerator's beam energy is being studied with a view to extending this further to the 1-4 GeV energy range at 100 percent duty factor.

The research participation of students, as undergraduate laboratory assistants and through graduate thesis work, is encouraged and forms an important part of the Bates program. A large number of students, from the universities of user physicists as well as from MIT, are so involved. Further information may be obtained from the office of the Director, Room 26-565, MIT, Cambridge, Massachusetts 02139, (617) 253-7592.

Bitter National Magnet Laboratory

The Francis Bitter National Magnet Laboratory, supported by the National Science Foundation, conducts a program of research and development in science and engineering in areas involving magnetic fields. Continuous fields up to 23 teslas and pulsed fields to 75 teslas are available in a variety of configurations. High magnetic field, high resolution nuclear magnetic resonance spectrometers are used for the study of molecules of biological interest. A magnetically shielded room of walk-in size is available for ultra-low magnetic field experiments. The special facilities of the Laboratory are made available to research groups from other MIT departments and from institutions throughout the world.

The Laboratory's solid-state physics research program is an experimental and theoretical study of semiconductors, magnetic materials, and superconductors. Molecular biology studies are carried out using high resolution nuclear magnetic resonance spectrometry and the Mössbauer effect.

The Laboratory also conducts research and development programs aimed at the practical application of magnetic fields to technology and medicine. Current projects include studies of the weak magnetic fields of the human body, and the effects of magnetic fields on living systems, design of superconducting magnets for magnetohydrodynamic generators, studies of magnetic separation techniques, and development of magnetic acceleration systems for terrestrial and space applications.

Additional information may be obtained from the Director of the Laboratory, Building NW14, MIT, Cambridge, Massachusetts 02139, (617) 253-5541.

Cell Culture Center

The Cell Culture Center has been established and funded by the National Science Foundation to serve as a facility and resource for cell biologists throughout the United States. Its mission is to carry out large-scale cell and virus production that will allow scientists to conduct novel and important experiments in basic cell biology which could not be carried out with the materials and resources available in the investigator's own laboratory. The Center works directly with individual scientists on basic research problems, and carries out an active program for the development of new techniques for large-scale cell and virus production. In addition, the Cell Culture Center sponsors a master's degree program in animal cell and tissue culture sciences through the MIT Interdisciplinary Science Program. The Program offers course work in both the Department of Biology and the Department of Nutrition and Food Science, and laboratory experience in the Cell Culture Center. The Program provides students with excellent preparation for vocations that require a broad knowledge of the techniques of cell culture and animal virology. Inquiries concerning the facility are always welcome, and may be addressed to Donald J. Giard, Room E17-321, MIT, Cambridge, Massachusetts 02139, (617) 253-6430.

Center for Advanced Engineering Study

The MIT Center for Advanced Engineering Study provides opportunities for experienced engineers and scientists to attain and maintain the competence needed for continued leadership in an age of technological change. The Center offers educational programs for experienced men and women from industry, government, and educational institutions to acquire the understanding and skills needed to open technical frontiers.

The Center operates four major programs: 1) The Advanced Study Program — for engineers and scientists who come to MIT to study in advanced subjects; 2) The Self-Study Program — based on the use of specially prepared, high quality videotape presentations of advanced technology; 3) Conference and seminar programs — technical meetings in support of continuing education, and 4) Research and Development in Continuing Education.

Under the Advanced Study Program experienced engineers, applied scientists, technical managers, and educators attend regular MIT classes in programs individually tailored to their needs and objectives. Special programs have been developed in Air Transportation, Public Management, and Operations Research. For further information about the Advanced Study Program, inquire at Room 9-435, MIT, Cambridge, Massachusetts 02139, (617) 253-6161.

The Self-Study Program provides a library of approximately 800 videotapes and study guides made at MIT plus offerings from other institutions of higher learning. These tapes and study guides are available for purchase or rental. Inquiries should be directed to the Self-Study Program, Room 9-234, 253-7444.

The Conference and Seminar Program is designed to support our continuing education efforts by bringing to the campus, to other parts of the country, and to other places in the world, people with similar interests. These meetings range from three days to one month in duration and provide for an intensive exchange of information. Further information may be obtained in Room 9-335 or by calling 253-7406.

The Center is developing new approaches to continuing education for engineers, Project PROCEED, in which *problem*-centered educational materials, as distinguished from *subject*-centered materials, are prepared to assist engineers working on specific problems. Instruction and assistance are provided via printed modules and a computer-based Adaptive Reference System. The first topic, Industrial Energy Conservation, will be followed by several more each year. For more information, inquire at Room 9-366 or call 253-6520.

Brochures describing the above programs and current offerings are available upon request, and they are described in more detail under the School of Engineering section of this catalogue.

For further information about CAES programs, inquire at the office of the Director, Room 9-215, 253-4961.

Center for Advanced Visual Studies

The Center for Advanced Visual Studies provides artists of achievement with the opportunity to explore new artistic forms. Collaboration through a working dialogue between artists, and scientists and engineers is of primary importance in the exploration of new creative objectives. Mutually beneficial contact between artist and scientist allows the artist to develop the technical competence to utilize advanced technology.

The Center's main areas of interest are: environmental art and design; developmental artistic media work; interaction of art, science, and technology; celebrations; and education toward the new arts — video, holography, computer-aided design and programming, laser art, and sky art.

A limited amount of work space also is available for a small number of research affiliates and graduate students. A catalogue listing the Center's educational offerings, in association with the Department of Architecture, is available at the CAVS office in Building W11, 40 Massachusetts Avenue, MIT, Cambridge, Massachusetts 02139, (617) 253-4415.

Center for Cancer Research

The Center for Cancer Research provides facilities for interdepartmental work in various phases of fundamental cancer research. Graduate students in any of the Courses may ask to do doctoral thesis research under the supervision of the faculty of the Center. If accepted, they may be eligible for support as research assistants in the Center. Opportunities for undergraduate research are available, both for credit and in the Undergraduate Research Opportunities Program. Seminars in cancer research both for credit and as public colloquia of the Center are available. Further information may be obtained by contacting Ms. N. Ahlquist, Room E17-110, MIT, Cambridge, Massachusetts 02139, (617) 253-6400.

Center for Cognitive Science

The Center for Cognitive Science provides an intellectual and administrative focus for individual and collaborative research in cognitive science at MIT. In addition, a committee of the Center coordinates graduate and undergraduate study in cognitive science by working in conjunction with the relevant committees of the faculty.

The members of the Center represent the Departments of Electrical Engineering and Computer Science, Linguistics and Philosophy, Psychology, the Division for Study and Research in Education, the Artificial Intelligence Laboratory, and the Research Laboratory of Electronics.

A number of cooperative activities involving members of the Center and scientists at other institutions with programs in cognitive science are planned or in progress, and the members of the Center maintain active relations with scientists working at other academic, medical, and research institutions in the Boston area.

The Center now administers an extensive program of postdoctoral and predoctoral fellowships designed to attract outstanding young scholars to MIT for an extended interaction with members of the Center.

In addition to the Fellowship program, the Center coordinates a number of research projects in the areas of cognitive science pursued by visiting and permanent members of the Center. Computer-based laboratory and research facilities are maintained within the Center to support the conduct of such research.

A Cognitive Science Seminar and series of colloquia serve to disseminate scientific information and provide for the mutual exchange of students and workers in the field.

Further information regarding the activities of the Center may be obtained from the Administrative Assistant, Diana Kulfan, at the Office of the Director, Room 20D-105, MIT, Cambridge, Massachusetts 02139, (617) 253-4143.

Center for Computational Research in Economics and Management Science

This Center's purpose is to advance knowledge about modeling in economics, statistics, and management, and does so through algorithmic research and related software development. The Center focuses a unique set of resources on this task. Algorithmic research is performed by researchers representing the varied quantitative disciplines that underlie modern computer-intensive modeling. These disciplines include econometrics, statistics, numerical analysis, and operations research. Computer implementation is performed by a programming staff with special skills in designing and coding easily used interactive tools, of which the single most important is a comprehensive software environment called TROLL. TROLL contains programming tools and standard functions that facilitate the rapid implementation of experimental algorithms. In addition to being a software-development environment for algorithmic research, TROLL is also a modeling environment for applied studies. TROLL exemplifies the concept of the discipline-oriented (or application-oriented) operating system. In TROLL's case the discipline is econometrics and statistics; the system provides all standard techniques, and many experimental ones, for building and using econometric models.

Recent research at the Center has focused increasingly on the evaluation and improvement of model reliability. Other major research efforts focus on simultaneous equation estimation, nonlinear optimization, robust estimation, ARIMA time series models, and semiportable implementation of stable statistical and econometric algorithms.

The Center's research complements activities in several MIT departments and laboratories. The links include active participation in Center projects by faculty members of the Sloan School of Management; collaboration with the Statistics Group and the Energy Laboratory, the Laboratory for Decision and Information Systems, and the Operations Research Center on projects of mutual interest; and use of Center-developed software by the Departments of Economics, Political Science, and Civil Engineering.

Further information about the Center and its research program may be obtained from the Director, Professor Edwin Kuh, Room E38-210, MIT, Cambridge, Massachusetts 02139, (617) 253-8413.

Center for Health Effects of Fossil Fuels Utilization

The Harvard-MIT Division of Health Sciences and Technology and MIT Energy Laboratory have established a Center for Health Effects of Fossil Fuels Utilization and associated research programs. The Center and the research programs are funded by grants from the National Institute of Environmental Health Sciences and from other government and private agencies. The Center provides support for a comprehensive program of interdisciplinary research, involving a core of senior scientific staff and a number of postdoctoral, graduate, and undergraduate students. Participants include members from the MIT Departments of Nutrition and Food Science, Chemical Engineering, Mechanical Engineering, Biology, Chemistry, Materials Science

and Engineering, Aeronautics and Astronautics, and the Harvard Medical School.

Areas of research include efforts to determine the extents and mechanisms of formation of combustion-generated emissions products; to evaluate these species for mutagenic and/or carcinogenic potential; to evaluate respiratory effects of inorganic combustion-generated particulates; and to develop combustion control methods to mitigate any hazards identified. The Center also supports feasibility projects in new research areas such as the biological effects of diesel exhaust, the use of bacterial virus to explore the toxicology of compounds in combustion-generated soots, the development of a lung perfusion model for toxicologic studies, and polynuclearhydrocarbons in combustion exhaust particulates: release when inhaled by humans.

The Center also cooperates closely with other MIT and Harvard University investigators who are conducting research in areas related to health effects of fossil fuels utilization. Current research results and new developments in the field are presented through a program of seminars. An annual report discussing Center research projects is available upon request.

The Director of the Center is Dr. Gerald N. Wogan, Professor of Toxicology and Head of the Department of Nutrition and Food Science; the Associate Director is Dr. Jean F. Louis, Professor of Aeronautics and Astronautics and Associate Director of the MIT Energy Laboratory; the Executive Officer is Dr. Irving A. Berstein, Assistant Director for Research Program Development, Harvard-MIT Division of Health Sciences and Technology. Further information may be obtained by contacting Dr. Berstein, Room 26-165, MIT, Cambridge, Massachusetts 02139, (617) 253-8800.

Center for Information Systems Research

The Center for Information Systems Research (CISR) was established at the MIT Sloan School of Management in mid-1974. CISR's activities focus on research aimed at improving the effectiveness of information-processing tools and techniques available to managers in the private sector and policy makers in the public sector.

The Center is taking a multifaceted approach to the task of improving the effectiveness of information processing in organizations today. A set of corporate sponsors provides assistance in defining and investigating significant research areas. The sponsoring organizations represent several different commercial viewpoints and consist both of computer vendors and major users of information systems. In the public sector, CISR is developing and testing state-of-the-art management information systems to assist public policy makers. Basic research on fundamental issues (e.g., centralization and decentralization of computing, data base research) affecting both sectors is being performed. CISR is dedicated to disseminating significant research findings to the information systems user community through teaching, seminars, working papers, and publications.

Research at CISR is pragmatic, problem-based, and application-driven. Research efforts are performed primarily in application areas of immediate interest to managers and policy makers and are performed in areas in which results are expected to have a fruitful payoff within one to five years.

The Center was established in the Sloan School of Management, in part, due to the recognition by the School of the increasing complexity of the managerial job today and the need for vastly improved information-processing tools and techniques to carry out this job. Secondly, there was an evident need to institute more effective relationships between academics and private and public sector managers in a joint effort to improve computer-based information systems.

CISR's faculty brings a wide range of specialized training to information systems problems. This disciplinary training ranges from the technical fields of computer science and electrical engineering to the people-focused disciplines of law, psychology, and organizational behavior.

Further information about the Center may be obtained by contacting Judith Quillard, Assistant Director, CISR, Room E53-420, Sloan School of Management, 50 Memorial Drive, Cambridge, Massachusetts 02139, (617) 253-2348.

Center for International Studies

The Center for International Studies is a research center focusing on the international dimension of contemporary policy questions, particularly those related to scientific and technological change. The Center has no formal teaching program of its own; most of its senior staff are faculty members of various MIT departments, and there are opportunities for graduate students to participate in the Center's research programs. The following are the areas of current research focus:

science and public policy
arms control and defense studies
energy policy
international nutrition planning
environmental monitoring
communications policy
migration
international effects of regulatory policies
technology and development
problems of advanced industrial societies
international business
international political problems and conflict
political and economic development and
social science methodology

Further information about the Center and its research program may be obtained from the Director, Professor Eugene B. Skolnikoff, Room E38-648, MIT, Cambridge, Massachusetts 02139, (617) 253-3140.

Center for Materials Research in Archaeology and Ethnology

The Center for Materials Research in Archaeology and Ethnology is a major undertaking whose purpose is to encourage a new direction for research in anthropology, archaeology, art history, and related humanistic and social science disciplines by providing them with an expanded technical base in the sciences of organic and inorganic materials. The new Center was established in 1977 by nine educational, research, and cultural institutions in the greater Boston area: Boston University, Brandeis University, Harvard University, the University of Massachusetts, MIT, the Museum of Fine Arts of Boston, Robert S. Peabody Foundation for Archaeology, Tufts University, and Wellesley College.

The Center's research activities are carried out in a network of shared laboratories at member institutions and used by students and faculty of those institutions as well as by visiting scholars and graduate students who join the Center for shorter periods. The materials research laboratories include, among others, metallurgy, ceramics, lithics, palaeoethnobotany, and zoo-archaeology. The research program of the Center emphasizes rigorous laboratory study of artifacts and other kinds of cultural remains in order to determine the nature and structure of the materials of which they are composed and the extraction and processing regimes they have undergone. The Center is convinced that research aimed at understanding the relations among materials, technology, and society will be advanced most effectively by scholars who have a grounding in both a science and a social science or humanities discipline. Its subjects, offered at the graduate level and taught in the CMRAE Graduate Laboratory (20B-012), aim to educate such scholars.

Heather Lechtman is Director of the Center in addition to maintaining her present responsibilities as Professor of Archaeology and Ancient Technology in the MIT Departments of Humanities and Materials Science and Engineering. MIT serves as the Center's coordinating institution.

Further information about the Center and its programs may be obtained from the Director, Room 8-138, MIT, Cambridge, Massachusetts 02139, (617) 253-1375.

Center for Materials Science and Engineering

Major research programs currently supported by the Center emphasize interdisciplinary research on the synthesis and properties of materials in the following areas of thrust: 1a) predicting flow and fracture in high temperature alloys; 1b) deformation and fracture in polymer composites; 2) structure and properties of microcrystalline and glassy alloys produced by rapid solidification; 3) platinum surfaces and catalysts: environmental effects and surface alkyls; 4a) optical materials and devices; 4b) amorphous semiconductors; 4c) microelectronics materials and device structures; 5) phase transitions; 6) synchrotron radiation program. Major funding for these interdisciplinary programs is provided under the National Science Foundation Materials Research Laboratories program.

Participating in CMSE research programs are faculty groups from the Departments of Chemical Engineering, Chemistry, Electrical Engineering and Computer Science, Materials Science and Engineering, Mechanical Engineering, and Physics. Opportunities for postdoctoral, graduate, and undergraduate research can be investigated by contacting CMSE faculty members directly.

CMSE maintains excellent modern central service facilities such as crystal growing and characterization laboratories; optical and infrared and Fourier transform spectroscopy; scanning electron microscopy (SEM); transmission electron microscopy (TEM); scanning transmission electron microscopy (STEM) and image analyzing computer; analytical compositional analysis; X-ray diffraction; microelectronics fabrication and characterization; and ion implanter; and Scanning Auger, ESCA and LEED analysis available in the Surface Analytical facility. Also available are the Von Hippel Reading Room and a machine shop. Annual reports entitled *Research in Materials at MIT* and *Polymer Research at MIT* are published by CMSE covering all research in these areas at MIT. These reports are available through the Center by contacting the Administrative Office, Room 13-2098, MIT, Cambridge, Massachusetts 02139, (617) 253-6841.

Center for Policy Alternatives

The Center for Policy Alternatives (CPA) was established in 1972 within the School of Engineering to meet the growing need for interdisciplinary policy analysis. CPA's objectives are to identify and study important emerging social issues in which technology and engineering play a significant role, to assess the consequences of established institutional policies and develop alternative actions for decision makers, and to provide students and professionals with research and training opportunities in policy formulation and analysis.

The CPA approach to policy analysis is multidisciplinary, involving specialists with a wide variety of backgrounds. This multidisciplinary approach is necessary to address the complexity of policy issues and often requires the development of new research techniques that both encompass and extend traditional methods.

CPA differs from most policy research centers in that it is action oriented: developing alternative policies, identifying various means for implementing them, and evaluating the possible consequences of their implementation.

During 1980-81, some of CPA's research areas included science, technology and public policy; energy policy; communications policy; technological innovation; workplace and environmental regulation; and consumer policy.

An S.M. degree program in Technology and Policy was initiated in 1975 by the School of Engineering with the collaboration of CPA. Several CPA staff members teach courses in the Technology and Policy Program and are on its Steering Committee.

CPA staff also supervise Master's and Ph.D. candidates from various departments and advise students participating in interdisciplinary programs. Courses taught by CPA staff include Technology, Law and the Working Environment; Environmental Law; Management of Engineering; International Technology Transfer; Proseminar in Technology and Policy; and Government and the Chemical Process Industries.

Graduate and undergraduate students interested in participating in CPA research programs or in developing new policy research projects should contact the Office of the Director, Center for Policy Alternatives, MIT, Cambridge, Massachusetts 02139, (617) 253-1661.

Center for Space Research

The Center for Space Research offers students, faculty, and professional research staff an opportunity to participate in a broad program of space-related research. Its projects draw upon the interests and expertise of physical, social, and life scientists and engineers from many disciplines. Topics of current research include theoretical studies in cosmology and astrophysics such as: stellar evolution and stellar pulsation; the behavior of supernovae, pulsars, and quasars; and the development of models illustrative of the processes associated with novae, planetary nebulae, neutron stars, protostars, X-ray binaries, and bursters.

Space science studies include measurements of the properties of the interplanetary plasma, hard and soft X rays, and gamma rays using experimental techniques such as high altitude balloons, sounding rockets, orbiting satellites, and interplanetary spacecraft. Other space science studies include vestibular experiments to measure the changes in sensitivity of otolith function during weightlessness and the carry-over of any such changes to post-flight conditions. Coupled with the foregoing laboratory and flight experiments are ground-based optical, infrared, and radio frequency observations of astrophysical phenomena of current interest. The Center supports these field measurement programs with exploratory and developmental studies in the laboratory on interference spectrometry, X-ray counters, high-resolution collimators, high-accuracy pointing and stabilization systems, and star sensor aspect systems.

Laboratory facilities include X-ray sources, particle accelerators, vacuum chambers, and conventional electronic test and machine tool equipment. Extensive data handling and computational facilities are available for the analysis and reduction of scientific data. An experienced and well-equipped Laboratory for Space Experiments group provides design, construction, and testing support of the flight programs.

The variety of scientific and technical problems that arise in these investigations affords numerous opportunities for graduate thesis research as well as for graduate and undergraduate participation in research projects and seminars. Further information may be obtained in Room 37-241, MIT, Cambridge, Massachusetts 02139, (617) 253-7501.

Center for Transportation Studies

The Center for Transportation Studies has been established to promote cooperation in interdepartmental and intermodal matters, facilitate innovative research in transportation, and provide a focal point for educational programs in transportation within the Institute. The Center's research emphasis is on problem-oriented, interdepartmental, multi-modal research. It covers a wide spectrum ranging from broad conceptual planning through operation and management of transportation problems to new methods of transportation analysis, planning, and decision making.

The Center has developed a structure which promotes interaction among faculty members from all Schools at MIT as well as other universities and organizations concerned with transportation. Interdepartmental cooperation is essential in dealing with the complex problems found in this area since their solution requires close ties between technological possibilities and their social, economic, ecological, and political ramifications.

The research program of the Center is broadly based, incorporating both interdepartmental and intermodal elements. Research capability extends from the areas of social science and management to the technological research associated with the development of new modes of transportation. Recent research projects have concerned application of new methods to transportation planning, transportation energy contingency planning, railroad reliability and network planning, innovative urban transportation systems, transportation in developing countries, urban freight movement, airport planning and development, commodity movement, industry location, freight terminal simulation, energy transport, superport location, air traffic control, assessment of STOL/VSTOL air service potential, local service air carriers, and the logistics of freight modal choice and inventory control. Research sponsorship includes a range of government and industry organizations affording students wide opportunities to be involved in newly evolving research frontiers.

An interdisciplinary degree, the Master of Science in Transportation, is offered by graduate departments in cooperation with the Center. For more information on this graduate program, see the section on Transportation Studies under Interdepartmental Graduate Study.

Clinical Research Center

The MIT Clinical Research Center, a small, fully equipped and staffed research hospital on campus, opened in 1964. The major purposes of the Center are to enable interested scientists to perform research with human subjects and

to allow students at all levels to gain experience in working directly with human subjects and human disease. Many research projects are in progress, including those in nutrition, psychology, cardiology, endocrinology, gastroenterology, and mechanical, chemical, and electrical engineering. The studies in most cases are collaborative, involving both basic scientists and clinical scientists.

Patients and normal subjects may be seen as outpatients or may stay in the Center as inpatients for long periods of time at no cost to them. The facilities of the Center are open to all departments in the Institute, and its investigators are faculty members from many of those departments. Although most patients hospitalized in the Clinical Research Center come from the Boston metropolitan area, a significant number are referred from other parts of the United States, and some are referred from abroad.

Numerous routes of entry are available to undergraduates and graduate students who wish to take advantage of the Center's programs. These include a freshman seminar in medicine, undergraduate research projects, a weekly clinical seminar, graduate study with human subjects in medical sciences and biomedical engineering, and postdoctoral research for those who already have an M.D. or Ph.D. Further information may be obtained from the Center in Room E17-445, MIT, Cambridge, Massachusetts 02139, (617) 253-3091 or 3092.

Division for Study and Research in Education

The Division for Study and Research in Education is a special setting at MIT for learning about learning. The Division offers formal courses on both theoretical and practical problems in education, as well as seminars on issues of special interest. The Division provides opportunities for research and for working directly with learners in a variety of learning situations.

The members of the Division bring to their shared educational interests a wide diversity of academic experience, professional perspective, and personal concern. The resulting interplay of insights and methodologies has led to the emergence of several major themes: individual learning, institutional learning, and educational technology. Multidisciplinary clusters of faculty, students, and research staff apply theories of cognitive processing, insights into social processes, and educational technologies, to investigate the ways in which people think, solve problems, and learn to learn.

The Division for Study and Research in Education provides opportunities for faculty and students from departments of the Institute to join in its research on educational problems.

Among these opportunities is a program which provides a small number of Ph.D. candidates with experience in educational research. For details of this program, see the section in this chapter on Study and Research in Education under Interdepartmental Graduate Study.

Further information may be obtained from the Education Division Administrative Officer, Marion Wasserman, Room 20C-126A, MIT, Cambridge, Massachusetts 02139, (617) 253-7362.

Faculty members associated with the program are:

Benson R. Snyder, M.D.
Professor of Psychiatry
Director

Barbara Scott Nelson, Ed.D.
Assistant Professor of Education
Associate Director

Jerome S. Bruner, Ph.D.
Professor of Psychology
and Education
(Visiting)

Howard E. Gruber, Ph.D.
Professor of Education
(Visiting)

Roy Kaplow, Sc.D.
Professor of Metallurgy and Materials Science

Seymour A. Papert, Ph.D.
Professor of Education and Mathematics

Martin Rein, Ph.D.
Professor of Sociology and Education

Donald A. Schon, Ph.D.
Ford Professor of Urban Studies and Education

Judah L. Schwartz, Ph.D.
Professor of Engineering Science and Education

Hermina Sinclair-de Zwart, Ph.D.
Professor of Psycholinguistics
(Visiting)

Harold Abelson, Ph.D.
Associate Professor of Education and Electrical Engineering

Jeanne S. Bamberger, M.A.
Associate Professor of Education and Music

Susan Carey, Ph.D.
Associate Professor of Psychology and Education

Andrea Al-Vin di Sessa, Ph.D.
Associate Professor of Education

Margaret L.A. MacVicar, Sc.D.
Associate Professor of Physical Science and Cecil and Ida Green Professor of Education

Daniel Nathan Osherson, Ph.D.
Associate Professor of Education and Psychology

Sherry Turkle, Ph.D.
Associate Professor of Sociology

Edwin F. Taylor, Ph.D.
Senior Research Scientist
Director, Educational Video Resources

Karen C. Cohen, Ph.D.
Principal Research Associate

Eleanor Duckworth, Ph.D.
Research Associate

Robert Lawler, Ph.D.
Research Associate

Edith Ruina, M.S.W.
Research Associate

Daniel Watt, Ph.D.
Research Associate
(Visiting)

Sylvia Weir, M.D.
Research Associate

Bertrand Schwartz, Sc.D.
Senior Lecturer
(Visiting)

Sir Geoffrey Vickers
Senior Lecturer
(Visiting)

John Terry, Ph.D., Lecturer

William T. Martin, Ph.D.
Professor of Education and Mathematics, Emeritus

Marion Wasserman
Administrative Officer

Jerrold Reinach Zacharias, Ph.D., L.H.D., Sc.D.
Institute Professor, Emeritus
Professor of Physics, Emeritus

Electric Power Systems Engineering Laboratory

The Electric Power Systems Engineering Laboratory (EPSEL) is an interdepartmental laboratory within the School of Engineering. It is principally concerned with problems related to the generation, transmission, distribution, and utilization of electric energy, but work in the field of high power semiconductor devices and their application also is under way in the laboratory. Several faculty members within the group have had experience in the electric power industry, and close contact with the industry is maintained through on-campus research, consulting activities, and participation in the activities of professional societies.

Research programs currently in progress include contamination flashover of insulation; microprocessor control of electric energy systems; design, construction, and testing of an alternator with a superconducting field winding; an electromagnetically scaled model of a power system; induction heating; motor controls; energy storage systems; control of power systems and power plants during emergency situations; load demand modeling, innovative load management (cogeneration pricing), dynamic control schemes; the development of new simulation techniques for studying power electronic energy conversion and control systems; magnetically levitated ground transportation systems; and concentrator systems for photovoltaic energy conversion. Since most of the research is experimentally oriented, design and instrumentation is a major concern almost comprising an additional research area.

Further information may be obtained by contacting Professors G. L. Wilson, F.C. Schweppe, J.L. Kirtley, Jr., J.G. Kassakian, or G. C. Verghese in Room 10-171, MIT, Cambridge, Massachusetts 02139, (617) 253-4631.

Energy Laboratory

Current Energy Laboratory research projects this year involve about 140 research staff, 50 faculty, and 280 students from various departments in all five MIT Schools. The educational aspects of this research are significant as both graduate and undergraduate students become an integral part of the interdisciplinary research teams working on both fundamental and mission-oriented projects that address the technical and socioeconomic aspects of important energy issues.

The **International Energy Studies** program conducts research on economic, political, and strategic aspects of international energy trade and on the financial implications of the large reciprocal flows of wealth associated with that trade. The core of this program is long-standing research on the nature, structure, and behavior of international markets in oil, nuclear fuels, and other energy commodities, including analysis of conditions in supplier and consumer nations. New directions for research include couplings between domestic US and foreign markets, security of supply concerns and their effect on national policies and international relations, the roles of public and private sectors in dealing with supply crises, and the energy problems of the developing world.

The **Utility Systems** program brings together faculty and research staff from engineering and policy science departments at MIT to analyze utility operations and growth both in the short run and the longer run. Research, writing, and teaching have concentrated on three major areas: 1) electric utility operations and control; 2) economics and policy decisions associated with adoption of new, generally utility-interfaced energy technologies; 3) development of modeling tools for both utility operation and utility capacity expansion analysis.

The **Energy Markets, Pricing, and Regulation** program conducts research on the structure and performance of the domestic system for the supply, conversion, and use of energy, and on the interactions between that system and the domestic and international macroeconomy. Current projects include research on domestic and international macroeconomic consequences of energy supply shocks and price uncertainty; the wealth and income distribution effects of changing energy supply and price conditions; and the structure and regulation of the US electric utility industry.

Continuing research on determinants of primary energy supply focuses on oil, gas, and coal, with current emphasis on the interaction between environmental and coal development policies. Current research on energy demand focuses on the determinants of factor use and productivity in manufacturing activities, in particular the relation between capital goods and energy, and the determinants of appliance choice, energy efficiency, and use in the household sector. Closely related to the research program is a continuing series of evaluative studies of major energy policy models and policy studies.

The **Center for Energy Policy Research** gives special focus to policy research and analysis in the Energy Laboratory, with particular emphasis on making results available and useful to policy makers. With support from a wide range of corporate and noncorporate interest groups (called Associates), the Center holds conferences and seminars to bring together key government and private organizations to work on energy policy issues. The work of the Center is carried out by professional staff members from the Energy Laboratory and faculty and students from several MIT departments (with particularly heavy involvement by the Sloan School of

Management and the Department of Economics). Specialists from the Center's Associates are also involved in the work.

The **Energy Systems** program studies future energy systems options by considering a combination of the most promising technologies that may have a significant impact on the energy problems of the nation, and also the world as a whole. This program has two important tasks: 1) to construct and evaluate the impact of energy system options for different societies both in the near term and in the long term, and 2) to identify R & D needs and to initiate projects to solve the identified problems. International cooperative activities are planned for this program.

The **Energy Conversion** program emphasizes high temperature gas turbines with related hot gas cleanup and cooling, fluidized and electrofluidized beds, environmental assessments of advanced energy conversion systems, and MHD power generation. The fluidized bed program is concerned with developing a mathematical model for the fluidized bed combustion program and establishing a data base management system for the technology. The MHD program is a large, interdisciplinary effort considering topics such as coal combustion and devolatilization, ash behavior, magneto fluid dynamics of MHD generators, magnet design, materials and electrodes problems, and system study of MHD plants.

The **Stationary Combustion** program emphasizes parallel modeling and experimental investigations of combustion processes of gaseous, liquid, and solid fuels in both steady and unsteady operation. Specific projects include: turbulent combustion in furnaces and combustors; reduction of pollutant emissions from liquid fuel spray flames; radiative heat transfer from flames in furnaces; soot formation; combustion characteristics of coal/oil mixtures and coal/water slurries; behavior of nitrogen in coal; fluidized combustion; NOx emission from shale- and petroleum-derived liquids; and spray combustion.

Research in the **Health Effects** program concentrates on determining the mutagenic, carcinogenic, and respiratory toxicity of combustion-generated particulates and polycyclic compounds. A unique feature of this program is a direct coupling of research teams in engineering, analytical chemistry, and the biological sciences.

The **Synthetic Fuels Center** provides a focus within the Energy Laboratory for research on conversion of coal, oil shale, and other energy resources to liquid and gaseous fuels. All aspects of synthetic fuel production and use are of potential interest; some current research projects include pyrolysis and/or hydropyrolysis of coal and biomass, catalytic hydrogenation reactions, and shale oil recovery systems.

The **Process Modeling** program focuses on computer simulation of industrial processes. The ASPEN (Advanced System for Process Engineering) project is developing a next-generation process simulator to perform steady-state heat and material balances, equipment sizing, and cost estimation and economic evaluation.

The **Transportation Propulsion** program is based on the activities of the Sloan Automotive Laboratory. The work falls into four general areas: fundamental combustion studies, internal combustion engine research, gas turbine and burner research, and policy and technology studies.

The **Advanced Technology** program examines new and emerging technologies and provides supportive research for more near-term programs. Electrochemistry research concerns electrodes and electrolytes for high density batteries and fuel cells, and electrochemical processing. In directed energy processes, ceramic powders are being synthesized and modified using laser heat sources. Other programs are concentrating on microstructural control in materials for ceramic processing. Solar energy research centers on solar heating/cooling, amorphous photovoltaics, and broad band antireflective coatings.

Research in the **Environmental Management** program seeks to identify and reduce the environmental impacts of energy-related facilities and includes a diverse range of research projects. Current efforts include the design of open- and closed-cycle cooling systems for electric power plants, transport of buoyant effluents, water management issues associated with coal development, and environmental implications of ocean thermal energy conversion.

The **Electric Utility** program encourages communication between the Energy Laboratory and electric utilities, especially those located in the northeastern United States. The program serves to inform participating utilities about ongoing MIT research activities; to identify and discuss utility needs and priorities; and to develop and coordinate research projects responsive to utility needs, both regional and generic. Ten member companies currently participate in the steering of the program. At an annual general seminar, representatives of those companies receive updated information about MIT research activities. They then attend three or more workshops that provide opportunities for in-depth discussions of MIT research programs and proposals and of utility needs and priorities.

The **Nuclear** program has the following broad objectives: 1) to provide direct technical contributions to nuclear plant reliability and safety; 2) to develop and/or investigate possible improvements in nuclear plant design for fuel management that could lead to reduced power costs and more efficient utilization of nuclear fuel resources; and 3) to develop and communicate data and information that will contribute to public understanding of nuclear power.

Students interested in participating in Energy Laboratory research projects should apply to the graduate program of one of MIT's academic departments associated with the Laboratory. Further information may be obtained by contacting the Director's Office, Energy Laboratory E19-439, MIT, Cambridge, Massachusetts 02139 (617) 253-3400.

George Russell Harrison Spectroscopy Laboratory

The G. R. Harrison Spectroscopy Laboratory is dedicated to advancing our knowledge of the structure and dynamics of atoms and molecules and the properties of liquids and solids, utilizing the techniques of modern spectroscopy. These techniques include the use of lasers and high-resolution spectrometers. As an interdepartmental laboratory, the Spectroscopy Laboratory encourages participation and collaboration among staff members in various disciplines of science and engineering.

At present, several departments conduct research programs in the Spectroscopy Laboratory. In addition, scientific visitors from the US and abroad participate in the work of the Laboratory.

Current research areas include high resolution laser spectroscopy of excited vibrational and electronic molecular levels, optically pumped molecular lasers, various kinds of double resonance experiments using coherent sources, laser saturation spectroscopy in both the steady state and time delayed modes, dichroism spectroscopy of low temperature solids, spectroscopy kinetics and energy transfer in flames and other reactive systems, laser-nuclear spectroscopy, superradiance, structural studies of biological molecules using Raman techniques and X-ray diffraction data, and photoacoustic spectroscopy of biological materials.

One important recent development is the establishment within the Laboratory of the MIT Regional Laser Center, supported by a grant from the National Science Foundation. This Center will make available to researchers from MIT and Lincoln Laboratory, and the many university and industrial research institutions throughout the northeast, one of the most extensive collections of lasers assembled in the US for spectroscopic research.

Research in the Center will cover a number of fundamental and applied areas, including laser chemistry and the spectroscopy of atoms and molecules; the interaction of radiation and matter; the structure of atoms and molecules; problems in biology and nuclear physics; and relaxation processes in physical systems.

Innovation Center

The MIT Innovation Center is for students who want to become innovators and entrepreneurs. These are the people who patent inventions, develop ideas into products, start new companies, or provide the creative leadership for new enterprises within larger organizations. The Innovation Center is organized by the School of Engineering with the support of the School of Management to serve students from throughout the Institute. Logistic support is provided by the Department of Aeronautics and Astronautics.

There are two major branches of the organization. The Innovation Education Program uses conventional classroom and project laboratory subjects to guide students through the earlier phases of learning the innovation process. The Innovation Co-op is a product development laboratory which provides a professional push in the marketing of products and gives the student clinical exposure to the latter phases of the innovation process.

Students at any level, both graduate and undergraduate, and from all departments, may participate.

Students who wish to participate in the program should contact the Innovation Center, or register for 16.671J Invention or 16.672 Entrepreneurship, 16.675 Invention Development Laboratory, 16.676 Internship in New Enterprise Development. (16.671J also has subject numbers for Chemical Engineering, Ocean Engineering, Electrical Engineering and Computer Science, and Mechanical Engineering.)

Further information may be obtained by contacting the Innovation Center, Room W91-208, MIT, Cambridge, Massachusetts 02139, (617) 253-5180.

International Food and Nutrition Program

The International Food and Nutrition Program (IFNP), jointly established by the Department of Nutrition and Food Science and the Center for International Studies, responds in an interdisciplinary fashion to the urgent need for increasing and broadening the knowledge required for improving the nutritional status of people, especially in the poor countries of the world. Individuals involved in the IFNP select their primary discipline and graduate degree objectives in MIT departments including Nutrition and Food Science, Political Science, Economics, Urban Studies and Planning, and the Anthropology/Archaeology Section of the Humanities Department. IFNP is affiliated with the Office of International Health of the Harvard School of Public Health. Courses at MIT and Harvard are available to full-time students at either institution.

Primary activities of the IFNP include:

1
Graduate-level courses that provide comprehensive and in-depth analysis of problems and issues of primary significance in understanding the central role of nutrition in both national and international policy and development.

2
Applied and operational research including that to fulfill thesis requirements in a relevant discipline. Frequently the research is based on field activities in developing countries aimed at identifying and improving effective approaches to national and regional nutrition planning, and implementing and evaluating programs to combat problems of malnutrition among target populations.

3
Provision of advisory, program analysis and evaluation, and advanced training services to governments and international agencies dealing with specific aspects of nutrition planning, policy identification, and programming.

4
An International Food and Nutrition Policy advanced study program, in collaboration with the Office of International Health and relevant departments of the Harvard School of Public Health. Students with relevant disciplinary training and the capacity to influence the nutrition programs and policies of their countries are given an opportunity for highly multidisciplinary and practical training. This program receives 12 to 16 United Nations University Fellows per year and others sent by other international organizations, bilateral assistance agencies, foundations, and governments.

IFNP sponsors two weekly seminar series involving distinguished visitors, and multidisciplinary topics, a Summer Session Program, and two series of publications.

Further information may be obtained from Dr. Nevin S. Scrimshaw, Director of the Program, Room 20A-201, MIT, Cambridge, Massachusetts 02139, (617) 253-5101.

Laboratory for Computer Science

The Laboratory for Computer Science is an interdepartmental laboratory for research and development in computer science. The Laboratory includes 17 research groups, currently staffed by approximately 275 people including faculty, students, and staff members. The academic members of the Laboratory are from the Departments of Electrical Engineering and Computer Science, Humanities, Mathematics, Architecture, Division for Study and Research in Education, and the Sloan School of Management.

The Laboratory for Computer Science was established in 1963, for the advancement of time-shared computer systems. It developed the Compatible Time-Sharing System (CTSS), one of the first time-shared systems in the world, based on pioneering work at what was then the MIT Computation Center. Subsequently, the Laboratory developed Multics, an improved system that introduced several new concepts in time-sharing. These two major developments stimulated research activities in the application of on-line computing to such diverse fields as engineering, architecture, mathematics, biology, medicine, library science, and management. Since that time, the Laboratory's objectives have expanded, leading to research across a broad front of activities that now span four principal areas: 1) Knowledge-Based Programs; 2) Machines, Languages, and Systems; 3) Theory; and 4) Computers and People.

The Laboratory for Computer Science fosters participation in research by undergraduate and graduate students. Research assistantships are available to graduate students for work in all aspects of the research program, and undergraduates may work at the Laboratory under the Undergraduate Research Opportunities Program. Facilities are provided for thesis research and special projects to both graduate and undergraduate students. All jobs at the Laboratory are unclassified.

Further information may be obtained by contacting John J. Hynes, Room NE43-109, MIT, Cambridge, Massachusetts 02139, (617) 253-5828.

Laboratory for Information and Decision Systems

In the Laboratory for Information and Decision Systems fundamental and applied research is carried out in broad interdisciplinary areas closely coupled with graduate study. The major portion of the research effort falls in the following main areas: system science and control engineering, communication science and systems, and computer and information systems.

The research in the Decision and Control Sciences Group deals with theoretical advances in mathematical system theory, modern estimation, and control. Areas of intensive investigation are related to basic understanding of large-scale systems, decentralized control strategies, stochastic and adaptive control, reliable synthesis methods, distributed parameter systems, numerical methods, and bilinear systems. Concurrent with the theoretical investigations is a major effort to apply the state of the art to advanced application areas. Typical application areas currently receiving attention are: transportation systems, interconnected power systems, design of adaptive digital stability augmentation systems for aircraft, design of data management systems for failure detection and isolation, air traffic control, command-and-control systems, automotive engine control, and control of complex manufacturing processes. The application-oriented research is often done in collaboration with industry.

The research in the Communication Systems Group deals with broad theoretical and applied issues in communication theory, information theory, and related disciplines. A major research program deals with the basic understanding of analyzing and controlling data communication networks, with special emphasis on routing algorithms. Other research programs deal with fundamental issues in theory of images, digital signal processing algorithms, digital communications technology, and cable TV systems.

The research in the Computer and Information Systems Group deals with basic problems in the use of computers in complex information transfer and retrieval systems. A specific study involves the coupling of interactive information systems that interface heterogeneous data bases. Another study deals with the use of computers to problems related to newspaper operation and production (automated newspaper layout, digital storage of newspaper graphics). The use of computers, especially microprocessors, in several application areas (avionics, vehicle identification, traffic control, bioengineering) is also under intensive investigation.

Further information may be obtained by contacting the Director, Professor M. Athans, at (617) 253-6173, Room 35-308 or the Associate Director, Professor R. Gallager, at 253-2533, Room 35-204, MIT, Cambridge, Massachusetts 02139.

Laboratory for Manufacturing and Productivity

The Laboratory for Manufacturing and Productivity of the School of Engineering provides an interdisciplinary center for research and education in manufacturing and productivity at MIT. The goal of the Laboratory is advancement of the science and technology of manufacturing in three ways: through fundamental research leading to innovative manufacturing processes; conceptual breakthroughs in the understanding of planning, design, and production operations; and education of scientists and engineers trained in the synthesis as well as the analysis of manufacturing issues.

The Laboratory draws upon the wide range of expertise of faculty and staff in such departments as Mechanical Engineering, Electrical Engineering and Computer Science, Chemical Engineering, Materials Science and Engineering, and Ocean Engineering as well as the Center for Policy Alternatives and the Sloan School of Management. Equally important to the Laboratory are the experience and perspective contributed by the representatives of industrial firms associated with the Laboratory's cooperative research programs. Topics of current interest include:

Axiomatics: the establishment of a conceptually new approach to manufacturing decision making designed to facilitate rational design of products and optimization of manufacturing systems.

Polymer Processing

Flexible Materials Processing

Machine Dynamics

Manufacturing Resources: including not only innovative design of manufacturing processes in order to conserve energy, materials, and human resources, but also development of methods to analyze manufacturing systems and investigation of manufacturing policy and the social aspects of manufacturing.

Intelligent Machines

Tribology: the study of friction and wear

Computer-Aided Design/
Computer-Aided Manufacturing

Metals Processing

In addition to research projects sponsored by individual organizations, a large proportion of the Laboratory's work is supported by several consortia of industrial firms. Among these ventures are the MIT-Industry Polymer Processing Program, the MIT-Industry Flexible Materials Processing Program, the Machine Dynamics Program, and the MIT-Industry Manufacturing Resources Program. These programs, which deal with the generic issues involved in the field, offer exciting opportunities for basic research in areas of technological importance to industry.

Opportunities for undergraduate and graduate students are available for thesis research and a limited number of postdoctoral research positions also are available.

Additional information may be obtained from Professor N. P. Suh, Director, or Dr. M. B. Packer, Assistant Director, Room 35-136, MIT, Cambridge, Massachusetts 02139, (617) 253-2234.

Laboratory for Nuclear Science

The Laboratory for Nuclear Science performs basic research in nuclear and elementary particle physics, supporting research interests of faculty in the Department of Physics by maintaining and administering support facilities adapted to studies in high-energy and nuclear structure physics. The Bates Linear Accelerator, a high-intensity electron machine, has greatly extended the Laboratory's capabilities. In addition to MIT physicists, this facility is made available to other users on a nationwide basis. The Laboratory operates a computer facility available to staff and students. Among many projects are theoretical studies of the atomic nucleus and elementary particles; experimental programs using bubble chambers, wire chambers, and counter hodoscopes to study strong, electromagnetic and weak interactions of elementary particles and other high-energy phenomena; programs oriented toward the application of high-speed electronic computer techniques to the problems of nuclear and elementary particle data analysis; a broad program of nuclear studies using heavy-ion accelerators; and programs in radioactivity and in medium- and low-energy photonuclear and nuclear particle research. As part of the nuclear physics program, members of the Laboratory are engaged in experiments at the MIT Bates Linear Accelerator and the Brookhaven Tandem Accelerator. The high-energy physics program involves experiments at the Fermi National Accelerator Laboratory, the Brookhaven National Laboratory, the Stanford Linear Accelerator, and at the German high-energy electron-positron storage ring facility in Hamburg.

Further information may be obtained from Laboratory for Nuclear Science Headquarters, Room 26-505, MIT, Cambridge, Massachusetts 02139, (617) 253-2395.

Laboratory of Architecture and Planning

The Laboratory of Architecture and Planning (LAP) was created in 1973 as part of the School of Architecture and Planning for the purpose of fostering research which contributes to the understanding, education, and practice of architecture, planning, and closely related fields.

Projects currently administered by the Laboratory include: studies of energy conservation and appropriate technology; projects concerned with the development of techniques for assessing the environmental impacts of development and for mediating disputes concerning such developments; demonstrations of solar architecture; projects about neighborhood and community development; projects focusing on the use of media as a tool for public participation in community planning; and innovative approaches to communicating research findings to the public.

The LAP provides a range of continuing education opportunities for the architectural and planning professions. The Laboratory also promotes the integration of research into the educational environment of the School and the Institute through the sponsorship of lectures, seminars, and conferences; publication support, and a program of architecture case studies.

A significant feature of the Laboratory's method is its involvement of a wide variety of people and institutions both inside and outside MIT. These include faculty and students from MIT departments and centers, as well as from other educational institutions; the alumni of the School of Architecture and Planning; architectural and planning practitioners; and client groups, including firms, public agencies, and community organizations.

Further information may be obtained from the Laboratory, Room 4-209, MIT, Cambridge, Massachusetts 02139, (617) 253-1350.

Lincoln Laboratory

The Lincoln Laboratory, located in Lexington, Massachusetts, is a Federally sponsored center for research and development in advanced electronics, with special emphasis on applications to national defense. The Laboratory is staffed and operated by MIT.

Lincoln Laboratory activities extend from fundamental investigations in science, through technological development of devices and components, to the design and development of complex systems. A continuing program of research in advanced electronics techniques provides a background of experience and ideas for work in specific programs, as well as a source of new scientific and technological advances for civilian and military application.

Specific programs include space communications, re-entry studies and technology, seismic detection and discrimination of nuclear explosions, computer systems and digital signal processing, space surveillance, photovoltaic power systems, and air traffic control. Research also is conducted in the fields of optics, solid-state devices, radar systems, and integrated communication networks for speech and data.

Opportunities for research in many of these technical areas are available to MIT faculty members and qualified students. Inquiries may be directed to Dr. Melvin A. Herlin, Assistant to the Director, LIN A-163, extension 181-225.

Materials Processing Center

The formation of this Center emphasizes the growing interest and involvement of the materials community at MIT in technological problems relating to improved ways of producing and shaping materials so that they perform more effectively, with acceptable economic and social costs.

Center activities encompass all engineering materials including metals, ceramics, polymers, electronic materials, composites, superconductors, and thin films. The Center interacts with industry and government in seeking to develop, extend, and apply the scientific and technological base of materials processing, and to broaden its educational base.

An important underlying theme of the Center is that performance of materials can be controlled through control of internal structure, from the macroscopic to the atomic level. Another important theme is that economic and low-energy production of materials in a competitive world depends on rapid assimilation of many technologies into materials processing, and on modification and adaptation of materials processes to better utilize these technologies including distributed intelligence, robots, and concepts of systems engineering.

The Center is currently undertaking a broad range of research activities, and is developing new curricula, seminars, and continuing education programs. It encourages and sponsors specialized research and academic appointments, including the extended residence at MIT of industry and government personnel as visiting faculty, adjunct faculty, and post-doctoral researchers. Faculty and staff participate in the Center from a number of departments at MIT, principally the Departments of Materials Science and Engineering, Mechanical Engineering, Electrical Engineering and Computer Science, and Chemical Engineering.

Further information may be obtained from Professor M. C. Flemings, Director, at (617) 253-3233, Room 8-407; Professor H. K. Bowen, Associate Director, at 253-6892, Room 12-011C; or Dr. G. B. Kenney, Assistant Director, at 253-3244, Room 4-415, MIT, Cambridge, Massachusetts, 02139.

Mining and Minerals Resources Research Institute

In recent years there has been a reawakening as to the importance of mineral resources, and their engineering and management, to the well-being of modern industrial society. The Mining and Minerals Resources Research Institute (MMRRI) at MIT has been established with support from the Office of Surface Mining under the control of the US Department of the Interior. The support includes an annual institutional grant, funding for a limited number of fellowships and scholarships, and support of research, the last being obtained through proposals which are made to the Department of the Interior. A major responsibility of the MMRRI is to support the interdisciplinary activities related to mineral resources at MIT for both undergraduate and graduate students, and to bring to the attention of the community opportunities for careers in mineral resources engineering and management. The MMRRI at MIT also has the responsibility for developing a coordinated program on mineral resources among MIT and several other universities in Massachusetts, in particular, the University of Massachu-

setts and Boston College. Information on the various activities of the Mining and Minerals Resources Research Institute may be obtained from the Office of the Director, Room 4-140, MIT, Cambridge, Massachusetts 02139, (617) 253-3305.

Neurosciences Research Program

The Neurosciences Research Program (NRP) is an international, interdisciplinary, and inter-university organization of scientists operating as a research center of MIT. Its main purpose is to facilitate and promote the development of theoretical interpretations bridging the gaps separating the data and concepts of traditional scientific disciplines engaged in research on the nervous system at its various levels of organization: molecular, cellular, neurophysiological, and behavioral. Theoretical breakthroughs are essential if the flood of new information is to be transformed into a scientific understanding of how the nervous system mediates the behavior of animals, including the mental life of human beings.

The NRP consists of a center staff located in Boston, Massachusetts, in Brandegee House, and operating with the advice and guidance of almost 40 scientists in various parts of the world (NRP Associates).

Further information may be obtained by contacting F. G. Worden, Director, 165 Allandale Street, Jamaica Plain Station, Boston 02130, (617) 522-6700.

Nuclear Reactor Laboratory

The Nuclear Reactor Laboratory (NRL) provides the focus for a wide range of research programs which involve the use of nuclear radiations. Research programs in various MIT departments and centers including Physics, Materials Science and Engineering, Earth and Planetary Sciences, Chemical Engineering, Nuclear Engineering, and Nutrition and Food Science are made possible and supported by the capabilities in the NRL. Outside institutions also make use of the unique facilities.

Current areas of research include: applications of nuclear trace analysis to problems in the physical and engineering sciences, in the life sciences, geosciences and the environment; neutron and nuclear physics; neutron scattering studies of solids, liquids, and dense gases; radiation effects on materials, bulk and near surface radiation damage studies of nuclear and fusion reactor materials; reactor physics and reactor engineering; nuclear medicine; and isotope development.

Facilities of the Nuclear Reactor Laboratory are also used for teaching activities by several departments and other institutions. The NRL also provides special services to regional hospitals and industries, e.g., short-lived isotopes for medical purposes, where these services are not readily available from other sources.

The NRL operates a 5-million watt research reactor (MITR-II), originally completed in 1958, which is one of the largest university reactors. Recent redesign and rebuilding of MITR-II has significantly enhanced this reactor's capabilities.

Experimental facilities and instrumentation at the NRL include: neutron diffractometers, 2 and 3 axis, polarized beams, spin flippers; neutron inelastic scattering spectrometers; a neutron interferometer; magnetic and cryogenic sample control; a wide variety of sample irradiation facilities with fast and slow neutron fluxes up to 10^{14} per cm^2 and sec; a temperature-controlled in-pile facility which allows simultaneous neutron and ion bombardment; and a fast reactor blanket facility.

Other experimental facilities and instrumentation include: a thermal column with large hohlraum; radiochemistry laboratories; hot cells for dismantling or testing, including mechanical property measurements; a variety of nuclear detection equipment and software; trace analysis facilities; a materials characterization laboratory with equipment for mechanical property measurements and microstructural characterization; and shielded hot cells for handling and testing radioactive materials.

The Nuclear Reactor Laboratory provides facility users with both scientific and technical assistance as required for the optimum use of NRL facilities.

A current summary report is available which describes the activities at the NRL in greater detail. For information, inquire at the office of the Director, Room NW12-208, MIT, Cambridge, Massachusetts 02139, (617) 253-4201 or 253-4202.

Operations Research Center

Operations research seeks to build a science and technology of decision making. The field is concerned with the operational and systems aspects of engineering, scientific, and management problems. For example, operations research deals with the optimal geographic location of nuclear power plants rather than the design of nuclear reactors; the management, organization, and scheduling of production rather than the technology of machines; and the collection, allocation, and distribution policies of a blood bank rather than the chemistry of preserving blood. In these and other cases, the operational analysis of a system may influence the technological developments, and vice versa, so that operations research studies are frequently interdisciplinary in character and may arise in widely different fields. Operations research also is concerned with the mathematical abstraction and analysis of the methods used in these studies.

The Operations Research Center, established in 1953, provides educational and research opportunities for students and faculty interested in the interdisciplinary field of operations research. Varied programs leading to the master's and doctoral degrees with emphasis on either applied or theoretical areas are available.

The Center interacts with faculty members from all the Schools at MIT; its staff members and students are affiliated with numerous departments, including Urban Studies and Planning, Management, Mathematics, Physics, Aeronautics and Astronautics, Electrical Engineering and

Computer Science, and Civil, Mechanical, and Ocean Engineering.

For more information on graduate programs in operations research, see the section on Operations Research under Interdepartmental Graduate Study.

Plasma Fusion Center

The Plasma Fusion Center, formed in 1976, provides an intellectual and administrative focus for experimental and theoretical studies in plasma fusion physics and related engineering disciplines. The primary objective is to provide the strong technical and administrative leadership required for effective coordination and implementation of all Department of Energy sponsored fusion research at MIT. The timely development of fusion energy is one of the most urgent and technically complex challenges facing society.

Outstanding technical excellence keynotes administrative and technical decisions made by the Plasma Fusion Center, along with providing the intellectual environment that fosters and encourages independent creativity, and integrating the collective fusion activities into a cohesive program. The Plasma Fusion Center also works closely with the Institute administration to achieve the following broader Institute goals:

— To provide, both nationally and internationally, the strong technical leadership required for the timely development of fusion energy;

— to provide the intellectual environment for the expert educational training of students and research scientists and engineers.

Fusion research activities fall into four major programmatic Divisions.

Fusion Systems. The objective of this Division is to identify and investigate the technological problems associated with fusion reactors and advanced fusion systems and explore the possibility of mitigating technological constraints by optimal choice of plasma physics regimes. The subprogram areas include: safety and environmental studies, blankets and structures, gyrotron and advanced millimeter source development, tokamak system studies, and millimeter and submillimeter wave detector development.

Fusion Technology and Engineering. This Division aims to provide critical engineering support for operating confinement experiments and advanced design projects. It also develops advanced superconducting magnet technology for the national fusion program. The subprogram areas include: project engineering and advanced design, superconducting magnet development, superconducting materials development, and divertor development.

Applied Physics Research. The aim of this Division is to develop the basic experimental and theoretical understanding of plasma heating and confinement properties. The subprogram areas include: basic experimental research on tokamak and mirror systems, advanced fusion concepts, fusion theory and computations, MACSYMA, diagnostics and laser development, and intense-charged particle beam research.

Confinement Experiments. This Division develops practical understanding of the stability transport and radiation properties of high-temperature fusion plasmas at near-reactor conditions and methods for heating plasmas to fusion temperatures. The subprogram areas include: ALCATOR A and ALCATOR C.

Compact high-field (magnetic field) toroidal field confinement experiments have dominated the experimental program to date. Recently, work on Torsatrons, an offshoot of stellarator research, has been undertaken, and plans for the construction of a new tandem mirror facility are underway. MIT's first ALCATOR machine, ALCATOR-A, has established a number of world records in obtaining the highest value for the product of plasma density times confinement time. A second machine, the recently completed ALCATOR-C, is expected to achieve higher values even closer to those required for a breakeven fusion device. Two smaller machines, VERSATOR-II and CONSTANCE-II, are used to study particular aspects of toroidal and mirror-confined plasmas, respectively. Other work related to this family of phenomena is being pursued. Conceptual designs for fusion reactors are undertaken, and the program has a balance between experimental and theoretical studies. Fusion activities in the Departments of Aeronautics and Astronautics, Electrical Engineering and Computer Science, Materials Science and Engineering, Mechanical Engineering, Nuclear Engineering, and Physics are affiliated with the Plasma Fusion Center.

People interested in exploring the interdepartmental aspects of the Plasma Fusion Center should contact Dr. Ronald C. Davidson, Director, MIT Plasma Fusion Center, NW16-202, Cambridge, Massachusetts, 02139, (617) 253-8102.

Research Laboratory of Electronics

Established at the end of World War II as the Institute's first interdepartmental laboratory, the Research Laboratory of Electronics has evolved an on-campus research environment which seeks to provide faculty members and their students with the diverse services and facilities of a large laboratory. Participants from approximately 10 academic departments conduct research in three broad areas: general physics, plasma dynamics, and communication sciences. At present there are approximately 20 research groups.

Research in **general physics** is primarily concerned with the structure of matter, in all its forms. This work covers a wide range of topics in atomic and molecular physics, and in condensed matter science. The experimental techniques used in these studies include radio frequency and optical spectroscopy, X-ray scattering, laser light scattering, photo-acoustic spectroscopy, and nonlinear optics. The laser is a primary tool in many of these investigations.

The **plasma dynamics** program seeks to understand the basic properties of ionized media. Plasmas are the most common ingredient of the universe; they also play a crucial role in controlled thermonuclear fusion. Research in this area includes studies of plasma turbulence, heating, confinement, and stability. Plasma diagnostic techniques involve measurements in various portions of the electromagnetic spectrum (microwave, millimeter wave, infrared, optical).

Research in **communication sciences and engineering** spans a broad range of topics pertinent to communication processes in manufactured and living systems, as well as interactions between them. Fundamental studies of signals and systems are coupled with various applications such as speech and picture transmission, seismic detection, and optical communication channels.

Almost all of the research in RLE is conducted or supervised by academic faculty members and students. Approximately 100 members of the faculty are affiliated with the Laboratory, and work with 250-300 graduate students and 50-100 undergraduates. Because the research in RLE includes such a broad spectrum of topics it provides opportunities for a wide variety of student thesis projects.

Additional information may be obtained by contacting the Director's Office, Room 36-413, MIT, Cambridge, Massachusetts 02139, (617) 253-1557.

Sea Grant College Program

Dedicated to advancing the vital roles of engineering and science in the development of ocean and coastal resources, the Sea Grant Program funds, promotes, and coordinates multidisciplinary research projects, educational opportunities, and advisory services. Following the lead of the National Sea Grant Program, created by Congress in 1966 to foster innovative and wise use of America's coasts, continental shelf, and offshore waters, MIT recognizes the need to respond to opportunities in the marine field, and to solve current technological, economic, social, and political problems caused by our increasing and conflicting uses of the seas. The designation in 1976 of MIT as the nation's twelfth Sea Grant College, the first private institution to achieve this distinction, strengthened the Institute's commitment to furthering wise use and development of the ocean's resources.

The Sea Grant research program reflects the conviction that the Institute's expertise and facilities, applied to improving and to understanding scientific and engineering methodologies and nontechnological and environmental constraints, can solve critical problems in marine resource utilization and coastal zone development. Sea Grant research strives for balanced use of oceans and coasts, greater harvests of food and useful materials from the sea, the prudent extraction of offshore oil and undersea minerals, and the application of engineering to improved methods of working in and on the seas.

In addition to research, the Sea Grant Program supports innovative education at MIT in ocean utilization and coastal zone development. Each year, an interdisciplinary design subject and an ocean engineering laboratory provide graduate and undergraduate students with the chance to apply classroom knowledge to "real-world" situations. The Program has supported pioneering textbooks and new curricula in and related to the field of ocean engineering. A recently started project is providing new educational opportunities for professional fishermen.

MIT Sea Grant's Advisory Services publish technical reports on the Institute's marine research projects, sponsor symposia and lectures on ocean-related topics, and through outreach activities work with local governments, business, and organizations to transfer technology to the public. The Advisory Services staff supplies comprehensive information on many facets of resource development in the oceans and coastal zones, and fosters a strong linkage between MIT and marine industries.

More information on Sea Grant Program projects and services may be obtained by contacting Mr. Dean A. Horn, Director, or Ms. Elizabeth T. Harding, Communications Manager, (617) 253-3461.

Statistics Center

The Statistics Center provides educational and research opportunities for students and faculty interested in statistics, biostatistics, and econometrics. Access to statistical expertise is provided by the Center's Statistical Consulting Service and collaborative research activities.

The Center interacts with faculty members from all the Schools at MIT; its staff members and students are affiliated with many departments and interdepartmental centers, including Mathematics, Management, Economics, Nutrition and Food Science, Center for Transportation Studies, Center for Computational Research in Economics and Management Science, and the Operations Research Center. There are also usually several visitors in residence.

Current ideas of active theoretical research include sequential analysis, robust regression, log-linear models, time-series analysis, detection of influential data, cluster analysis, information retrieval, and statistical computing and graphics. Areas of application include nuclear reactor safety, energy demand models, toxicology, environmental statistics, fingerprint analysis, weather prediction, clinical trials, reliability of econometric models, and the analysis of actuarial data.

More information about research, consulting, and educational activities may be obtained by contacting the Statistics Center, Room E40-140, MIT, Cambridge, Massachusetts 02139.

Technology Adaptation Program

The Technology Adaptation Program (TAP) is concerned with the following:

developing an understanding of the characteristics of technologies that are appropriate to countries in various stages of development;

identifying criteria for the selection and adaptation of technologies appropriate for use in developing countries;

understanding the processes by which technological knowledge and skills can be effectively introduced, disseminated, and used in developing nations; and

determining the long-term and short-term social and economic consequences of importing technologies rather than improving those which are indigenous.

TAP is administered by a Policy Committee which draws its members from the Schools of Engineering, Humanities and Social Science, and the Sloan School of Management. Members of the faculty who either have, or have had, specific research projects under the sponsorship of this program come from the following departments: Aeronautics and Astronautics, Architecture, Civil Engineering, Economics, Electrical Engineering and Computer Science, Materials Science and Engineering, Mechanical Engineering, Political Science, Sloan School of Management, and the Energy Laboratory.

The MIT/Cairo University Technological Planning Program was initiated in 1976, under TAP auspices, to assist Cairo University in developing capabilities which could contribute to the formulation and implementation of science- and technology-related policies, to the end of aiding in the realization of Egyptian development goals. Three specific objectives have been identified: mobilization of academic interest in applied research on specific development plans; organization of technical research in collaboration with Egyptian government ministries; and establishment of an institutional framework through which permanent applied research and training capability can be organized.

Graduate students from various departments participate under faculty supervision in the research carried on under this program.

Further information may be obtained from the TAP Administrative Office, Room 39-525, MIT, Cambridge, Massachusetts 02139, (617) 253-7227.

Wallace Astrophysical Observatory

The George R. Wallace, Jr. Astrophysical Observatory is a versatile facility for research and teaching in optical astronomy, one of the oldest branches of science. It directly supports the growing student and faculty interest at MIT in astronomy and related sciences.

Located in Westford, Massachusetts, the nucleus of the facility is a 24-inch optical telescope and its associated computer, which permits the monitoring and real-time reduction of data outputs. A 16-inch telescope primarily for instruction purposes has also been installed, providing the Observatory with the flexibility to support a range of activity from observation to instruction, including the testing of new instrumentation and methods of data analysis. Several departments of the School of Science and the School of Engineering participate in the work of the Observatory, along with interdepartmental centers and laboratories on the campus.

Further information may be obtained by contacting Professor James L. Elliot, Room 54-422, MIT, Cambridge, Massachusetts 02139, (617) 253-7556.

Wallace Geophysical Observatory

The George R. Wallace, Jr. Geophysical Observatory is a unique research facility designed to monitor ground motions and to aid in the development and testing of new seismic and other geophysical instrumentation. It is the center of activity for MIT's 10-station network in New England.

The Observatory, located 35 miles north of Boston in Westford, Massachusetts, has a large, multi-room underground vault and a surface control room. The vault has a controlled temperature environment and instrument piers resting directly on the basement granite. The Observatory contains sensitive seismometers and instruments for monitoring ground tilts and the earth's tidal motions. The surface building houses a work area and control and recording instruments, although most of the data is telemetered directly to the Department of Earth and Planetary Sciences for recording and analysis. Data from the Observatory along with the numerous resources of the Department provide students and staff with a unique facility to pursue research concerning the interior of the earth.

Further information may be obtained by contacting Professor M. Nafi Toksöz, Room 54-518, MIT, Cambridge, Massachusetts 02139, (617) 253-6382.

Other Opportunities

A number of research organizations in the Boston-Cambridge area have close ties with MIT faculty members which may lead to opportunities for interdepartmental research. In particular, the Charles Stark Draper Laboratory which maintains a relationship with the Institute that permits students to engage in joint research activities.

Draper Laboratory

The Charles Stark Draper Laboratory (formerly the Instrumentation Laboratory) separated from MIT on July 1, 1973 to become an independent nonprofit research and educational organization. Both MIT and the Laboratory recognize the mutual advantages of maintaining close and special relationships, and mechanisms exist to permit the continuation of joint research activities and to allow the Laboratory to continue its unique contributions to the Institute's educational program.

The professional field of interest has traditionally been the instrumentation of practical problems in dynamic geometry — e.g., guidance and control of aerospace and marine vehicles. The Laboratory is mission oriented in that its goal is the design, development, and realistic testing of the theory, components, subsystems, systems, and their interrelationships that lead to a complete operational system. Probably the most publicized achievement of the Laboratory has been the technical development and supervision of the production and operation of Apollo guidance and control systems. During the past several years, the Laboratory has been broadening its areas of activities in instrumentation to other fields such as geophysical and oceanographic engineering that have a growing need for the application of the Laboratory's unique talents and resources. These new activities are expected to continue to grow in the future, as the needs and benefits for improved instrumentation are recognized and acknowledged.

The Laboratory experience in instrumentation has introduced information processing requirements resulting in new computer science activities and software applications in industrial automation, control for advanced energy systems, and specialized communication.

A number of MIT faculty members maintain a close association with the Laboratory, and thesis research opportunities exist which fulfill the residency requirement for an MIT degree in all phases of systems engineering beginning with basic theory, mathematical analysis, computer studies, component design and evaluation (mechanical, electrical, and optical), and system synthesis. These areas of research are live and up-to-date, with the student in direct daily association with the professional staff of engineers and scientists of the Laboratory. In this way, the student learns to appreciate the economic and human, as well as the technical, aspects of a system. Students also may be employed by the Laboratory and work directly on a project. These opportunities provide an excellent technical internship which greatly broadens the student's educational experience.

CSDL, within walking distance of the main campus, is located at 555 Tech Square, Cambridge, Massachusetts 02139. Further information may be obtained by contacting Dr. Rudrapatna V. Ramnath, (617) 258-2393, or Institute extension 182-82393.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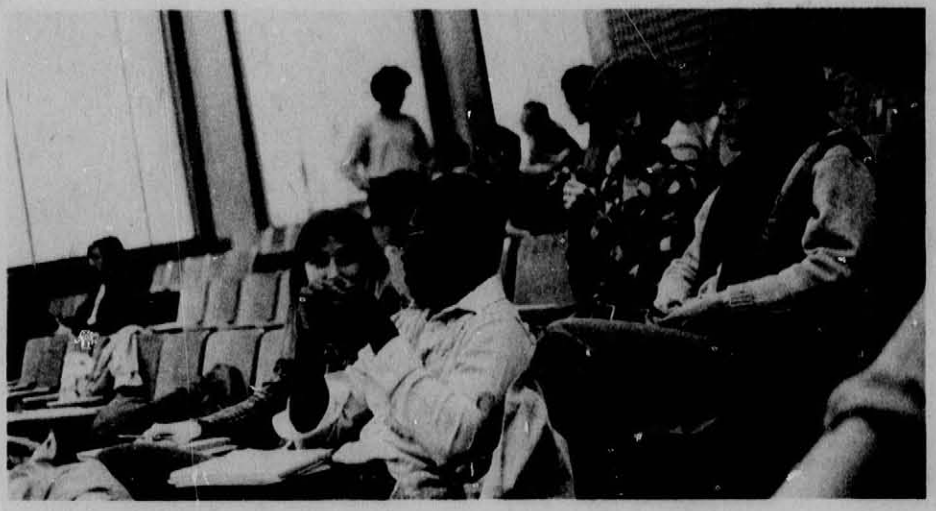
VI Departmental Programs and Requirements

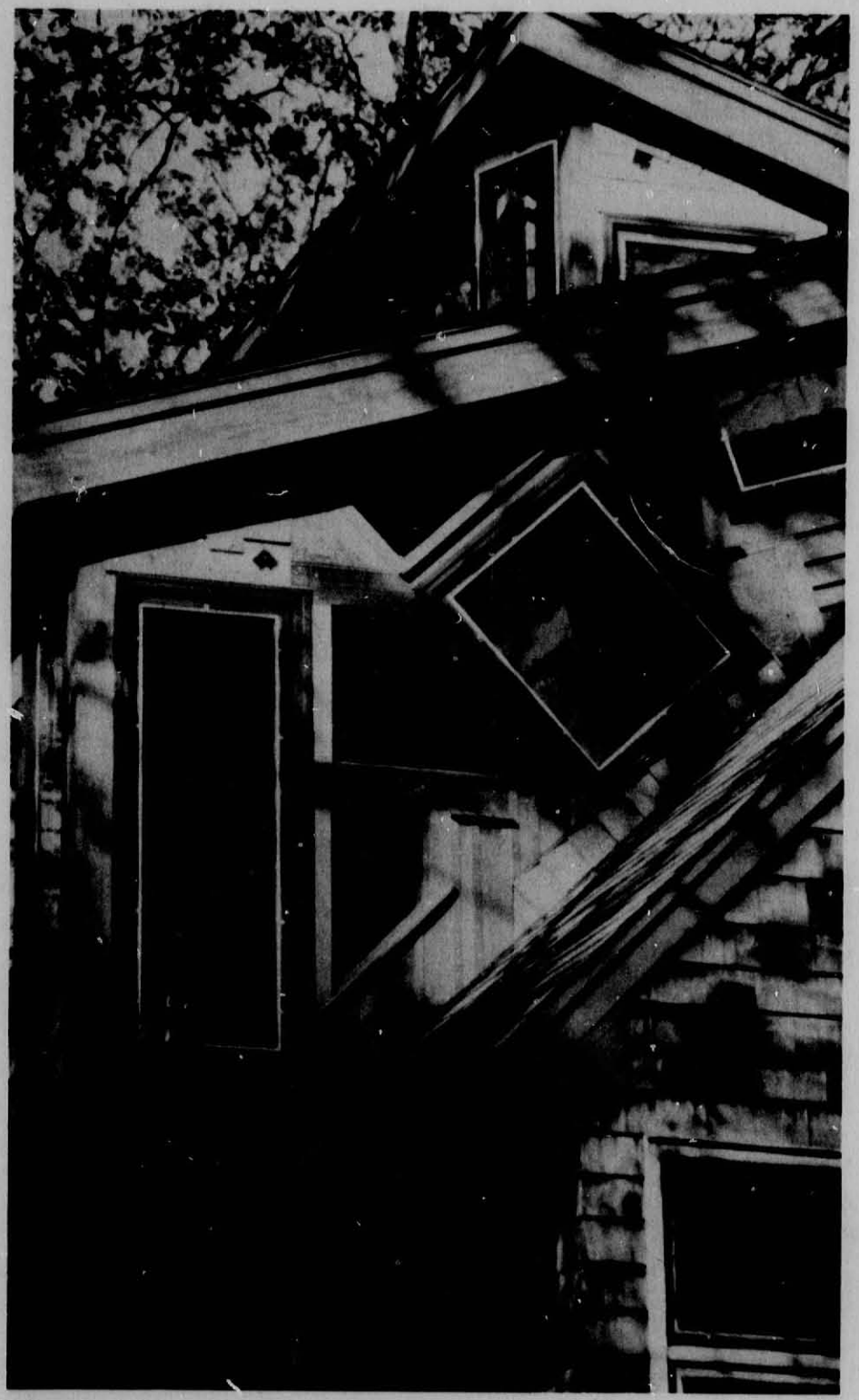








School of Architecture and Planning



The School of Architecture and Planning offers educational programs that will prepare students for practice, research, and further study on the frontiers of professions that determine the form and quality of the physical environment and shape social and environmental policies and opportunities. The programs are intended to prepare students to understand and structure successfully the complex interaction of cultural influences, social policies, human requirements, and aesthetic values that are an integral part of social and environmental change.

The School offers undergraduate, graduate-professional, and doctoral programs in architecture, visual arts, and planning. Special mid-career programs allow students to formulate curriculum plans that meet their particular requirements. Consequently, the School must select students who will exercise a high degree of responsibility and initiative in the formulation of their educational career plans.

Degrees and Special Programs

The Department of Urban Studies and Planning offers an undergraduate S.B.; a graduate professional M.C.P., recognized by the National Education Development Committee of the American Planning Association; and the Ph.D. It also offers a five-year S.B./M.C.P. program for undergraduates. The Department's special programs include the Community Fellows Program and the Special Program for Urban and Regional Studies (SPURS). These programs allow mid-career practitioners who work in urban and regional development from minority communities in the US and developing countries to study and do research independently during one academic year.

The degree programs now offered by the Department of Architecture include: Bachelor of Science in Art and Design; Master of Architecture, accredited by the National Architectural Accrediting Board; Master of Science in Architectural Studies; Master of Science in Visual Studies; and the Ph.D. program which focuses in the area of history, theory, and criticism of architecture, art, and environmental

studies. In addition, courses are offered through the Harvard/MIT Aga Khan Program for Islamic Architecture.

Members of both departments offer subjects during MIT's Independent Activities Period. In conjunction with the Harvard Graduate School of Design there is a small program of continuing education throughout the year.

At the undergraduate level the departments offer both preprofessional and general educational programs in architecture, art, and urban studies and planning. Undergraduate concentrations are available in Environment and Policy in both departments. While they are not preprofessional, these programs may be preludes to work and graduate education in a number of different fields.

Arts and Media Technology

In addition to the scholarly study of history, theory, and criticism, the School offers studio experience in direct visual expression. There are five programs in Arts and Media Technology. The Creative Photography Laboratory, the Visible Language Workshop, the Film Section, and the Architecture Machine Group combine teaching, practice, and research in publication, graphics, film and photography. The Center for Advanced Visual Studies, in association with the Department of Architecture, provides an opportunity for students to work on art projects at an environmental scale. This nucleus offers possibilities for undergraduate concentrations in the visual arts, and attracts students from other MIT Schools and departments.

Departmental Interaction

Departmental self-sufficiency is balanced by strong interaction with other academic units at MIT. Several faculty members hold joint appointments in both departments in the School. Others have joint appointments in departments outside the School such as Economics, Psychology, Civil Engineering, and Humanities. Teaching and research in several areas such as urban economics, building construction, energy, communications, law, operations research, and the arts are linked to other parts of the Institute. Students and faculty from the Departments of Architecture, Urban Studies and Planning, and Mathematics, and the Schools of Management and Engineering work together on research projects in solar energy, transportation, and resource planning.

Research and Field-Related Opportunities

The School's research, amounting to $2.16 million last year, offers important educational opportunities for students. As research assistants, students not only carry out work on existing projects but also help to formulate ideas for new proposals.

Current research reflects the wide spectrum of student and faculty interests. These include: a study of reinvestment in urban neighborhoods; a study of the design professional's representations of public space, urban form, and human activity; the development of a large computer-based model for the purpose of informing regional development policy choices; study of the effect of housing and its environs on the elderly; the study of passive solar energy systems; computer graphics for design; land use and facilities siting; multi-regional input/output analysis of transportation; and national housing goals. Many of these research projects are administered through the Laboratory of Architecture and Planning which fosters the growth and development of research in the School. Research, particularly in the field of housing policy, is also conducted at the Harvard-MIT Joint Center for Urban Studies.

In architecture and planning, students have had a wide variety of field-related experiences including programming public services for the City of Cambridge; providing research assistance to Boston neighborhood organizations; staffing citizen land use planning organizations; and providing advocacy planning and design assistance for groups that traditionally have been restricted in their use of the environment or access to professional services. Students have worked for a variety of government and private agencies, including the Office of State Planning; the Department of Mental Health; local government planning, finance, and housing committees; and design, construction, and planning firms. Additional opportunities for student fieldwork have been provided through research and community service projects and internship programs in US government agencies.

Students

In 1980-81 there were 470 students in the School — 276 in architecture and 194 in planning — of whom 20 percent were undergraduates. The backgrounds, undergraduate majors, and job experiences of the students entering the graduate programs vary. The School also serves a large number of students, particularly undergraduates, from other departments at MIT. A limited number of non-degree special students are also admitted to the departments each term for the study of particular subject areas and the development of specialized skills.

The School encourages shifts in its composition in response to the necessity for minorities and women to become effective architects, artists, planners, researchers, and teachers. Minority graduate students, including Puerto Ricans, blacks, Chicanos, and Asian Americans, comprised approximately 21 percent of the total 1980-81 enrollment. Within the graduate degree programs, almost half of the students were women.

Office of the Dean

Jean Pierre de Monchaux, M.Arch.
Professor of Architecture and Urban Planning
Dean

Lois A. Craig, B.A.
Associate Dean
Principal Research Associate

Barbara Barlow
Assistant to the Dean

Michael Joroff, M.C.P.
Director, Laboratory of Architecture and Planning

Department of Architecture

Julian Beinart, M.C.P., M.Arch.
Professor of Architecture
Head of the Department

Leon Sennett Groisser, Sc.D.
Professor of Structures
Executive Officer

Professors

Wayne V. Andersen, M.Arch., Ph.D.
Professor of the History of Art

Stanford Anderson, M.Arch., Ph.D.
Professor of History and Architecture

Jean Pierre de Monchaux, M.Arch.
Professor of Architecture and Planning
Dean, School of Architecture and Planning

Horacio Caminos, Arq.
Professor of Architecture

N. John Habraken, B.I.
Professor of Architecture

Imre Halasz, Dipl. Arch.
Professor of Architecture

Adel A. Ismail, Ph.D.
Aga Khan Visiting Professor

Richard Leacock, D.F.A.
Professor of Cinema

John Randolph Myer, B.Arch.
Professor of Architecture
(On leave, fall)

Nicholas Peter Negroponte, M.Arch.
Professor of Computer Graphics

Otto Piene, M.A.
Professor of Visual Design
Director, Center for Advanced Visual Studies

William Lyman Porter, M.Arch., Ph.D.
Professor of Architecture and Planning

Robert Ormerod Preusser
Professor of Visual Design

Maurice Keith Smith, B.Arch.
Professor of Architecture
(On leave, spring)

Waclaw Piotr Zalewski, D. Tech. Sci.
Professor of Structures

Associate Professors

Edward Blair Allen, M.Arch.
Associate Professor of Architecture
(On leave)

Michael H. Burgoyne, B. Arch., Ph.D.
Aga Khan Visiting Associate Professor

Muriel Cooper, B.F.A.
Associate Professor of Visual Studies

Eric Dluhosch, M.Arch., Ph.D.
Associate Professor of Building Technology

Richard Filipowski, B.A.
Associate Professor of Visual Design

David Hodes Friedman, Ph.D.
Associate Professor of History and Architecture

Sandra C. Howell, Ph.D.
Associate Professor of Behavioral Science in Architecture
(On leave, spring)

Shun Kanda, M.Arch.
Associate Professor of Architecture

Tunney F. Lee, M.Arch.
Associate Professor of Architecture and Urban Planning

Starr Ockenga, M.F.A.
Associate Professor of Photography

Robert J. Slattery, M.Arch.
Associate Professor of Architecture

Chester Lee Sprague, M.Arch.
Associate Professor of Architecture
(On leave, fall)

Jan Wampler, M.Arch.
Associate Professor of Architecture

Assistant Professors

Harvey J. Bryan, M.Arch.
Assistant Professor of Building Technology

Nabeel Hamdi, Dipl. Arch.
Assistant Professor of Housing Design

M. David Lee, M.Arch.
Assistant Professor of Architecture and Urban Planning

Andrew Lippman, M.S.
Assistant Professor of Media Technology

Ronald L. MacNeil, M.F.A.
Assistant Professor of Visual Studies

Edward Robbins, Ph.D.
Assistant Professor of Anthropology in Architecture

Kenneth R. Sloan, Jr., Ph.D.
Assistant Professor of Computer Graphics

Beeke Sell Tower, Ph.D.
Assistant Professor of the History of Art

Barry Zevin, M.Arch.
Assistant Professor of Architecture

Adjunct Professors

Giancarlo De Carlo, L.A.
Adjunct Professor of Architecture

Robert Bradford Newman, M.Arch.
Adjunct Professor of Environmental Controls

William M.C. Lam, B.Arch.
Adjunct Professor of Environmental Controls

Richard Chester Tremaglio, M.Arch.
Adjunct Professor of Architecture

Principal Research Associate

Timothy E. Johnson, S.M.

Research Associates

Richard A. Bolt, Ph.D.
Reinhard Goethert, M.Arch.

Lecturers

Nishan Bichajian
Gunter Nitschke, Dipl. Arch.

Technical Instructors

Ignacio Garabieta-Orueta, Dipl.
William F. Kelley, B.B.A.
Theodore P. O'Brien, Jr.
Lynn Silverman, M.A.
Joel Slayton, M.A.
Brian Swift, M.F.A.

Administrative Officer

Anne Shepley, B.A.

Assistant to the Head of the Department

Nancy Jones, B.A.

Administrative Assistants

Linda Laplante, M.A.
Beth Luchner, M.A.

Professors Emeriti

Lawrence Bernhart Anderson, M.Arch.
Professor of Architecture, Emeritus
Dean of the School of Architecture and Planning, Emeritus

Herbert Lynes Beckwith, M.Arch.
Professor of Architecture, Emeritus

Pietro Belluschi, Dott.Ing., LL.D., Sc.D., D.F.A.
Professor of Architecture, Emeritus
Dean of the School of Architecture and Planning, Emeritus

Eduardo Fernando Catalano, M.Arch.
Professor of Architecture, Emeritus

Albert George Henry Dietz, Sc.D.
Professor of Building Engineering, Emeritus

Gyorgy Kepes, M.A.
Institute Professor, Emeritus
Professor of Visual Design, Emeritus
Director, Center for Advanced Visual Studies, Emeritus

Department of Architecture

The Department of Architecture includes a number of diverse fields of interest in architecture and the arts. The education that it offers encourages students to combine theoretical interest with tangible application and to consider the social consequences of their work. The diversity of attitudes and working methods found in these fields enriches a student's experience in the Department and suggests a variety of alternative career paths. Undergraduate and graduate students have the opportunity to structure their own academic programs to suit their special aptitudes and interests within an overall curriculum framework. While there are general distribution requirements and specific degree program requirements, it is possible to concentrate on any of these departmental fields: architectural design, building technology, the visual arts, and the history, theory, and criticism of architecture.

The Architectural Design curriculum for undergraduates and for graduate students provides a flexible framework for study which places responsibility on the students individually to define their own educational directions. There is no single core curriculum. In each of the three levels of design studios, students have the opportunity to choose among several offerings which reflect some of the range of interests in the Department. Though the faculty members who conduct or participate in these studios may have intellectual and professional concerns that incorporate many areas in the Department, studio offerings usually relate to the following general areas.

Studios concerned with the Built Form of the physical environment work with additive processes for the design and construction of environments responsive to people's needs and activities. Another group of studios pays special attention to the users of the physical environment, often by concentrating on specific client groups including the handicapped, the elderly, the poor, minorities, and urban populations in developing countries. The field of Environmental Design extends the concern for users to a scale embracing both physical and institutional design; this area of the Department is closely allied with the Department of Urban Studies and Planning.

Studio offerings in all interest areas can and do establish ties to real world issues through investigation of actual building sites and/or programs, or through connection with ongoing departmental research in social and technological issues in architecture. The Department believes that through exposure to varying approaches to architecture, students can better select and define their own roles in the architectural world.

Students, faculty, and research staff in Design Technology principally use the School's computer center to experiment with modeling techniques, graphic representations, and design methods. Students may take subjects in this area and may participate in the research work which is concerned with developing the computer's capabilities in assisting with the design process.

Building Technology includes research and teaching in building structures, construction processes, industrialized building systems, acoustics, energy in buildings, and solar architecture. Members of the building technology faculty offer subjects examining the technical or contextual aspects of their fields, and also either conduct or participate in architectural design studios. Students may then, for example, have the opportunity both to study problems of energy resources and technologies, and to use what they have learned in designing physical environments.

The character of each arts program in the Department of Architecture reflects the interests and directions of its faculty and students, and its position within the Department and within the Institute's scientific and technological community. Each of the arts fields offers a full range of subjects which may be followed independently or in conjunction with other programs. These fields include: Film and Video, Photography, Visible Language Workshop, Environmental Art, and Visual Design, and are related to History, Theory, and Criticism. In these programs, students explore the potentialities and technical imperatives of the media being used through direct involvement in workshop contexts; these practical studies are supplemented by analytical, critical, and introspective studies which are concerned with the relation of the work to the maker, the viewer, the user, and the subject. In becoming familiar with both expressive and technical means offered by the medium, the student acquires the ability to form and transmit new discoveries about the environment.

The existence of these arts activities in the context of the Department and of the Institute also offers diverse interdisciplinary opportunities which are important to the intellectual life of the School. These opportunities, as illustrated by the following examples, span disciplines and interests within the Department, among departments, and even between beginning and advanced professional levels. The Visible Language Workshop, for instance, combines interests in publications media shared by photographers, visual designers, and others in the Department. Architecture students may explore the film medium as a tool in programming and design processes. Students in architecture, visual design, or environmental art may become involved in some of the research conducted at the Center for Advanced Visual Studies.

Undergraduate Study

The History, Theory, and Criticism program is organized in two parts for the study of art and of architecture and urban form. Studying history, theory, and criticism is important for artists and architects because it offers ways of developing and organizing concepts and because it increases one's understanding of the physical and social context of one's work. The faculty are most concerned with the creative process itself, both in understanding the meanings of an artist's or architect's actions, and more importantly, in being able to contribute directly to analytical and design processes. Thus, some of the faculty in this field work in conjunction with design studios.

The History of Architecture offerings deal with social and physical contexts of the built urban environment on many scales. While not limited to any particular period of time, they generally focus on examining contexts and developing analytical methods that are important to contemporary understanding and that influence the basic premises on which architects work. Students encounter history, theory, and criticism of film and photography mainly through those arts programs. Interdisciplinary history subjects also are offered. Advanced work in history, theory, and criticism is possible through the Department's Ph.D. program in Architecture, Art, and Environmental Studies.

The Department offers two undergraduate courses of study: Course IV, leading to the Bachelor of Science in Art and Design, and Course IV-B, leading to the Bachelor of Science.

Bachelor of Science in Art and Design Course IV

Course IV is a flexible program for students whose primary interest falls within the subject area of the Department. There are four possible areas of concentration: visual arts (including visual design, photography, the Visible Language Workshop, environmental art, and film making); architectural design; building technology (including structures, building process, energy systems, and environmental control); and history, theory, and criticism of architecture. Within a broad framework, students develop individual courses of study best suited to their needs and interests.

The requirements for the S.B. in Art and Design curriculum are intended to establish a basis for common understanding among the students majoring in the Department. The Restricted Electives begin with an introductory subject that explores issues which are of common concern in the Department and in which many members of the faculty participate. It is designed to be taken by freshmen and sophomores. The remaining Restricted Electives include beginning work in the arts, architecture and the building process, and the history and social context of art and architecture.

Students should discuss their educational interests and plans with a faculty advisor not later than the beginning of the fall term of their junior year. The Department has prepared a list of subjects which gives the requirements for each of its four areas of concentration. Each area of concentration is divided into a number of branches, and many subjects are listed within each branch. The philosophy of the curriculum is that, in each area, a student deals with all or most of the branches of the area and gets deeply involved in a particular branch, while always having a variety of subjects among which to choose within each branch.

Students who plan to continue their studies for the graduate degree, Master of Architecture, must apply for admission to the graduate M.Arch. program. Students who have fulfilled the requirements for the Bachelor of Science in Art and Design normally are able to satisfy the requirements for the M.Arch. in two years if they include in their undergraduate program a sufficient number of professional subjects. This requires careful use of a student's Unrestricted Electives.

Students who intend to continue with graduate studies in the visual arts, building technology, and history, theory, and criticism of architecture should consult with an appropriate faculty member to design a program of study within this curriculum which establishes the basis for graduate study.

Bachelor of Science in Art and Design Course IV

	General Institute Requirements	Total Units
	Specific science and humanities and social science subjects[1]	132
	Science Distribution Requirement	36
	Laboratory Requirement	12
	Departmental Program	
	Restricted Electives	**at least 63**
	One subject from each of the following six groups:	
	Group 1 Introductory Subject	
4.01	Issues in Architecture	2 2 8
	Group 2 Design Information	
4.201	Introduction to Computers and Graphics	4 0 8
4.26	Built Form Observations	2 3 7
	Group 3 Environmental Technology	
4.30	Basic Structural Theory[2]	3 3 6
4.402J	Basic Building Construction	3 3 6
4.41	Materials, Techniques and Form	3 3 6
	Group 4 History of Art and Architecture	
4.616	Selected Topics in Architecture of the Ancient World	3 0 6
4.626	Selected Topics in Architecture in the Middle Ages	3 0 6
4.636	Introduction to Renaissance Architecture	3 0 6
4.641	Painting and Sculpture in the 19th Century	3 0 6
4.642	Modern Art from Impressionism to Cubism	3 0 6
4.647	Selected Topics in Architecture 1750 to the Present	3 0 6
4.648	American Landscapes, Towns and Buildings	3 0 6
4.651	Modern Art from Cubism to the Present	3 0 6

	Restricted Electives (continued)	
	Group 5 Social Context	
4.742J	Shaping the Urban Environment	3 0 6
11.001	Introduction to Urban and Environmental Planning and Development	3 0 9
11.002	Introduction to Public Policy Analysis and Governmental Action	3 0 9
11.131	The Urban Neighborhood	2 0 7
	Group 6 Arts	
4.821	Visual Design Projects I	3 0 6
4.823	Form and Design I	2 4 6
4.825	Form and Color	3 0 6
4.870	Words, Images, Graphics Tools and Ideas	2 4 6
4.921	Creative Photography I: Regular Workshop	4 4 4
4.971	Introduction to Moviemaking	4 6 2
	Planned Electives	**72**
	A coherent set of subjects (in addition to a restricted elective in the area of concentration) within one of the following areas of concentration. Specific listings of subjects and distribution requirements in each area of concentration (plus related subjects) are obtainable in Department Headquarters.	
	Architectural Design	
	Building Technology	
	History, Theory, and Criticism of Architecture	
	Visual Arts	
	Unrestricted Electives[2]	**45**
	Total Units Required for the S.B. Degree	**360**

1
Subjects in the Humanities Fields Visual Arts and Design, History of Art and Architecture, and Urban Studies used in fulfillment of the Department Program may **not** be used to satisfy the Humanities and Social Science Requirement. Students cannot have the same departmental area of concentration and Humanities Field of Concentration.

2
4.30 Basic Structural Theory partially fulfills this requirement and also will be credited towards the Science Distribution Requirement, thereby providing 12 additional units of Unrestricted Electives.

Bachelor of Science Course IV-B

Course IV-B is offered for students who find that their basic intellectual commitments are to subjects within the Department of Architecture but whose educational interests and goals cut across departmental boundaries. These students may, with the approval of the Department, plan a course of study that directly suits their interests while including the fundamental areas within the Department. For example, students might profitably combine subjects in architecture with subjects in urban studies and planning, computer sciences, systems analysis, acoustics, etc., creating a coherent program of study especially designed to meet individual needs and interests.

In following this curriculum, students are required to fulfill the General Institute Requirements, departmental restricted electives, and planned electives selected by the student. Students desiring to follow this curriculum must submit to the Department, not later than the beginning of the fall term of their junior year, a statement of educational goals, including a list of the restricted, planned, and unrestricted electives selected to achieve these goals. At an earlier date, interested students should discuss their interests and intended programs with faculty members in the Department.

Bachelor of Science
Course IV-B

	General Institute Requirements	Total Units
	Specific science and humanities and social science subjects[1]	132
	Science Distribution Requirement	36
	Laboratory Requirement	12
	Departmental Program	
	Restricted Electives	**at least 51**
	One subject each from five of the following six groups:	
	Group 1 Introductory Subject	
4.01	Issues in Architecture	2 2 8
	Group 2 Design Information	
4.201	Introduction to Computers and Graphics	4 0 8
4.26	Built Form Observations	2 3 7
	Group 3 Environmental Technology	
4.30	Basic Structural Theory[2]	3 3 6
4.402J	Basic Building Construction	3 3 6
4.41	Materials, Techniques and Form	3 3 6
	Group 4 History of Art and Architecture	
4.616	Selected Topics in Architecture of the Ancient World	3 0 6
4.626	Selected Topics in Architecture in the Middle Ages	3 0 6
4.636	Introduction to Renaissance Architecture	3 0 6
4.641	Painting and Sculpture in the 19th Century	3 0 6
4.642	Modern Art from Impressionism to Cubism	3 0 6
4.647	Selected Topics in Architecture 1750 to the Present	3 0 6
4.648	American Landscapes, Towns and Buildings	3 0 6
4.651	Modern Art from Cubism to the Present	3 0 6
	Restricted Electives (continued)	
	Group 5 Social Context	
4.742J	Shaping the Urban Environment	3 0 6
11.001	Introduction to Urban and Governmental Planning and Development	3 0 9
11.002	Introduction to Public Policy Analysis and Governmental Action	3 0 9
11.131	The Urban Neighborhood	2 0 7
	Group 6 Arts	
4.821	Visual Design Projects I	3 0 6
4.823	Form and Design I	2 4 6
4.825	Form and Color	3 0 6
4.870	Words, Images, Graphics Tools and Ideas	2 4 6
4.921	Creative Photography I: Regular Workshop	4 4 4
4.971	Introduction to Moviemaking	4 6 2
	Planned Electives	**96**
	A coherent set of subjects which, with other parts of the program, is aimed at a well-defined interdisciplinary goal. Each program must be prepared and submitted to the department not later than the beginning of a student's junior year and must be approved by the Department or the Undergraduate Degree Committee.	
	Unrestricted Electives[2]	**up to 33**
	Total Units Required for the S.B. Degree	**360**

Students in either program of the Department of Architecture may, upon consultation with a faculty advisor, exercise flexibility in scheduling completion of the General Institute Requirements. It should be emphasized, however, that any program of studies that involves postponing first-year physics and mathematics limits the possibilities of easy transfer from Architecture to those departments that presuppose the completion of most of the General Institute Requirements by the end of the sophomore year. In addition, some advanced subjects in departments other than Architecture presume the knowledge acquired in fulfilling the Requirements; registration in subjects in those departments may be precluded or postponed if a student has deferred any of the General Institute Requirements.

1
Subjects in the Humanities Fields, Visual Arts and Design, History of Art and Architecture, and Urban Studies used in fulfillment of the Department Program may **not** be used to satisfy the Humanities and Social Science Requirement.

2
4.30 Basic Structural Theory partially fulfills this requirement and also will be credited towards the Science Distribution Requirement, thereby providing 12 additional units of Unrestricted Electives.

Graduate Study

The Department offers four graduate degree programs — the Master of Architecture, the Master of Science in Visual Studies, the Master of Science in Architecture Studies, and the Ph.D. in Architecture, Art, and Environmental Studies.

The Master of Architecture is awarded to students who complete a program, accredited by the National Architectural Accrediting Board, that is an essential step toward licensure for architectural practice.

The Master of Science in Visual Arts program explores arts and media technology; it accepts only students who have already demonstrated a high level of competence and achievement in their field.

The Master of Science in Architecture Studies program stresses research and inquiry in the built environment; the degree is meant both for students who already have their first professional architecture degree and those whose previous education matches the program.

The Ph.D. program is an advanced degree program initiated in the area of History, Theory, and Criticism, and is meant for students interested in research in areas represented in the Department.

Master of Architecture

The Master of Architecture is awarded upon the satisfactory completion of an approved program of at least 164 units, of which 96 units must be in "A" subjects, and an acceptable thesis. Completion ordinarily requires two years of residence beyond the Institute's undergraduate Bachelor of Science in Art and Design. A substantial number of candidates are admitted with a Bachelor's degree from other institutions. Those who have not yet studied in a department of architecture require a minimum of three and one-half years of residence to fulfill the requirements for the M.Arch. degree.

Architectural Design studios are the center of the M.Arch. degree program. While there are as many approaches as there are design instructors, they all share a concern for context, process, form, use, users, method, neighborhood, the environment, participation, systems, growth and change, and for understanding.

As the aims and scope of the profession are continually and rapidly being modified in response to new applications of science on one hand, and to shifts in social climate on the other, students must recognize early that there are many possible professional roles. They must then assume much of the responsibility for structuring their own educational programs. While the professional curriculum specifies that a student study a range of subjects in several interrelated fields, students in the M.Arch. program have a number of choices within each of the study areas offered in the Department, and have the opportunity to concentrate in one area which they may define.

Master of Science in Visual Studies

This program offers graduate education in visual studies and visual media with emphasis on their technological development, communications applications, and use in and as art. It is expected that students from varied backgrounds with common interest in visual processes, tools, and purposes take advantage of research and study opportunities in the Institute setting.

There are five areas of concentration: film/video, centered in the Department's Film Section; environmental art, focusing on teaching and research in the Center for Advanced Visual Studies; graphics design, in the Visible Language Workshop; photography, centered in the Creative Photography Lab; and computer graphics, based in the Architecture Machine Group. Students may pursue the degree either in a single area of concentration or in a joint combined area — for example, computerized typography, environmental graphics, or digital video.

The degree is awarded upon completion of an approved program including core subjects from each of the five areas of concentration, and an acceptable thesis. The program requires two full academic years of residency.

Master of Science in Architecture Studies

This program is designed to provide a place for students, teachers, and researchers to work in a climate which stresses the investigative component of understanding the built environment. It is open to students with professional degrees in architecture, or to students with degrees in other fields who demonstrate experience and significant achievement in those fields. The S.M.Arch.S. degree is awarded on satisfactory completion of an approved program of study and the completion of an acceptable thesis. The Department requires two full academic years of residency.

The program shares a common interest in the methods of inquiry, development and testing of knowledge, and the building and application of theory as it pertains to the built environment. It allows students to specialize in areas in which they wish to obtain particular abilities. The three major areas of study are: 1) Environmental Design — a joint enterprise of the Department of Architecture and the Department of Urban Studies and Planning. This area covers the following major interests: environmental design, models and evaluation, policy analysis, behavior and programming, and history and theory. 2) Housing and Settlement Design — which concentrates on issues of human habitation as related to design. Sub-areas of research and teaching are methods, behavior studies, Technology and Settlement Design. This area deals with problems in developing countries. 3) Building Systems Design — concentrating on the architectural applications of various aspects of the technology of building and their related systems. Emphasis is on energy systems, industrialized building systems, structural systems, and environmental control in building.

Each of these study areas has its core in the Department, and strong relationships outwards to other departments and academic groups.

Doctor of Philosophy in Architecture, Art, and Environmental Studies

The Ph.D. program, initiated in the area of History, Theory, and Criticism, is designed to draw on the unique range of disciplines and professions within the Department of Architecture. It emphasizes the study of Western (19th and 20th centuries) and Islamic Architecture, and urbanism, and methodological issues that inform or link historical and practical work. A small number of Ph.D. candidates may work in close association with the faculty and its research in two areas: studies in architecture and environmental structure; and studies in Islamic architecture and urbanism. The latter area is a part of and is supported by the Aga Khan Program for Islamic Architecture.

Candidates for the program already should have a Master's Degree or the equivalent through advanced work. Previous university work may be in academic or professional schools, and in the history of architecture, some professional experience is recommended also. Candidates with degrees from other institutions are required to be in residence for two academic years.

Each student admitted to the program should consult with one principal professor to work out both a three-person advisory committee and a general plan of study. Progress through the program follows a sequence of subject work, qualifying papers, general examinations in major and minor fields, and dissertation writing and defense. Proficiency in two languages is mandatory. Students are encouraged to take subjects appropriate to their programs in other departments at MIT, and at Harvard and Wellesley; active collaboration with MIT's gallery and exhibitions program and with other institutions in the Boston-Cambridge area also is possible.

Inquiries

Further information concerning academic programs in the Department, admissions, financial aid, assistantships, etc. may be obtained from: Department of Architecture, Room 7-303, MIT, Cambridge, Massachusetts 02139, (617) 253-7791.

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Associate Professor of Urban Studies and Planning
Head of the Department

Bernard Joel Frieden, M.C.P., Ph.D.
Professor of City Planning
Executive Officer

Professors

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Professor of Urban Studies and Political Science

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Professor of Urban Land Development
(Visiting)

Jean Pierre de Monchaux, M.Arch.
Professor of Architecture and Planning
Dean, School of Architecture and Planning

Aaron Fleisher, Sc.D.
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Robert M. Fogelson, Ph.D.
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Frank Sidney Jones, M.B.A.
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John Tasker Howard, M.C.P.
Professor of City Planning, Emeritus

Kevin Andrew Lynch, B.C.P.
Professor of City Planning, Emeritus

Department of Urban Studies and Planning

Undergraduate Study

The Department of Urban Studies and Planning offers several degree and non-degree programs: Bachelor of Science in Urban Studies; Master of City Planning; Doctorate in Urban Studies and Planning; Joint programs with the Departments of Architecture, Civil Engineering, Political Science, and Economics; a Special Program in Urban and Regional Studies (for mid-career professionals from developing areas); the Community Fellows Program (for mid-career professionals from minority communities in the United States); and special student status for part-time mid-career professionals interested in taking individual courses.

City and regional planners in the US and other parts of the world are involved in a variety of activities aimed at shaping the pattern of human settlements and providing housing, public services, employment opportunities, and other crucial support systems that comprise a decent living environment. Planning encompasses not only a concern for the structure and imageability of the built environment, but also a desire to harness the social, economic, political, and technological forces that give meaning to the everyday lives of men and women in residential, work, and recreational settings. For planners operating at the neighborhood, metropolitan, state, or national level, in the public or the private sector, the tasks are the same: to help define goals and objectives, to formulate and implement programs and policies responsive to individual and group needs, and to work with and for various communities in allocating both economic and natural resources most efficiently and most equitably.

Planners are often described as "generalists-with-a-specialty." Specialties have been thought of in functional terms (such as housing, transportation, land use, health care, etc.) or in terms of the geographic levels at which decision making takes place (neighborhood planning, town planning, regional planning, planning for international development, etc.) Subspecialties within the planning field also have been described in terms of the roles that planners are called upon to play: manager, designer, regulator, advocate, evaluator, futurist, etc.

The Department of Urban Studies and Planning seeks to train professionals and scholars who as practitioners, managers, advisors, or policy analysts are able to deal with the processes of urban and regional development, environmental planning and design, and public policy analysis and implementation. The Department is committed to educating planners who can advocate the interests of underrepresented constituencies.

A focus on practice and the development of practice-related skills is central to the Department, particularly to students in the professional degree (M.C.P.) program. One means of acquiring these practice-related skills and of integrating them with classroom knowledge is through the Department's fieldwork and internship programs. Through fieldwork, students can acquire competence by witnessing others in action and by participating in and bringing field experiences back into the academic setting for reflection and discussion. Students may work as staff members to community organizations or government agencies, or as interns under the direction of faculty members involved in field based projects for "outside" clients. Academic credit is awarded according to the time committed. In some cases stipends are related to fieldwork or internship programs.

Opportunities for concentration and specialization available to students are included in the descriptions of the degree programs that follow.

During the month of January, the Department of Urban Studies and Planning offers a series of "mini-subjects" in specialized fields not covered by the regular curriculum. The Institute-wide January Independent Activities Period provides a unique opportunity to experiment with innovative approaches to teaching and flexible learning environments. In many instances, student organized activities initiated during the Independent Activities period have subsequently been incorporated into the basic academic program.

Bachelor of Science in Urban Studies Course XI

The Department of Urban Studies offers an interdisciplinary, preprofessional program in applied social science, which provides knowledge of 1) urban systems and processes of change in social and physical environments, 2) alternative approaches to improving urban and environmental conditions and 3) analytical skills for evaluating the public policies and programs that shape these conditions. Fieldwork, internships, and participation in faculty research projects provide work experience and communication skills for employment in urban and environmental planning and related fields. The program prepares students to do graduate work in urban planning, public policy analysis, environmental design, law, and social sciences.

The core of the program includes a set of subjects that give basic knowledge of urban and environmental systems and of the disciplines applied and integrated. Students take one introductory subject, four fundamental subjects and then specialize by adding at least 48 units of focused, advanced study. The senior colloquium and senior project, complete their study in the fourth year.

The senior colloquium helps students formulate, design, and undertake a senior project. The senior project (10-30 units, depending on scope) may involve policy analysis, a research project, or a report on a problem-solving experience accomplished through a fieldwork assignment, an internship, or a workshop.

Departmental research and internships are an important part of the program. Students obtain research and professional experience by working on projects designed by the faculty or by themselves. They are strongly encouraged to contribute to at least one research project and to complete an internship as part of the Urban Studies curriculum.

Three areas of specialization have been structured by the Department and are described here.

Environmental Planning serves students seeking careers in managing and analyzing the quality of the environment through planning, law, engineering, and other "environmental professions" such as landscape architecture, water resource management, and air pollution control. This specialization examines the form and function of natural and urban systems, techniques for describing and evaluating environmental change, approaches to analyzing and implementing environmental policy, and mechanisms for assessing the choices posed by the environmental impacts of technological advances. Students develop analytical capabilities which allow them to critically examine issues such as land use, energy, and water pollution.

Neighborhood and Community Planning emphasizes the study of the built environment; and techniques of describing, evaluating, and guiding spatial and physical change. Students learn about interactions between communities and the people who inhabit them. They acquire skills in defining needs and goals, in assessing alternative development patterns and policies, and methods for implementing planned changes in urban areas. The specialization relates economic and political aspects of development to planning methods and theory.

Public Policy, Urban Management, and the Law focuses on the nature of public institutions, the processes of policy formation, analysis and implementation, and research and management techniques for planning and executing public policy. Subjects examine factors that influence public choices — political and economic interests, social structure, and value considerations. Fieldwork and internship subjects give students institutional experience and help them to develop skills in analysis and management. This specialization prepares students for subsequent work in government, public administration and management, and law. Several core subjects in this specialization are taught jointly with the Department of Political Science.

Bachelor of Science in Urban Studies Course XI—Option 1

	General Institute Requirements	**Total Units**
	Specific science and humanities and social science subjects	132
	Science Distribution Requirement[1]	36
	Laboratory Requirement[2]	12
	Departmental Program	
	Required Subjects	**at least 52**
11.001	Introduction to Urban and Environmental Planning and Development	3 0 9
	or	
11.002	Introduction to Public Policy Analysis and Governmental Action	3 0 9
11.005	Urban Social Structure and Process	3 0 6
11.188	Laboratory in Research Methods	2 5 5
11.190	Senior Colloquium	2 0 7
	Senior Project	10-30
	Fundamentals of Applied Social Science	**at least 48**
11.007J	Politics and Public Policy	3 0 9
11.008J	Urban Economics	3 0 6
11.009	Technology and the City	3 0 6
11.010	Community Sociology	3 0 6
11.012	Institutions and Communities	3 0 6
11.013J	American Urban History	3 0 6
11.014J	History of the Physical Environment of Urban America	3 0 6
11.015	Models and the Metropolis	3 0 9
11.016	Introduction to Environmental Analysis	3 0 6
11.017	Introduction to the Political Economy of Urban Poverty	3 0 6
	Planned Electives[3]	**at least 44**
	Areas of Specialization (A coherent selection of at least five subjects including those listed below for each area of specialization.)	
	Environmental Planning	
11.122	Environmental Policy and Regulation	3 0 9
11.123	Environmental Quality Assessment	3 2 7
11.124	Workshop in Environmental Planning and Design	4 4 8
	Planned Electives (continued)	
	Neighborhood and Community Planning	
11.131	The Urban Neignborhood	2 0 7
11.132J	Shaping the Urban Environment	3 0 6
11.133	Introduction to Design	Arr.
11.139	Introduction to Community Development	3 0 6
	Public Policy, Urban Management, and the Law	
11.164J	Urban Politics, Planning, and Public Policy	3 0 6
11.165	Law and Public Policy	3 0 9
11.166	Legal Institutions and Social Change	3 0 6
11.167	Seminar on Legal Institutions	3 0 6
11.168	Workshop in Urban Management and Public Policy	4 4 8
	Unrestricted Electives	**Up to 36**
	Total Units Required for the S.B. Degree	**360**

1 Suggested subjects—11.015, 11.123, and a statistics subject

2 Suggested subjects—11.188 or 11.185J

3 Students may suggest alternative subjects in each category

Bachelor of Science Course XI — Option 2

This option, in cooperation with Civil Engineering, is designed for students who want to combine the skills of the two fields. Such programs concentrate, for example, on environmental engineering, on transportation systems related to land development, or on constructed facilities and environmental planning. Other combinations are possible.

The program is administered by a committee of faculty representing the two departments. Applications are made directly to this committee through either department. The committee advises students on the choice of courses to meet their study objectives.

This is a combined degree. The diploma names only the Department of Urban Studies and Planning, but a letter provided upon graduation by the Combined Program Committee confirms the student's participation in the program.

Graduate Study

Bachelor of Science Course XI—Option 2

	General Institute Requirements	Total Units
	Specific science and humanities and social science subjects (1.01J required in the Departmental Program, satisfies one humanities and social science subject requirement.)	123
	The Science Distribution Requirement can be satisfied by 1.00 and 18.03 which are required in the Departmental Program, plus appropriate subjects totaling[1]	12
	Laboratory Requirement[1]	12
	Departmental Program	
	Required Subjects	81
1.00	Principles of Computer-Based Engineering Problem Solving	3 1 8
1.01J	Engineering Aspects of Economic Analysis	4 0 8
1.02	Civil Engineering Systems Analysis I	3 1 8
1.03	Civil Engineering Systems Analysis II	3 1 8
11.001	Introduction to Urban and Environmental Planning and Development or	3 0 9
11.002	Introduction to Public Policy Analysis and Governmental Action	3 0 9
11.190	Senior Colloquium	2 0 7
18.03	Differential Equations	4 0 8
	Planned Electives	**at least 72**
	Subjects which assure breadth and depth in the area of specialization	**at least 18**
	Civil Engineering subjects	**at least 18**
	A Special Studies project or thesis, the content of which requires a synthesis of the knowledge within the scope of the joint program.	**at least 12**
	Unrestricted Electives	**at least 60**
	Total Units Required for the S.B. Degree	**360**

[1] Suggested subject—11.188

Bachelor of Science Course XI Option 3: Urban and Regional Planning in Developing Countries

This option provides training in urban studies and planning in the setting of developing countries. It is designed particularly for those students who come from developing countries or who are preparing to work in such places.

In addition to the Institute Requirements, students electing this option must take one of the two introductory subjects offered by the Department, the Urban Studies laboratory, the senior colloquium, and the thesis; and a set of subjects in issues of regional development, and the politics, economics, and social aspects of development. Electives are chosen in conference with the student's advisor and are intended to develop a basic competence in analysis and planning in some specific areas.

The major problem area foci available are housing, transportation, and urban policy, but arrangements can be made to combine work in other departments such as Architecture, Civil Engineering, Economics, or Political Science.

Five-Year S.B.-M.C.P. Option

Undergraduate urban studies majors may apply for admission to the Department's Master in City Planning (M.C.P.) Program at the end of their junior year. Students accepted into the five-year program are exempted from the undergraduate thesis requirement and receive both the Bachelor of Science and the Master in City Planning at the end of five years. Admission is limited to those undergraduates who have demonstrated exceptional professional promise. More information on the five-year program can be obtained from the Director of the Undergraduate Urban Studies Program or the Chairman of the M.C.P. Committee.

The Department of Urban Studies and Planning offers graduate work leading to the Master in City Planning and the Doctor of Philosophy. The Course is open to students with varying backgrounds. Urban studies, architecture, political science, civil engineering, economics, sociology, law, management, and public administration all offer suitable preparation. Applicants from other fields are also accepted. Undergraduate preparation for urban studies and planning usually differs from that required for scientific degrees at MIT. Further information concerning academic programs in the Department, admissions, financial aid, etc. may be obtained from the Graduate Admissions Secretary, 7-338, MIT (253-2024).

Master in City Planning

The basic professional degree in the planning field is the Master in City Planning (M.C.P.). The Department of Urban Studies and Planning provides graduate education for men and women who assume professional roles in public and private agencies, in the United States and abroad. The Department seeks to provide M.C.P. students with the skills and specialized knowledge needed to fill traditional as well as emerging planning roles.

The two-year M.C.P. Program emphasizes the mastery of the tools necessary for effective practice and is therefore distinct from liberal arts programs in urban affairs. An intensive course of study stresses skills for policy analysis and institutional intervention. The Master's Program is recognized by the American Planning Association.

A student's plan of study in the M.C.P. program is set forth in a program statement developed jointly by the student and faculty advisor. The program statement describes the purposes and goals of study, the proposed schedule of subjects, the manner in which competence in a specialization is developed, and an indication of a possible thesis project topic. The program statement is submitted to the M.C.P. Committee, which monitors each student's progress.

By the end of the first semester, each M.C.P. student selects an area of specialization from among those described below. This specialization is the focus of the student's work during the remaining three semesters of the program. An original thesis project is required of each M.C.P. student.

Degree Requirements

In order to complete the degree requirements, students are expected to take a minimum of 30 credit units each term or a minimum of 120 total units, in addition to the thesis. (Please note that most subjects count as 9-12 units of credit.)

Phase I: The Professional Core

Four core subjects provide incoming M.C.P. students with the fundamental knowledge and skills essential for effective planning practice. M.C.P. candidates are required to complete or place out of the core subjects during their first year of study. Briefly, the core subjects are:

— 11.200 The Planning Process: an introduction to the basic theories of planning practice, emphasizing the roles that planners play and the value dilemmas central to planned intervention
— 11.210 Economic Analysis for Planners: an introduction to economic analysis for planners, emphasizing basic concepts for policy analysis and the organization of economic institutions
— 11.220-11.229 methods modules, especially Introduction to Statistical Concepts for Planning: a series of modules (averaging six to nine weeks in length) that provides an introduction to techniques for structuring problems, obtaining and analyzing data, and drawing conclusions or making policy inferences from these data (each M.C.P. candidate is expected to complete or place out of the statistics module and at least two additional modules). Modules cover decision analysis, impact assessment, cost-benefit analysis, multivariate analysis, and the analysis of neighborhood and regional change, survey design, as well as other analytic and communications techniques.
— 11.230 Institutional Analysis: an introduction to the tools for analyzing bureaucratic and organizational settings, including a survey of applied organizational theory.

Students have an opportunity to test out of Economic Analysis, Methods, and Institutional Analysis, and are encouraged to take the placement exams, if only to diagnose their own strengths and weaknesses.

Phase II: Specializations

M.C.P. students select an area of specialization by the end of the first semester. Specializations at the M.C.P. level include: environmental design; environmental planning and policy; neighborhood and community development; regional economic development; area planning for developing countries; housing; and transportation (in conjunction with the Department of Civil Engineering), and public policy and management.

Environmental Design involves conceptualizing and guiding changes in the spatial environment. Work in this area at MIT involves acquiring knowledge about the interactions between people and the settings they inhabit; understanding the historical evolution of current forms of settlement; improving methods for analyzing, programming, designing, and implementing environmental change; anticipating and coping with the impacts of changes in the form and functioning of human settlements; and developing processes for regulating and managing environments over time.

Environmental Planning and Policy emphasizes the study of the legal, institutional, and economic tools by which society conserves and manages its environmental resources. Substantive areas of concern include energy facility siting, pollution control, land use, growth management, and coastal zone management. Students examine the interactions between built and natural systems, techniques for describing and evaluating changes in environmental quality, approaches to environmental policy analysis, and mechanisms for assessing the choices posed by the environmental impacts of new technology.

Neighborhood and Community Development integrates economic, social, and political theories of development with planning methods. Emphasis is on community planning, including the location and organization of community services and facilities; the impact of housing, capital, and labor markets on the operation of the local economy; strategies for intervening in neighborhood income and employment structures; analysis of current and alternative policies towards neighborhoods; and the development of new techniques for defining community needs, assessing alternative policies, and implementing planned change.

Regional Economic Development involves the study of economic growth and locational change. Emphasis is on the production and distribution of goods and services; job creation and employment processes; development finance, trade, migration, and capital flows; techniques for analyzing regional development; and the evaluation of domestic, foreign, and international regional economic policies. Currently, special attention is paid to domestic issues and the application of regional input-output techniques.

The study of **Area Planning for Developing Countries** applies the theories and the techniques of regional and urban planning to developing countries. Emphasis is on national and subnational area planning in the context of national development policy; political and social aspects of development; and policy issues posed by alternative urban and rural development strategies. Research topics include criteria for infrastructure investment; housing policy; and rural development. Social science applications are central to this work.

Housing, Real Estate, and Land Development focuses on the management of urban growth, and on the design, location, and financing of housing. Emphasis is on public policies that affect housing

conditions and private development, incentives in the development sector, land use regulations, and assessment of housing needs. Real estate development, construction, and the operation of financial institutions are related fields of interest.

Teaching and research in **Transportation Planning** take place in several departments at MIT. Coordination is provided by the Center for Transportation Studies. Topics of special interest include transportation systems analysis, transportation policy studies, transportation technology assessment, and the management of transportation enterprise. A number of faculty members and students are interested in the relationship between transportation and particular problems, such as regional development, urbanization, and the pricing of commodities.

Public Policy and Management focuses on understanding the study of public institutions, the environment in which public policy is made, the processes of policy formulation, and management techniques for the implementation of public policy. This area of specialization is designed to help meet the increasing demand for professionals with broadly applicable skills in public policy analysis and management. It seeks to equip students with the expertise they need to be effective in practice, including the ability to assess the consequences of current public policies, the ability to develop and evaluate alternatives, and the ability to propose socially responsible strategies for public action.

Coursework in an area of specialization typically includes: 1) an overview of problem setting and policy analysis in the particular field; 2) historical and comparative approaches to problem solving or policy implementation; and 3) specialized analytical techniques. Specializations are tailored to individual student's interests.

Phase III: Synthesis

In the third semester, M.C.P. students begin the process of synthesis. While this process encompasses all aspects of a student's educational program, it emphasizes a workshop or practicum and the preparation of a thesis. Workshops are organized around client-centered projects. Students work in teams and have a "hands-on" opportunity to develop and apply skills for policy development and institutional intervention.

The Department encourages M.C.P. students to avoid the traditional perception of the thesis as a "minidissertation," and to think instead of a client-oriented, professional document, which bridges academic and professional concerns. While most of the data collection, analysis, writing, and revision of the thesis occurs during the last semester of the second year, students are urged to begin the process of defining a thesis topic early in the third semester.

Fieldwork and Internships

Students in the M.C.P. Program are encouraged to integrate fieldwork and internships with academic course work. The Department provides a variety of individual and group field placements involving varying degrees of faculty participation and supervision. Academic credit is awarded for field experience, although some students decide against requesting credit, and choose instead to participate in the work-study financial aid program. The Department also sponsors a variety of seminars in which students have an opportunity to reflect on their field experiences.

The HUD Intern Program is a special Federally funded program for minority M.C.P. students. The HUD Program and the Office of Education's Public Service Intern Program provide tuition and fieldwork placements in public and nonprofit agencies.

Dual Master's Degrees in Urban Studies and Architecture

Students who have been admitted to either the Department of Urban Studies and Planning or the Department of Architecture are invited to propose programs for joint work in the two fields leading to dual degrees. Degree combinations may be M.C.P./M. Arch. or M.C.P./S.M.Arch.S. Program proposals must be made prior to the student's final academic year in the first degree program and are considered during the spring admissions process. Normally, students are expected to meet the core requirements of both degrees, but may submit a joint thesis and count some subjects completed for one degree towards the other, thus decreasing the overall time required for the two degrees.

Dual degree programs may include an innovative combination of work in any of the fields of specialization of the two departments. They may represent preparation for professional roles which bridge the two fields or the definition of new roles which are needed but not yet defined. Students pursuing dual degrees work with advisors in both departments.

Dual Master's Degree in Urban Studies and Transportation

Students who have been admitted to study for the Master of City Planning or the Master of Science in Transportation are invited to propose programs for joint work in the two fields leading to a dual degree — Master of Science in Transportation (M.S.T.) and Master of City Planning (M.C.P.). This takes the form of an application for admission to the second degree. Applications must be made prior to the student's final academic year in the first degree program and are considered during the spring admission process. Normally, students are expected to meet the core requirements of both degrees, but may submit a joint thesis and count some subjects completed for one degree towards the other, thus decreasing the overall time required for the two degrees.

A minimum number of units is set for each student (on an individual basis) within the range 160 to 180 units plus thesis. The number is determined by: 1) relevance of the student's prior degree to these degrees, 2) relevance of prior work experience, 3) complementarity between the two degree programs in the case of each student.

Doctor of Philosophy

Advanced students, especially those seeking research or teaching careers in planning or urban studies, may apply for admission to the doctoral program. Admission requirements are substantially the same as for the Master's degree; however, more emphasis is placed on academic preparation in the student's proposed area of specialization.

The doctoral program emphasizes public policy related issues, the development of fundamental research competence, and flexibility in the exploration of interdisciplinary questions. Areas of specialization are currently being built around research clusters — teams of faculty and students with shared interests in topics such as housing and economic development; land use and environmental policy; formal models in planning, regulation, and evaluation; community change and neighborhood quality; land development policy in developing countries; informal service networks among the low-income elderly; and the nature of planning practice.

After successful completion of a required first-year doctoral seminar, a subject covering statistical principles and techniques, and general examinations, each Ph.D. candidate must prepare a written doctoral dissertation evidencing the capacity to do independent research. To be eligible for financial aid, students in the Ph.D. program must complete at least 30 credit units each term.

Subject to the approval of a faculty advisor and the doctoral committee of the Department, a Ph.D. candidate engages in a program of study which provides a broad background in urban studies and advanced work in a major and minor area of specialization. These areas may be in any sub-field related to urban studies or planning in which the Department of Urban Studies and Planning, together with other MIT departments, offers strong support. Proposed fields of specialization must be approved by the Ph.D. Committee in the Department.

Doctoral candidates who already hold the Master in City Planning usually require at least two terms of study in residence before beginning their dissertations. Other candidates may require up to six terms, depending on prior preparation. In order to be eligible for the Ph.D., a student must complete 180 credit units. Previous work at MIT or elsewhere may be counted toward the degree. The general requirements for the Ph.D. are specified in Chapter IV of this catalogue.

Interested and qualified students can undertake joint doctoral programs with the Department of Political Science or the Department of Economics. Doctoral students in urban studies may be associated with the research program of the MIT-Harvard University Joint Center for Urban Studies or the School's Laboratory of Architecture and Planning.

Special Student Status

A limited number of non-degree students are admitted to the Department each term. (Special student status is not available to any individual for more than two terms except under extraordinary circumstances.) Special student status is especially designed for mid-career professionals interested in developing specialized skills, but it also is available to others interested in participating in the activities of the Department on a limited basis. Although a person may be admitted to the Department as a special student, permission to register in each subject must be granted separately by the instructors involved. Students applying for admission to regular departmental degree programs are not eligible for special student status.

Community Fellows Program

Every year 10-12 women and men from various parts of the United States are selected as Fellows. They and their families are relocated to the Boston area for the ten-month academic year. This is done because it is important for the Fellow's primary support system to remain intact. CFP pays tuition to MIT so that Fellows can take any courses they wish at MIT, Harvard, and other affiliated universities. Fellows spend a good portion of the year working on a research-development project of their own choosing that is implemented after the fellowship year. Fellows are encouraged to utilize the vast resources of MIT in order to successfully achieve their project objectives. Project work is guided by a mentor, either an MIT faculty member or "outside" expert in the Boston area. Additional assistance comes in the form of research funds to be used for travel, equipment, and materials required to carry out project work. The Program is imbued with a strong family orientation, expressed throughout the year.

The Community Fellows Program, which is a non-degree program, seeks to expose the Fellows to a range of political and ideological positions bearing on the existence of people of color in America and the development of their communities. Out of the exposure, achieved through reading, lectures, discussions, and travel, it is hoped that the Fellows come to know where they are anchored in cultural, political, and ethical terms. The Program seeks to enhance the collective work possibilities of the Fellows by promoting, in work and deed, the belief that people of color in America cannot achieve maximal economic and political development without the sharing and/or pooling of their talents, skills, and resources.

Information and applications may be obtained from Professor Melvin H. King, Community Fellows Program, Room 7-341, MIT, Cambridge, Massachusetts 02139. Applications are accepted until March 31.

Special Program for Urban and Regional Studies of Developing Areas (SPURS)

SPURS provides an opportunity for a small number of especially qualified persons to spend a year at MIT studying the problems of urban and regional change within a broad context of national development. It is a program of study, deliberately flexible, and not leading to a degree.

The Program is designed for mature individuals in mid-career who hold responsible positions in public or private organizations that are closely concerned with urban growth and regional development. Their experience may be in such diverse fields as architecture, engineering, sociology, economics, government, or business. Principal criteria for admission are the ability and experience of the individual. All applicants must have a thorough command of English, i.e., achieve a TOEFL score of at least 500. Preference is given to applicants from developing countries, although a few from Western Europe and the United States are admitted. It is assumed that Fellows from outside the United States return to their home countries upon completion of the academic year.

SPURS Fellows build their study programs individually, in consultation with Program faculty members. The main emphasis is on the courses and other offerings available at MIT, Harvard and elsewhere in the environs. Options include regular courses, informal seminars, and independent projects designed with advice from interested faculty members. Jointly, the Fellows may organize meetings on technical subjects, informal seminars, and talks by visiting professionals and scholars. They are assisted in the arrangement of these activities by several members of the faculty in the Urban Studies and Planning Department and other departments at MIT.

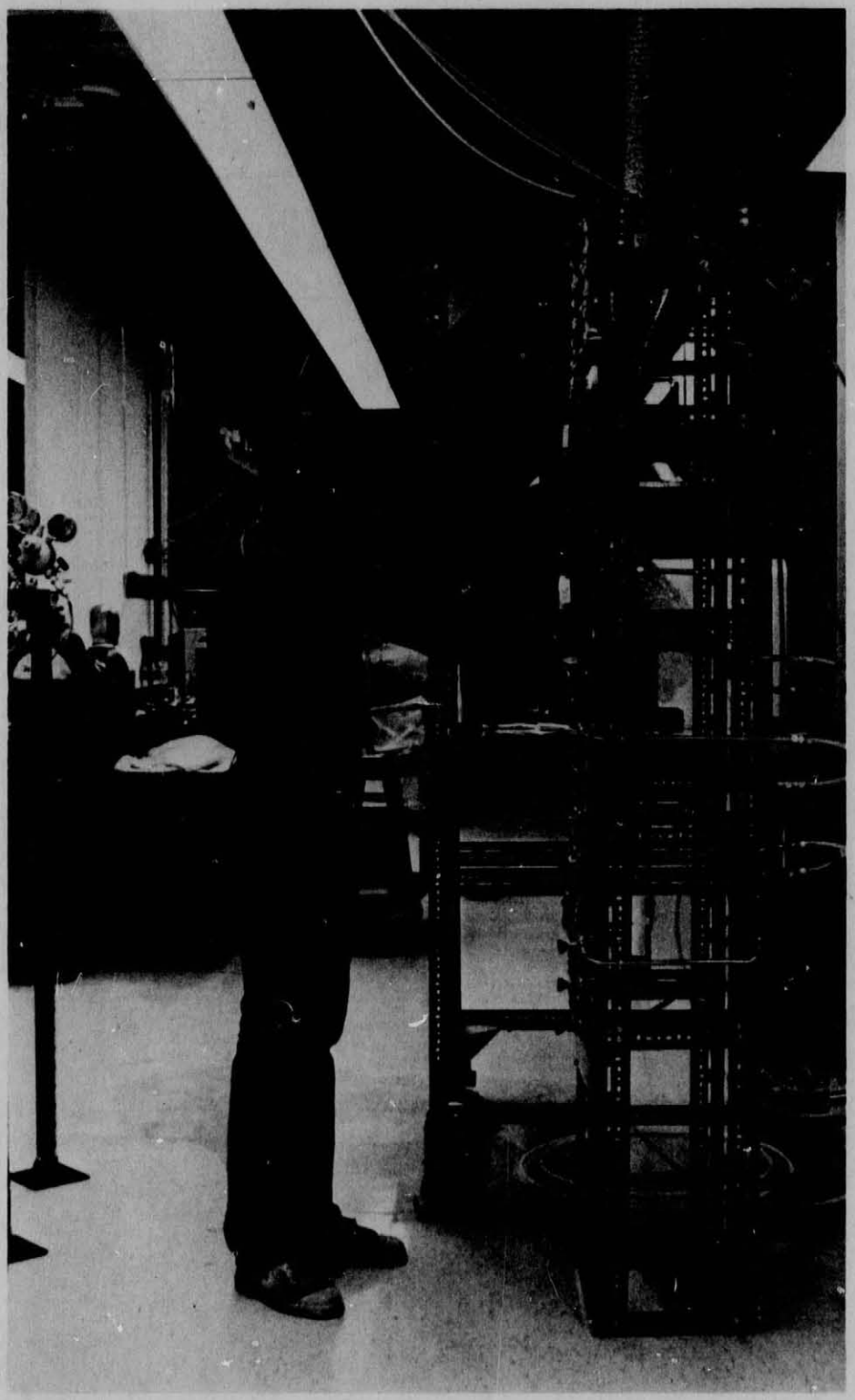
Areas of special emphasis include: development of urban and regional growth strategies within the framework of national development and planning; problems of low-income and migrant housing and settlement in cities; environmental planning; transportation; project evaluation; social aspects of the development process; technology transfer; and formal planning and programming techniques.

SPURS offers participants the opportunity to work with people from other countries interested in similar problems and to meet leading scholars, policy makers, and advanced graduate students in the fields of urban and regional planning. It is a program within the Department of Urban Studies and Planning — a department which encourages the innovation and multidisciplinary approaches, and whose faculty has extensive experience in guiding urban and regional programs in developing countries. In addition, SPURS maintains close ties with other relevant programs and departments at MIT, Harvard, and Boston University, including the international Nutrition Planning Program at MIT, the Boston University African Program, and the Joint Center for Urban Studies of MIT and Harvard University.

The academic year runs from September through May. Application forms may be obtained from: Director, SPURS, MIT, Room 10-400, Cambridge, Massachusetts 02139.

Completed applications should be submitted by mid-March. Applicants are notified of acceptances shortly thereafter. Late applications also are considered.

School of Engineering



Never has the challenge of engineering been more exhilarating, the opportunities of engineering been more exciting than they are today, a time when resource limitations and environmental constraints are in conflict with the desire of society for an improved quality of life. Never has the role of the engineer been more exacting.

Engineering is concerned with developing and using scientific knowledge and technology to meet the needs of a complex society in ways that are sensitive to the constraints imposed by that society.

Shaping the physical and chemical behavior of materials into efficient systems providing energy, transport, communications, food, security, and the other needs of society is clearly the central activity of engineering, and that activity must be carried out within a social context, always subject to physical, economic, political, and legal bounds, and to the cultural value structure of the society.

Such concerns have created a large demand for engineering graduates, not only to enter the professional practice of engineering, but to bring the strengths of the engineering curricula to other fields by entry into law, medicine, management, and government science.

The School of Engineering at MIT recognizes today's educational challenges and is responding to them by continuing to offer unique educational opportunities for advancement of the science and technology base of engineering. The School is also expanding its involvement in the application of engineering science and technology to the development of new technological solutions; in the identification of the relevance of such solutions in meeting society's needs; in the determination of their impacts on the social and natural environment; and in the steps required to translate meaningful solutions into reality.

In all of these activities the School of Engineering has continued to operate on the basis that its principal objective is to educate men and women so that they can become leaders in industry, govern-

ment, and educational institutions. Hence their education at MIT is viewed as being only one step in a life-long process of continual education and growth. The various curricula within the School are designed to emphasize underlying principles and their use in engineering, and to develop in students a versatility of mind and an ability to learn anew. In this same spirit, individual subjects and departmental programs are constantly under review and revision to reflect advances in knowledge and new issues in its application.

The School of Engineering is organized into eight departments: I Civil Engineering, II Mechanical Engineering, III Materials Science and Engineering, VI Electrical Engineering and Computer Science, X Chemical Engineering, XIII Ocean Engineering, XVI Aeronautics and Astronautics, and XXII Nuclear Engineering.

While the various departments do provide a convenient basis for administration of the School, it should be noted that they increasingly share common interests in terms of the problem areas to which their particular scientific disciplines and technologies are applied. This sharing of interests is illustrated in the following table which lists some of the broad applications areas in which the School of Engineering's faculty and students are currently involved, and shows the departments which are most closely involved in them.

The School of Engineering offers formal graduate degree programs in both the departmental areas and in a number of interdepartmental areas including: Biomedical Engineering, Environmental Studies, Instrumentation, Operations Research, Materials, Mineral Resources Engineering and Management, Technology and Policy, and Management of Technology. In addition, numerous other interdepartmental opportunities exist at both the undergraduate and graduate levels. With the faculty and resources of all the departments available, the student is able to develop a program that satisfies his or her own intellectual and professional objectives. The student interested in an interdepartmental program will find it helpful to study the departmental descriptions and also to read the specific sections covering interdepartmental opportunities that combine, in various manners and degree, disciplines from the Schools of Science, Management, Humanities and Social Science, and Architecture and Planning with those of the School of Engineering.

Applications / Departments	Civil Engineering	Mechanical Engineering	Materials Science and Engineering	Electrical Engineering and Computer Science	Chemical Engineering	Ocean Engineering	Aeronautics and Astronautics	Nuclear Engineering
Energy	•	•	•	•	•	•	•	•
Transportation	•	•	•	•		•	•	
Communication			•	•		•	•	
Manufacturing		•	•	•	•		•	
Construction	•		•			•		•
Materials	•	•	•	•	•	•	•	•
Environment	•	•	•	•	•	•	•	•
Medicine		•	•	•	•		•	•
Governance	•	•		•		•	•	•

Engineering Internship Program

The Engineering Internship Program, an educational program available to students in the School of Engineering, combines traditional on-campus academic programs with off-campus work experience in industry and government. The program is motivated by the belief that work experience can be an important aspect of a sound engineering education. By giving students an opportunity to participate in the world of work through professional activities early in their careers, it is hoped that students can:

1
make more informed choices from among the various on-campus educational offerings, and

2
obtain a better understanding of career opportunities available to them after graduation.

Programs of combined work and study are not new to MIT, where experience in this form of engineering education dates back to 1907 in what is now the Department of Electrical Engineering and Computer Science. Over the years, it has evolved into an educational program that is acclaimed throughout the United States for its excellence. The Engineering Internship Program is modeled on the existing program in the Department of Electrical Engineering and Computer Science (Course VI-A) and will run in parallel with it.

Emphasis is placed on ensuring that students in the program are placed in rewarding "real-world" company assignments that extend the learning experience into areas that are not available at MIT. Toward this end, there is extensive faculty participation and advising in both the on- and off-campus components of the program.

Program Description

The following program description is typical of most participating departments. However, individual departmental programs may differ in certain areas.

Programs have been established in the Departments of Aeronautics and Astronautics (XVI-C), Civil Engineering (I), Electrical Engineering and Computer Science (VI), Materials Science and Engineering (III-B), Mechanical Engineering (II-B), Nuclear Engineering (XXII-A), and Ocean Engineering (XIII-C). Please see the listing in the appropriate department for a detailed description of these programs.

The Engineering Internship Program is designed principally as a joint undergraduate and graduate program that leads to the simultaneous award of the S.B. and S.M. in an engineering department upon successful completion of all degree requirements.

Students normally enter the program in the summer after their sophomore year at MIT. Sophomores in good standing in the School of Engineering are eligible to apply for the program and, if selected by a participating company during the on-campus interview process, will participate by registering in the appropriate departmental program.

The program consists of three work assignments at the same industrial firm. There are two undergraduate work assignments of three months' duration each — one after the student's second year at MIT and one after the third year. During the first term of the fourth year, a student applies to the department for admission into the graduate program. For those students who are accepted to the graduate program, there is one additional work assignment of seven months' duration after the fourth year. Additional or substitute work assignments are possible by agreement among the company, student, and department.

For those students who are not admitted to the departmental graduate program, or do not continue on to graduate school for other reasons, the Internship Program will terminate at the end of the spring term of the fourth year at the S.B. level.

Students who are accepted to the graduate program will often do a combined S.B.-S.M. thesis on a topic related to their work assignment. Usually, for such a thesis, the research will be performed primarily in-plant during the final work assignment, under the combined supervision of company staff and an MIT faculty member.

Students are paid during their periods of residence at the participating companies. While salary levels are a matter of negotiation between student and company, it is expected that salaries will be consistent with those paid to permanent staff members of comparable experience levels and abilities in the participating companies. It is also expected that a company will fund each student's travel from MIT to the company at the beginning of each assignment and his or her travel back to MIT at the end of the assignment.

Further information on the program may be obtained from the department of registration or from J.R. Martuccelli, Director, Engineering Internship Program, MIT, Room 1-211, Cambridge, Massachusetts 02139, (617) 253-8051.

School-wide Electives

The School of Engineering offers a set of School-wide subjects, each of which is of interest to students from a number of departments in the School. A School-wide subject may: integrate knowledge from several disciplines and illustrate the commonality of the intellectual underpinnings of the departments in the School of Engineering; be at the interface between the academic program of the School of Engineering and the programs of other Schools at MIT; be a service subject to engineering students and other students; and/or be germane to many engineering students, without being central to any one departmental program. A list of current School-wide Electives follows. Please note that registration for these subjects takes place through one of the departmental numbers. Subject descriptions may be found in the subject description chapter of this catalogue.

Computer Models of Physical and Engineering Systems U(1)
1.16, 2.101, 3.05, 10.11, 13.51, 16.008, 22.006

Introduction to Technology and Law U(1)
1.19, 2.998, 10.803, 13.97, 16.792, 22.085

Management in Engineering U(1)
2.96, 6.930, 10.806, 13.52, 16.993, 22.002

Entrepreneurship G(2)
2.942, 6.936, 10.801, 13.78, 16.672, 22.86

Engineering Risk-Benefit Analysis (A) G(2)
1.482, 2.943, 3.577, 6.938, 10.816, 13.621, 16.794, 22.82

Inventions and Patents U(1)
3.172, 6.901, 16.673, 22.084

Engineering Systems Analysis (A) G(1)
1.146, 2.192, 3.56, 13.62, 16.784, 22.821

Introduction to FORTRAN (IAP)
No departmental numbers; registration through Information Processing Services. See IAP *Guide*. A not-for-credit two-week introduction to FORTRAN programming, offered in cooperation with IPS.

Interdepartmental Centers, Projects, and Laboratories

In addition, there exist at MIT a large number of interdepartmental centers, projects, and laboratories whose activities clearly transcend those of any single department. Those in which the School of Engineering is particularly involved are listed below. Additional information about many of these may be found in the Interdepartmental Study and Research chapter of this catalogue.

Artificial Intelligence Laboratory

Biomedical Engineering Center for Clinical Instrumentation

Center for Advanced Engineering Study

Center for Materials Science and Engineering

Center for Policy Alternatives

Center for Sensory Aids Evaluation and Development

Center for Space Research

Center for Transportation Studies

Cryogenic Engineering Laboratory

Division for Study and Research in Education

Electric Power Systems Engineering Laboratory

Energy Laboratory

Francis Bitter National Magnet Laboratory

Fuels Research Laboratory

Gas Turbine and Power Dynamics Laboratory

Harvard-MIT Division of Health Sciences and Technology

Heat Transfer Laboratory

Information Processing Center

Innovation Center

Joint Program in the Management of Technology

Laboratory for Computer Science

Laboratory for Information and Decision Systems

Laboratory for Manufacturing and Productivity

Laboratory for Nuclear Science

Lincoln Laboratory

Man-Vehicle Laboratory

Materials Processing Center

MIT Sea Grant College Program

Nuclear Reactor Laboratory

Operations Research Center

Ralph M. Parsons Laboratory for Water Resources and Hydrodynamics

Rehabilitation Engineering Center

Research Laboratory of Electronics

Sloan Automotive Laboratory

Technology Adaptation Program

Technology and Policy Program

Urban Systems Laboratory

Degree Programs in Engineering

Through its departments and various interdepartmental groups the School of Engineering offers a wide variety of educational programs. Although students are classified as graduate students or undergraduate students, large numbers of the latter often enroll in some graduate subjects, and both groups are strongly encouraged to participate in a variety of research, engineering applications, and public service projects. Together, these activities and interactions provide a rich educational experience.

Degrees are awarded by the departments of the School and in several interdepartmental fields. At the undergraduate level several departments also offer so-called "undesignated" degrees which lead to the Bachelor of Science without departmental designation. The curricula for these programs offer students opportunities to pursue programs of studies which are broader than could be accommodated within a normal four-year departmental program.

Most undergraduate departmental degrees are accredited by the Engineers' Council for Professional Development. However, given their more general nature, the School of Engineering has not sought accreditation for any undesignated degrees. Holders of an accredited degree can generally take examinations for professional registration with fewer years of experience than holders of unaccredited or non-engineering degrees. Also, an accredited degree may be required for certain jobs. As the situation varies markedly from field to field, students should discuss this question with their faculty advisor in their department of registration.

For undergraduates the curriculum of the first year encompasses study of physics, chemistry, mathematics, and humanities while still offering students many opportunities to make contact with engineering through undergraduate seminars, research opportunities, and elective subjects. In the second year, students typically continue these studies with subjects leading to the fulfillment of the Science Distribution, the Laboratory, and the Humanities, Arts, and Social Sciences requirements. An undergraduate student normally becomes affiliated with a particular department or designated program as early as the beginning of the sophomore year, and from that time on works closely with an advisor from that department or program. Or, alternatively, a student may elect to delay this choice until the start of the junior year without necessarily delaying graduation beyond four years.

However, a student with an interest in engineering is strongly encouraged to become involved with one of the engineering departments even during the freshman year, and may, for example, request that the freshman advisor be assigned from a particular department in the School of Engineering. Guidance in making such early contact may be obtained through the Undergraduate Research Opportunities Program, the Undergraduate Seminar Program, or through the individual departments. Details of the particular departmental programs and their degree requirements are presented in this chapter.

In addition to the usual departmental programs many opportunities exist for individual initiatives. For example, significant numbers of students find it possible to combine their primary undergraduate degree with a second undergraduate degree in another area, such as management, political science, economics, or another area of engineering. Others organize their programs so as to receive undergraduate and graduate degrees simultaneously. Completion of the undergraduate degree requirements in less than four years is also possible in some cases. Students are encouraged to explore these and other possibilities with their faculty advisors.

The preceding few paragraphs can give only a limited picture of the scope and quality of the educational opportunities available within the School of Engineering. Prospective and continuing students are invited to study the pages which follow to obtain a more complete picture of these opportunities. Inquiries about specific programs are welcomed and should be sent to the head of the appropriate department.

Office of the Dean

Gerald Loomis Wilson, Sc.D.
Professor of Electrical and Mechanical Engineering
Philip Sporn Professor of Energy Processing
Dean

Kent Forrest Hansen, Sc.D.
Professor of Nuclear Engineering
Associate Dean
(On leave)

Frederick James Quivey, M.B.A.
Assistant Dean for Administration

John Ronald Martuccelli, S.M.
Director, Engineering Internship Program

School Professors Without Departmental Affiliation

J. Herbert Hollomon, Sc.D.
Japan Steel Industry Professor of Engineering
Director, Center for Policy Alternatives

Alfred Adolf Heinrich Keil, Dr. Rer. Nat.
Professor of Ocean Engineering, Emeritus
Ford Professor of Engineering, Emeritus

Judah Leon Schwartz, Ph.D.
Professor of Engineering Science and Education

Myron Tribus, Ph.D.
Professor of Engineering
Director, Center for Advanced Engineering Study

Nicholas A. Ashford, Ph.D.
Associate Professor of Technology and Policy

Lawrence L. Bucciarelli, Ph.D.
Associate Professor of Engineering and Technology Studies

James M. Utterback, Ph.D.
Associate Professor of Engineering

Professor Emeritus

Alfred Adolf Heinrich Keil, Dr. Rer. Nat.
Professor of Ocean Engineering, Emeritus
Ford Professor of Engineering, Emeritus

Department of Aeronautics and Astronautics

James Wah Mar, Sc.D.
Jerome Clarke Hunsaker Professor of Aerospace Education
Head of the Department

Professors

Saul Sigmond Abarbanel, Ph.D.
Professor of Aeronautics and Astronautics
(Visiting)

Judson Richard Baron, Sc.D.
Professor of Aeronautics and Astronautics

Eugene Edzards Covert, Sc.D.
Professor of Aeronautics and Astronautics

Charles Stark Draper, Sc.D.
Institute Professor, Emeritus
Professor of Aeronautics and Astronautics, Emeritus
Senior Lecturer

John Dugundji, Sc.D
Professor of Aeronautics and Astronautics

Shaoul Ezekiel, Sc.D.
Professor of Aeronautics and Astronautics and Electrical Engineering

Morton Finston, Ph.D.
Professor of Aeronautics and Astronautics

Robert Louis Halfman, S.M.
Professor of Aeronautics and Astronautics
Associate Dean for Student Affairs

Norman Douglas Ham, Sc.D.
Professor of Aeronautics and Astronautics

Wesley Leroy Harris, Sr., Ph.D.
Professor of Aeronautics and Astronautics

Jerome Clarke Hunsaker, Sc.D., Eng.D.
Professor of Aeronautical Engineering, Emeritus

Karl Uno Ingard, Ph.D.
Professor of Aeronautics and Astronautics and Physics
(On leave)

Jack Leo Kerrebrock, Ph.D.
Richard Cockburn Maclaurin Professor of Aeronautics and Astronautics
(Absent)

Marten Teodor Landahl, Tekn.D.
Professor of Aeronautics and Astronautics

Yao Tzu Li, Sc.D.
Professor of Aeronautics and Astronautics, Emeritus
Senior Lecturer

Jean François Louis, Ph.D.
Professor of Aeronautics and Astronautics

Winston Roscoe Markey, Sc.D.
Professor of Aeronautics and Astronautics

John Francis McCarthy, Jr., Ph.D.
Professor of Aeronautics and Astronautics
(Absent)

James Elliot McCune, Ph.D.
Professor of Aeronautics and Astronautics

Rene Harcourt Miller, M.A.
H. N. Slater Professor of Flight Transportation

Earll Morton Murman, Ph.D.
Professor of Aeronautics and Astronautics

Amedeo Rodolfo Odoni, Ph.D.
Professor of Aeronautics and Astronautics and Civil Engineering

Theodore Hsueh-Huang Pian, Sc.D.
Professor of Aeronautics and Astronautics

Robert Warren Simpson, Ph.D.
Professor of Aeronautics and Astronautics

Edward Story Taylor, S.B.
Professor of Flight Propulsion, Emeritus
Senior Lecturer

Leon Trilling, Ph.D.
Professor of Aeronautics and Astronautics

Wallace Earl Vander Velde, Sc.D.
Professor of Aeronautics and Astronautics

Harold Yehuda Wachman, Ph.D.
Professor of Aeronautics and Astronautics

Henry Philip Whitaker, S.M.
Professor of Aeronautics and Astronautics

Sheila Evans Widnall, Sc.D.
Professor of Aeronautics and Astronautics
(On leave)

Emmett Atlee Witmer, Sc.D.
Professor of Aeronautics and Astronautics

Laurence Retman Young, Sc.D.
Professor of Aeronautics and Astronautics

Associate Professors

Edward Marc Greitzer, Ph.D.
Associate Professor of Aeronautics and Astronautics

Walter Mark Hollister, Sc.D.
Associate Professor of Aeronautics and Astronautics

Elmer Eugene Larrabee, S.M.
Associate Professor of Aeronautics and Astronautics

Manuel Martinez-Sanchez, Ph.D.
Associate Professor of Aeronautics and Astronautics

William Tilton Thompkins, Jr., Ph.D.
Associate Professor of Aeronautics and Astronautics

William Soule Widnall, Sc.D.
Associate Professor of Aeronautics and Astronautics

Yehoshua Y. Zeevi, Ph.D.
Associate Professor of Aeronautics and Astronautics
(Visiting)

Assistant Professors

Edward Francis Crawley, Sc.D.
Boeing Assistant Professor of Aeronautics and Astronautics

Antonio Luis Elias, Ph.D.
Boeing Assistant Professor of Aeronautics and Astronautics

Alan Harry Epstein, Ph.D.
Assistant Professor of Aeronautics and Astronautics

Joseph Haralambos Haritonidis, Ph.D.
Assistant Professor of Aeronautics and Astronautics

Robert Vincent Kenyon, Ph.D.
Assistant Professor of Aeronautics and Astronautics

Adjunct Professor

Richard Horace Battin, Ph.D.
Adjunct Professor of Aeronautics and Astronautics

Senior Lecturers

Raymond Lewis Bisplinghoff, Dr.Sci.Techn.
Charles Oswald Cary
William Rede Hawthorne, Sc.D.
Donald John Jordan, B.S.
John Regnier Wiley, S.B.

Lecturers

Philip Nathaniel Bowditch, S.B.
Paul Jon Cefola, Ph.D.
Philip Kenyon Chapman, Sc.D.
John Jacob Deyst, Jr., Sc.D.
Donald Charles Fraser, Sc.D.
Betsy Gidwitz, Ph.D.
Arthur Grossman, B.S.
Albert Lafayette Hopkins, Jr., Ph.D.
John Hovorka, Sc.D.
James Thomas Kneafsey, Ph.D.
Henry Herbert Kolm, Ph.D.
Stephen James Madden, Jr., Ph.D.
Rudrapatna V. Ramnath, Ph.D.
John Stanley Sinkiewicz, B.S.
Nawal Koshore Taneja, Ph.D.
John Pascal Vinti, Sc.D.
Joseph Yamron, S.B.

Technical Instructors

Robert Lee Renshaw, B.S.E.E.
Allan Ralph Shaw
Edward Donald Weiner

Administrative Officer

Donna Roby Savicki, M.S.

Senior Research Engineer

Charles McMaster Oman, Ph.D

Principal Research Engineer

Charles Waldo Haldeman, Sc.D.

Research Associates

Robert Haimes, M.S.
Alan Natapoff, Ph.D.
Choon Sooi Tan, Ph.D.

Research Engineers

Raymond Anthony Ausrotas, M.S.
Frank Herman Durgin, E.A.A.

Postdoctoral Associate

Dennis Francis Xavier Mathaisel, Ph.D.

Visiting Scientist

Alfred David Weiss, M.D.

Research Affiliates

Renwick Eugene Curry, Ph.D.
Kim Eric Drexler, S.M.
Arye Ravoz Ephrath, Ph.D.
Eliezer Gai, Ph.D.
Lindesay Ines Ker Harkness, Ph.D.
Howard Theodore Hermann, M.D.
Greg Leon Zacharias, Ph.D.

Visiting Engineers

Da-peng Chen
Jun He
Zu-wei Huang
Zhang Jin
Guo-Cai Tang
Qi-dong Yang

Professors Emeriti

Joseph Bicknell, S.M.
Professor of Aeronautics and Astronautics, Emeritus

Charles Stark Draper, Sc.D.
Institute Professor, Emeritus
Professor of Aeronautics and Astronautics, Emeritus
Senior Lecturer

Jerome Clarke Hunsaker, Sc.D., Eng.D.
Professor of Aeronautical Engineering, Emeritus

Otto Carl Koppen, S.B.
Professor of Flight Vehicle Engineering, Emeritus

Yao Tzu Li, Sc.D.
Professor of Aeronautics and Astronautics, Emeritus
Senior Lecturer

Walter McKay, S.M.
Professor of Aeronautics and Astronautics, Emeritus

Robert Karl Mueller, Sc.D.
Associate Professor of Aeronautics and Astronautics, Emeritus

Shatswell Ober, S.B.
Professor of Aeronautical Engineering, Emeritus

Edward Story Taylor, S.B.
Professor of Flight Propulsion, Emeritus
Senior Lecturer

Walter Wrigley, Sc.D.
Professor of Instrumentation and Astronautics, Emeritus

Department of Aeronautics and Astronautics

Undergraduate Study

The objectives of the Department of Aeronautics and Astronautics are to provide broad training in the philosophy, approach, and disciplines of Aerospace Engineering, and to conduct research at the forefronts of a wide range of technologies critical to the future development of aerospace.

The aerospace community is unusual in its emphasis on advanced technology, and in its responsibility for large complex vehicles and systems which demand uniform excellence in engineering and management. To retain its position of leadership, it must seek continually to advance basic understanding of a wide range of physical phenomena, to conceive new devices and systems based on this understanding, and to carry them through the development process to practical use. It encompasses a wide range of talent, from basic researchers to managers of organizations employing thousands of engineers. The MIT Department of Aeronautics and Astronautics is equally unusual in its commitment to providing training for and access to this broad range of opportunities in aerospace engineering. Its success in this endeavor is indicated by the large numbers of its alumni who are senior managers in government and in major aerospace firms, or in the forefront of basic research in the engineering sciences. The extensive involvement of its faculty with government and industry is a further measure of the Department's central role in the aerospace community.

The aerospace vehicle — be it a helicopter, commercial transport, satellite, or space shuttle — provides a focus for many aspects of aerospace engineering with which the Department deals. Throughout its teaching and research activities, the vehicles and the transportation systems of which they are major elements are used for motivation and coordination of the instruction and research. The faculty is also alert to the possibilities for application of aerospace-derived technologies to nonaerospace uses, resulting in a myriad of couplings to the scientific and engineering research communities.

At the undergraduate level, the Department seeks to provide a broad introduction to aerospace engineering, together with thorough basic training in all of the disciplines critical to aerospace. The departmental program comprises: 1) Unified Engineering, an introductory subject taught cooperatively by a number of senior faculty members, covering all of the basic disciplines in an interrelated format as well as experimental and systems approaches; 2) a choice of Advanced Required Subjects and access to Electives providing greater depth in each disciplinary area; and 3) the Experimental Projects Laboratory, in which each student conceives and executes an individual experiment. In addition, undergraduates are encouraged to become involved in the research activities of the Department through the Undergraduate Research Opportunities Program. Research opportunities are outlined under Graduate Study.

The graduate teaching and research activities of the Department are strongly interwoven, since the graduate subjects evolve from the research and professional interests of the faculty and in turn serve to introduce students to the areas of active research. Teaching activities are informally organized into six Divisions of Instruction: Mechanics and Physics of Fluids; Structures, Materials, and Aeroelasticity; Propulsion and Energy Conversion; Instrumentation, Guidance, and Control; Biomedical Engineering; and Aeronautical and Astronautical Systems. Research is conducted in the Departmental Laboratories including the Aerophysics and Fluid Dynamics Laboratories, the VTOL Technology Laboratory, the Aeroelastic and Structures Research Laboratory, the Technology Laboratory for Advanced Composites, the Gas Turbine and Plasma Dynamics Laboratory, the Man-Vehicle Laboratory, the Laser Systems Laboratory, the Flight Transportation Laboratory, and the Space Systems Laboratory. Each of these is described briefly in the section on Graduate Study. In addition to its departmental activities, the Department maintains close interaction with the Charles Stark Draper Laboratory.

Bachelor of Science in Aeronautics and Astronautics Course XVI

Undergraduate study in the Department leads to the Bachelor of Science in Aeronautics and Astronautics at the end of four years. The curricula provide flexibility to meet the needs of professionals in aerospace activity ranging from scientific research to responsible engineering direction of large enterprises.

Unified Engineering

The Undergraduate course of study is based on a core of two 24-unit subjects in Unified Engineering, offered in sets of two 12-unit subjects in two successive semesters. These subjects are taught cooperatively by a number of senior faculty members. Their purpose is to introduce new students to the disciplines and methodologies of aerospace engineering at a basic level, with a balanced exposure to analysis, empirical methods, and design. The areas covered include statics, dynamics, structures, fluid mechanics, thermodynamics, propulsion, control, and systems engineering. Several laboratory experiments are performed and a number of systems problems which interrelate the disciplines are included.

Unified Engineering is usually taken in the sophomore year; it fulfills the prerequisites for a variety of Advanced Required Subjects and Electives which deal more intensively with subjects in the five main areas of Aeronautics and Astronautics: 1) Mechanics and Physics of Fluids, 2) Structures, Materials, and Aeroelasticity, 3) Instrumentation, Guidance, and Control, 4) Propulsion and Energy Conversion, and 5) Aeronautical and Astronautical Systems. Alternatively, a student may take Unified Engineering in the junior year, and complete the Departmental requirements in the senior year. The Departmental requirements beyond Unified Engineering include a) one subject from each of the five above areas for students in Program 1 and b) one subject from each of three of these five areas for students in Program 2.

Electing Unified Engineering during the sophomore year offers students the opportunity to study one or more of the areas in considerable depth or to gain greater breadth by taking a variety of subjects. Taking Unified Engineering in the junior year allows students a full two years at the Institute before selecting the Department of Aeronautics and Astronautics. Either approach provides a well-rounded engineering education and excellent preparation for graduate study.

Advanced Required Subjects

These subjects treat more completely and in greater depth the material to which the student is introduced in Unified Engineering and/or in the other basic required subjects. They bring the student to a level appropriate for employment in industry as a junior engineer, and provide a solid base for graduate study. To ensure adequate breadth in each student's education, a distribution from among the undergraduate subjects is required. Thus, each student in Program 1 must take the following five subjects: a) Aerodynamics (16.02), b) Structural Mechanics (16.20), c) Principles of Automatic Control (16.30), d) Rocket Propulsion (16.53) or Aircraft Engines and Gas Turbines (16.54), and e) Flight Vehicle Engineering (16.84) or Space Systems Engineering (16.85).

Similarly, students in Program 2 (Avionics) must take the following advanced subjects: a) Introductory Digital Systems Laboratory and Solid State Circuits (6.111 and 6.301), b) Principles of Automatic Control and Feedback Systems (16.30 or 6.302) and Principles of Flight Guidance (16.40); in addition, one must choose c) either Flight Vehicle Engineering (16.84) and Aerodynamics (16.02) or Space Systems Engineering (16.85) and Structural Mechanics (16.20).

All students are advised, however, that maximum benefit will be derived 1) from Flight Vehicle Engineering if he/she has already completed 16.02 *and* 16.54 or 2) from Space Systems Engineering if the student has already completed 16.20 *and* 16.53.

Undergraduate Projects Laboratory

Each student has the opportunity in this subject to conceive, organize, and execute an individual experimental project under the supervision of a faculty member. A proposal is prepared; oral and written reporting of the results is required. This subject satisfies the Institute Laboratory Requirement.

Bachelor of Science in Aeronautics and Astronautics Course XVI

Any one of several programs leads to the degree of Bachelor of Science in Aeronautics and Astronautics. All programs leading to degrees in Aeronautics and Astronautics are accredited by the Engineers' Council for Professional Development (ECPD). If desired, the student may request an unspecified degree, Bachelor of Science. This degree is not so accredited.

Program 1 Aeronautics and Astronautics. Program 1 is appropriate for students desiring a broad exposure to aerospace engineering in the normal four years of residence at MIT.

Bachelor of Science in Aeronautics and Astronautics Course XVI Program 1 Aeronautics and Astronautics

	General Institute Requirements		Total Units
	Specific science and humanities and social science subjects[1]		132
	The subjects 8.03, 18.03 and 16.001 which are required in the Departmental Program appear on the list of Science Distribution subjects and can be used to satisfy the Science Distribution Requirement.		
	The subject 16.622, which is required in the Departmental Program, appears on the list of Laboratory Subjects and can be used to satisfy the Laboratory Requirement.		
	Departmental Program		
	Basic Required Subjects		96
3.094	Materials Technology	3 0 9	
6.071	Introduction to Electronics	4 2 6	
8.03	Physics III	5 0 7	
16.001	Unified Engineering I	4 3 5	
16.002	Unified Engineering II	4 3 5	
16.003	Unified Engineering III	4 3 5	
16.004	Unified Engineering IV	4 3 5	
18.03	Differential Equations	4 0 8	
	Advanced Required Subjects		75
16.02	Aerodynamics	4 0 8	
16.20	Structural Mechanics	5 0 7	
16.30	Principles of Automatic Control	3 0 9	
	Either		
16.53	Rocket Propulsion	3 1 8	
	or		
16.54	Aircraft Engines and Gas Turbines	3 1 8	
16.621	Experimental Projects I	1 1 1	
16.622	Experimental Projects II	1 7 4	
	Either		
16.84	Flight Vehicle Engineering	2 3 7	
	or		
16.85	Space Systems Engineering	4 0 8	
	Unrestricted Electives[2]		60
	Total Units Required for the S.B. Degree		363

1
This department recommends a) 3.091 or 5.60 to satisfy the Institute Chemistry/Biology Requirement, b) that an introductory digital computing/programming subject such as 2.10 or 6.030 be taken as early as possible, and c) that 21.760 Scientific and Engineering Writing, be taken as part of the Humanities Requirement.

2
Schedules of students in Course XVI may be arranged to leave available 24 units of Unrestricted Electives in the second year.

The required subjects may be supplemented with additional advanced undergraduate subjects or graduate subjects according to individual interests.

For example, a student who wishes to concentrate in fluid mechanics might consider including 5.60 Chemical Thermodynamics or 3.091 Introduction to Solid-State Chemistry in the first year; and 16.02 Aerodynamics and 18.075 Advanced Calculus for Engineers or another mathematics subject in the third year, together with another elective in applied aerodynamics or fluid mechanics such as 16.53 Rocket Propulsion, 10.39 Energy Technology, or 12.21 Physics of the Ocean. In the fourth year one or two more graduate subjects such as 16.035, 16.051, and/or 18.076 could follow up the field of interest suggested by the third-year elective choice.

For students especially interested in structures, materials, and aeroelasticity, the following graduate subjects are suggested: 16.21 Plates, Stability, and Thermoelasticity, 16.91 Structural Dynamics, and 16.29 Design with Filamentary Composite Materials. Other useful graduate subjects include 16.27 Finite Element Method and 16.23 Structural Design of Gas Turbine Engines. It is also highly recommended that students take a sequence of subjects in applied mathematics, beginning with 18.075 Advanced Calculus for Engineers, in their junior and senior years.

A suggested program for undergraduates concentrating in propulsion and energy conversion would include 16.53 Rocket Propulsion and 16.54 Aircraft Engines and Gas Turbines. It should also include fluid mechanics and solid mechanics beyond that in the Unified Engineering sequence, 16.02 Aerodynamics and 16.20 Structural Mechanics being recommended. Advanced Calculus for Engineers (18.075) and Introduction to Quantum Physics (8.211) also are recommended. Further subjects can be selected from graduate offerings; for example 16.541 Aircraft Turbine Engines for students interested in aircraft propulsion or gas turbines, or 16.55 Ionized Gases for those interested in advanced energy conversion.

An undergraduate program concentrating in instrumentation, guidance, and control should include 16.30 Principles of Automatic Control, 16.31 Principles of Instrumentation and Control, 16.32 Principles of Optimal Control, and 16.40 Principles of Flight Guidance, along with the Institute and departmental requirements.

Those students interested in Biomedical Engineering or the Man-Machine Interface may elect to register for 16.351J, HST 541J, and HST 542J, Quantitative Physiology; 16.352J Sensory-Neural Systems; 16.355J Man-Machine Systems; or 16.36 Flight Simulation.

Finally, for those students interested in aeronautical and astronautical systems, the Department recommends 16.821 A Management View of Engineering Seminar in the freshman and sophomore years, in addition to a two-term sequence of humanities which should be selected with a view to understanding the growth and structure of society. For example, 17.701 Human Nature and Public Policy could be included in the first two years. In the third and fourth years, economics is recommended. For those interested in Space Systems, 16.30 Principles of Automatic Control and 16.85 Space Systems Engineering are recommended. In the area of Flight Transportation, recommended subjects would be 16.54 Aircraft Engines and Gas Turbines, 16.30 Principles of Automatic Control, and 16.84 Flight Vehicle Engineering.

Program 2 Avionics Option. The Avionics Option prepares the student for a career in Aerospace Electronics. It also provides a strong foundation for graduate work in the fields of Instrumentation, Guidance, and Control. The program is designed for students who are interested in the application of electronics to guidance, navigation, surveillance/stabilization, instrumentation, and control of aircraft or spacecraft. New graduates traditionally have joined this professional area after having had an undergraduate major in electrical or aeronautical engineering, and having been introduced to the other half of their discipline through apprenticeship or graduate study. This option allows the student to learn the basics of both parts of the discipline as an undergraduate. The requirements include core subjects in Electrical Engineering as a sophomore if Unified Engineering is deferred to the junior year. The elective freedom can be utilized to take advanced subjects in guidance and control depending on the student's particular area of interest within the broad field of avionics.

Bachelor of Science in Aeronautics and Astronautics
Course XVI
Program 2 Avionics Option

	General Institute Requirements				Total Units
	Specific science and humanities and social science subjects[1]				132
	The subjects 6.002, 8.03, and 16.001 which are required in the Departmental Program appear on the list of Science Distribution subjects and can be used to satisfy the Science Distribution Requirement.				
	Either 6.111 or 16.62 which are required in the Departmental Program appear on the list of Laboratory Subjects and can be used to satisfy the Laboratory Requirement.				
	Departmental Program				
	Basic Required Subjects				99
6.002	Circuits and Electronics	4	2	9	
6.012	Electronic Devices and Circuits	4	0	8	
8.03	Physics III	5	0	7	
16.001	Unified Engineering I	4	3	5	
16.002	Unified Engineering II	4	3	5	
16.003	Unified Engineering III	4	3	5	
16.004	Unified Engineering IV	4	3	5	
18.03	Differential Equations	4	0	8	
	Advanced Required Subjects				84
6.111	Introductory Digital Systems Laboratory	3	7	2	
6.301	Solid State Circuits	3	3	6	
	Either				
16.02	Aerodynamics	4	0	8	
	or				
16.20	Structural Mechanics	5	0	7	
	Either				
6.302	Feedback Systems	3	2	7	
	or				
16.30	Principles of Automatic Control	3	0	9	
16.40	Principles of Flight Guidance	3	1	8	
16.62	Experimental Projects	2	6	4	
	Either				
16.84	Flight Vehicle Engineering	2	3	7	
	or				
16.85	Space Systems Engineering	4	0	8	
	Unrestricted Electives[2]				60
	Total Units Required for the S.B. Degree				375

1
This department recommends a) 3.091 or 5.60 to satisfy the Institute Chemistry/Biology Requirement, b) that an introductory digital computing/programming subject such as 2.10 or 6.030 be taken as early as possible, and c) that 21.760 Scientific and Engineering Writing, be taken as part of the Humanities Requirement.

2
Schedules of students in Course XVI may be arranged to leave available 24 units of Unrestricted Electives in the second year.

Cooperative Program
Course XVI-B

The cooperative program in Aeronautics and Astronautics provides undergraduates the opportunity to participate in professional activities in an aerospace organization before the senior year for about seven months. This industrial practice enables students to have a more professionally rewarding experience than is usual in summer employment. The program permits completion of requirements for the Bachelor of Science degree in four years. Students in this program become regular employees while working in the company, are subject to the regulations of the company, and are paid at prevailing rates. Students pay their own expenses while away from the Institute.

A student interested in the program should contact the professor in charge for details and an interview; also, the student should arrange a schedule with a faculty counselor which permits an absence from MIT during the second term of the third year. This should be done before January of the second year since subject choices in the second term of the second year may be affected. One summer at MIT usually is necessary.

The curriculum requirements for this degree in Course XVI-B are the same as for Course XVI with the addition of required registration for 16.80 Industrial Practice during the plant work period, in place of eight units of elective.

Engineering Internship Program
Course XVI-C

The Department of Aeronautics and Astronautics participates in the Engineering Internship Program (EIP) administered by the School of Engineering. It is intended as a five-year joint S.B.-S.M. program which features periods of work at a participating company alternating with periods of study at MIT. See additional discussion of this program in the School of Engineering section of this catalogue.

Interested students apply for participation in EIP during the spring term of their sophomore year. Companies select students for work assignments based on interviews at MIT and the student's record. Once a selection is made and accepted, both the student and the company agree to continue that association to completion of the Program.

On a normal schedule, the student stays at MIT for the fall and spring terms of the first four years and at the plant during the summers following the sophomore and junior years. The company pays travel expenses and the student earns a salary while at work. He or she also earns six units of credit for each work period by registering for 16.801. In the spring of the junior year, the student applies for admission to the graduate school in Course XVI. If not admitted, the Program terminates at the end of four years with award of the Bachelor of Science degree. If admitted, the student normally spends the summer following the senior year and the following fall term at the plant, during which time he or she works on a project which is expected to become a Master's thesis. The student also earns 12 units of graduate G credit through registration for 16.802. The following spring and summer terms he or she usually is required to be at MIT to complete the subject requirements and the thesis report. The Bachelor of Science and Master of Science degrees are then awarded simultaneously.

The advantage of this Program to the student is a continuing series of work experiences with study. This stimulates interest in the academic subjects and gives the student a professional perspective on his or her education. The curriculum requirements for Course XVI-C are the same as for Course XVI with 16.801 (twice) used as 12 units of elective. At the completion of the Program there is no obligation on the part of the student or the company for further employment. For further information, please see the Department EIP Coordinator.

Graduate Study

Inquiries

For additional information concerning academic and research programs in the Department, admissions, suggested four-year undergraduate programs (either with breadth or with emphasis in the various avenues in Aeronautics and Astronautics), interdisciplinary programs, financial aid, etc., please write to the Department of Aeronautics and Astronautics Undergraduate Office, Room 33-217, MIT, Cambridge, Massachusetts 02139, (617) 253-2279.

Graduate study in the Department of Aeronautics and Astronautics includes research work culminating in a thesis and study of graduate-level subjects in the Department and other departments and schools at MIT. Degrees are awarded at the Master's, Engineer's, and Doctoral levels. The range of subject matter available is best conveyed by brief descriptions of the activities of the Departmental Divisions of Instruction and the Departmental Laboratories.

Divisions of Instruction and Research Laboratories

The graduate subject offerings of the Department are informally organized into six Divisions: Mechanics and Physics of Fluids; Structures, Materials, and Aeroelasticity; Instrumentation, Guidance, and Control; Propulsion and Energy Conversion; Biomedical Engineering; and Aeronautical and Astronautical Systems. Research is conducted in a number of research laboratories. A faculty member is typically involved in teaching graduate and undergraduate subjects in one or more of the Divisions, and in conducting research in one or more of the Departmental Laboratories or at the Charles Stark Draper Laboratory.

A brief description of these activities is given below as a guide. More detailed information may be obtained from the Graduate Office or from individual faculty members.

Mechanics and Physics of Fluids. Since flight vehicles operate in a fluid environment, continuously for airborne vehicles and during entry into and exit from the atmosphere for space vehicles, students must become familiar with the principles of fluid mechanics. These principles govern forces such as lift and drag which act on the vehicle in flight, the aerodynamic heating during atmospheric entry, and the effects induced by the vehicle on its environment, such as noise and changes in atmospheric chemistry. Fluid mechanics is important to diverse fields of engineering since fluids serve as carriers of material, energy, and information. In aeronautics an improved understanding of the mechanics of low-speed flight is essential if air transportation is to realize its potential for shorthaul urban and suburban transportation. At near-sonic speeds, transport design involves severe aerodynamic constraints on energy use. In our continuing planetary exploration programs, both reentry into the earth's atmosphere at increasing speeds and satellite behavior require a better understanding of the physics of gas-surface interaction. All of these problems ensure a continuing emphasis on this discipline in aerospace engineering.

Research in Fluid Mechanics is carried on in several departmental laboratories, each accessing several computational systems interactively and also maintaining specialized experimental equipment. Gas dynamic research facilities include the hypersonic ($M = 7.5$) and supersonic wind tunnel at the Aerophysics Laboratory. Molecular beam techniques are employed in the Fluid Dynamics Research Laboratory to study interactions of the environment with vehicle surfaces to simulate combustion processes, and to investigate contrail and cloud formation. At the other end of the speed spectrum, the VTOL Technology Laboratory uses the large, low-speed Wright Brothers Wind Tunnel. This facility is used for research on conventional aircraft, helicopter rotor dynamics, and aerodynamics, as well as surface flow problems related to environmental constraints and wind loadings on building structures. An additional Acoustic Tunnel is equipped with an anechoic chamber for acoustical research on conventional and VTOL aircraft. A small low-speed, low-turbulence wind tunnel also is available for fluid mechanics research.

Structures, Materials, and Aeroelasticity. One of the many contributions of aerospace engineering has been the development of lightweight, durable, and damage-tolerant structures capable of operating over a wide range of temperatures and under a variety of loading conditions. The extreme importance of minimizing the structural weight of aircraft and spacecraft has required intensive effort on the part of the aerospace engineer directed towards the development of new structural concepts, of improved materials such as the filamentary compos-

ites, and of a better understanding of fracture and fatigue properties. At the same time, development of advanced structural concepts such as highly loaded shell structures typical of aircraft and spacecraft has required new analytical techniques whose availability has stimulated advances in many non-aerospace areas of structural design. The need to understand the dynamic response and the potential instabilities of slender flexible wings operating at high speeds has motivated the study of aeroelasticity. The need to protect the crew and contents of space capsules from the extreme heating associated with reentry into the earth's atmosphere has required the development of new thermal protection systems and analytical techniques.

Students studying different aspects of mechanics and materials may take advantage of joint subjects offered with other departments, and subject offerings in many other departments of the School.

Research activities of the Structures, Materials, and Aeroelasticity Division are conducted primarily in two laboratories: the Aeroelastic and Structures Research Laboratory and the Technology Laboratory for Advanced Composites. Facilities include vibration equipment, impact and impulse loading/response test equipment, programmable testing machines, and an autoclave (three feet in diameter by five feet long) for the fabrication of filamentary composite structural components. Research is being conducted on the structural technology and analysis of lightweight aircraft structures, wind turbines, aircraft jet engines, large space structures, nuclear power plant components (and safety), advanced filamentary composites (manufacturing technology, damping, fracture, and fatigue), and the application of the finite element and the finite difference method to the analysis of creep, and severe impulse or impact-induced transient structural responses of simple and complex structures under room- or elevated-temperature conditions.

Instrumentation, Guidance, and Control. The need for precise control of flight vehicles has resulted in the development by the aerospace engineer of a new discipline involving highly complex navigation equipment in closed loop systems which measure, guide, control, or enhance the performance of flight vehicles and other complex systems. The ability to operate aircraft under all weather conditions and to control spacecraft in all phases of flight are examples of the application of these systems. Faculty members in the Division teach and perform research in control theory and its applications, navigation systems, instrumentation, man-machine interactions, biological systems, lasers, digital systems, and other related topics.

One primary focus for the activities of the Instrumentation, Guidance, and Control Division is the Draper Laboratory (an independent organization) which maintains close contact with the Department. Many Department faculty and students are actively involved in research programs in this laboratory on guidance systems and components for all types of flight vehicles. Inertial guidance receives special attention in laboratories equipped with advanced facilities for research on all phases of control and guidance. In the past this work has resulted in the development of many flight vehicle systems including the Apollo spacecraft navigation and guidance systems. Present projects include guidance and control systems for the space shuttle vehicle, inertial instrument research, digital control computer development, industrial production control, biomedical instrumentation, and control theory research. These projects offer many opportunities for participation by students of US citizenship.

The Laser Systems Laboratory pioneers in the development and application of laser technology. Specific activities include: optical primary and secondary frequency/wavelength standards; optical gyroscopes; laser doppler velocimeters; holographic techniques for nondestructive testing; ultra-high-resolution spectroscopy and interaction of intense radiation with atoms and molecules.

Biomedical Engineering. The Man-Vehicle Laboratory applies control and instrumentation disciplines to biological and psychological problems. It has been selected to perform manned space experiments on Spacelab-1 to investigate balance, adaptation to zero-g, and "space motion sickness." In addition, it conducts flight simulator studies on man in the loop, vehicle display and control, and air traffic control research. The laboratory also works on bioinstrumentation, physiological control systems, and clinical applications of the aerospace sciences. Activities include modeling of the human visual and vestibular system, flight simulation, cognitive learning and work on diagnostic instrumentation for diseases of the eye and ear.

Propulsion and Energy Conversion. Progress in atmospheric and space flight has been paced by the development of more efficient, lighter propulsion systems. More efficient gas turbines have made possible significant airport noise reductions in civil aircraft without severe performance penalties. Modern high bypass turbofan engines are reducing the fuel consumption of commercial transports. High thrust/weight military engines provide unprecedented performance for lighter aircraft. Progress in solid and liquid propellant rockets has enabled more reliable and economical manned and unmanned space missions including the Space Shuttle now under development.

The advancements in technology derived from development of these systems have wide application in energy production which almost universally involves high temperature gases and plasmas.

Research in Propulsion and Energy Conversion is conducted in the Gas Turbine and Plasma Dynamics Laboratory. The activities there include research on fluid dynamics of compressors and turbines, reduction of emissions from combustion systems, and noise generation by aircraft engines, as well as study of the application of gas turbines to commercial power generation. Research in magnetohydrodynamic (MHD) power generation is directed at more efficient power production from coal, and is carried on by an inter-

departmental, interdisciplinary group. Work in low-density plasma physics is motivated by fusion power plants.

Aeronautical and Astronautical Systems. One of the keys to the success of aerospace engineering has been the development of the now-popular concept of systems engineering. The high levels of expenditure involved in the development of aeronautical and astronautical systems, their complexity and dependence on a variety of disciplines (evident from these divisional descriptions), the high degree of interaction among these disciplines which prevents their being analyzed and optimized independently of each other, have all required the development of some method for integrating the total system and the development of formal analytical tools to optimize it as a whole rather than by parts. From this need has grown the concept of systems engineering whose successful application to the space program and to the analysis of transportation systems has amply demonstrated its effectiveness as an engineering tool.

The broad coverage of systems engineering clearly implies that the responsibilities of the engineer include far more than the design synthesis and construction of devices and facilities. The engineer must be aware of the social implications of his or her work and design, not only for maximum efficiency and safety, but also for minimum disruption of the environment.

Students interested in working in aeronautical and astronautical systems should, therefore, place primary emphasis on a broad educational base which should include subjects in most of the divisions described above. In addition the student should obtain training in the disciplines which support systems analysis, such as probability and statistics, operations research, economics, and computer science, and should also maintain an awareness of the external disciplines which help shape society, such as economics, law, and the social sciences. Most of this material necessarily would be obtained in the graduate program. However, the undergraduate student can become prepared for a more effective graduate program by a judicious choice of undergraduate elective subjects. In addition, there are ample opportunities for undergraduate research particularly in the Space Systems Laboratory.

The research of the Systems Division is conducted in the Flight Transportation, the Space Systems, and the VTOL Technology Laboratories. The Flight Transportation Laboratory conducts research in many areas of flight transportation covering airline operations, air traffic control operations, aircraft navigation and guidance, airport planning, and the application of advanced operations research techniques to transportation systems. The Space Systems Laboratory analyzes concepts for space utilization and exploration, including space manufacturing, the design of large space structures, and space transportation.

Entrance Requirements for Graduate Study

In addition to the general requirements for admission to the Graduate School, applicants must have a strong undergraduate background in some of the fundamentals of aerospace engineering and mathematics as described in Undergraduate Study. Two terms of advanced mathematics beyond the Department's undergraduate curricula are required either prior to, or as part of, all graduate programs. Gaps in preparation can be filled early in the graduate program; additional time in residence should be expected if such gaps require many undergraduate subjects.

New graduate students are normally admitted as candidates for the degree of Master of Science. Admission requirements for candidates for the Engineer in Aeronautics and Astronautics are more rigorous and such admission is ordinarily considered only after the candidate has spent some time in residence at MIT. Admission to the Doctoral program is offered to students who have been accepted for graduate study and have passed the Doctoral Qualifying Examination. The examination is usually taken during the first year of graduate study in the Department, but not later than the third term. The examination seeks to measure the candidate's fundamental understanding of the principles underlying aerospace engineering and aptitude for engineering research.

The Department of Aeronautics and Astronautics requires that all entering graduate students demonstrate satisfactory English writing ability by taking the Writing Diagnostic Examination offered by the Writing Program of the MIT Humanities Department. The exam is usually administered during the week after the initial date of registration in Graduate School. Those whose skills are found deficient will be required to complete remedial training specifically designed to fulfill their individual needs.

In addition, foreign candidates whose language of instruction has not been English for at least five or more years and/or those whose TOEFL score falls below 600, must take the MIT English Evaluation Test for Foreign Graduate Students after registration. The examination is held in early September and late January. On the basis of performance on this examination, the faculty may prescribe remedial courses in English offered at MIT.

Master of Science in Aeronautics and Astronautics

The general requirements for the Master of Science degree are cited in Chapter IV of this catalogue. The specific Departmental requirements are: an acceptable thesis, and at least 66 subject units, typically in graduate subjects relevant to the candidate's area of technical interests. Of the 66 units, 42 units must be in "A" subjects. Full-time students normally must be in residence one full academic year. Students holding Research Assistantships will require a longer period of residence.

The Department requires two terms of advanced mathematics beyond 18.03 Differential Equations or its equivalent either prior to or as a part of the Master's program. The choice of subjects in the

area of major interest and the thesis topic are arranged individually by each student in consultation with a faculty advisor; the program of study must have the approval of the faculty advisor, who acts in behalf of the Department faculty.

Master of Science in Technology and Policy

Students interested in applying their aeronautical engineering background to problems of policy and socioeconomic assessment of technology may apply for the interdepartmental Master of Science Program in Technology and Policy. This program combines subjects in advanced technology with subjects in economics, systems analysis, political science, and law. It engages the student in significant project work integrating technology and policy. Well-qualified students may complete this program in one calendar year. General requirements and application procedures are described in Chapter V of this catalogue.

Engineer in Aeronautics and Astronautics

The Program leading to the degree of Engineer in Aeronautics and Astronautics is offered for students interested in a greater breadth of graduate subjects than is normally associated with a Master's or Doctoral program, and less emphasis on research than required of Doctoral candidates. The minimum study program of 162 subject units must include graduate subjects from each of the Divisions of Instruction, and the thesis work must have a strong engineering, as opposed to scientific, orientation. Two years beyond the Bachelor of Science degree normally are required for completion of this degree by a full-time student.

Doctor of Philosophy and Doctor of Science

The general requirements for this degree are given in Chapter IV of this catalogue. A candidate is admitted to the Doctoral program upon passing the Doctoral Qualifying Examination. After selecting an area for study and research, the candidate in consultation with the thesis supervisor forms a doctoral/thesis committee, which assists in the formulation of the individual's research and study programs and monitors the student's progress. The subjects selected to fulfill the major and minor program requirements must be approved by the committee. One foreign language is required and also must be approved by the student's committee. The candidate's mastery of the major area is tested by a written and an oral General Examination administered by the doctoral/thesis committee after completion of the major subjects.

Demonstrated competence for original research at the forefront of aerospace engineering is the final and major criterion for granting the Doctorate degree. The candidate's thesis serves in part to demonstrate such competence, and on completion is defended orally in a presentation to the faculty of the Department, which may then recommend the award of the degree.

Interdisciplinary Programs

The graduate division of the Department participates in several interdisciplinary fields which are of special importance for Aeronautics and Astronautics. Research effort related to these programs is actively pursued in Department laboratories and by the Department's faculty.

Biomedical Engineering. This program is available to students interested in biomedical instrumentation and physiological control systems where the disciplines involved in Aeronautics and Astronautics are applied to biology and medicine. Graduate study based on this program may be pursued within the Departmental program, the Health Sciences and Technology S.M.-Ph.D. Program in Medical Engineering and Medical Physics, or the Interdepartmental Ph.D. program in Biomedical Engineering. At the Master's degree level, students in the Department may specialize in biomedical engineering, emphasizing quantitative physiology, instrumentation and control, and biostatistics, or in man-machine systems and engineering psychology and in instrumentation and statistics.

The Interdepartmental Ph.D. program in Biomedical Engineering is intended for students with a strong engineering background who wish to make a career commitment to biomedical engineering. The Harvard-MIT Program in Medical Engineering and Medical Physics is for students wishing a more intensive exposure to the medical sciences as preparation for a career of research focused on clinical problems. For a further description of these programs, please see Chapter V, Interdepartmental Study and Research. Most biomedical engineering in the Department of Aeronautics and Astronautics is conducted in the Man-Vehicle Laboratory. Further information is contained in the brochure "Biomedical Engineering at MIT and Harvard," available from the Biomedical Engineering Committee, Room 37-219, MIT.

Flight Transportation. For students interested in a career in flight transportation, there is available a program which incorporates a broader graduate education in disciplines such as economics, management, law, and operations research than is normally pursued by candidates for degrees in Engineering. Graduate research emphasizes one of the five areas of flight transportation: Flight Vehicle Control; Airport Planning; Airport Design; Air Transportation Systems Analysis; and Operations Research, with subjects selected appropriately from those available in the Departments of Aeronautics and Astronautics, Civil Engineering, Economics, and the Center for Transportation Studies (See Chapter V, Interdepartmental Graduate Study). A special interdepartmental program may be established for the doctoral student (or participation in the Operations Research Center Program may be considered).

Fellowships, Research and Teaching Assistantships

Financial assistance for graduate study may be in the form of fellowships or research or teaching assistantships. There are several endowed and departmental fellowships which are granted to students of exceptional promise. Among the endowed fellowships are those named after

Donald W. Douglas, Richard D. duPont, and Lester D. Gardner. The Department attempts to place a student in a laboratory in which the research activity is closely related to the student's interests. Both the fellowship student and the research assistant work with a faculty supervisor on a specific research assignment. The student gains experience invaluable in any career in engineering in organizing the work leading to a thesis, i.e., defining and carrying out a research problem, learning and applying new experimental techniques and analytical tools, and organizing and writing a technical document.

Inquiries

For additional information concerning academic and research programs in the Department, admissions, interdisciplinary programs, financial aid, assistantships, etc., please contact the Department of Aeronautics and Astronautics Graduate Office, Room 33-217, MIT, Cambridge, Massachusetts 02139, (617) 253-2260.

Innovation Program

The Department has initiated and provides logistic support for the MIT Innovation Program which is organized by the School of Engineering with the support of the Sloan School of Management. The primary goals are to develop an atmosphere conducive to inventiveness and to provide the facilities and organization necessary to carry out the development of promising ideas. The complete process of bringing a new concept or device from the idea stage, through development and testing, including marketing and the legal aspects of patents and licensing, is undertaken.

Conventional classroom and project laboratory subjects are recommended by the Innovation Center to guide students through the early phases of learning the innovation process. The Innovation Co-op is a product development laboratory which provides a professional push in the development and marketing of products and gives the student clinical exposure to the latter phases of the innovation process. Students are encouraged to develop their ideas into products. The first step is to develop a working model, perform a marketing survey, and prepare a business plan which is presented to the Innovation Co-op. This activity can take place as a laboratory subject, thesis, or special project. A product whose business plan is accepted is developed by the Co-op to the stage where it can be marketed as a new venture or presented to industry under a license arrangement. Students are involved in the operation of the Co-op as project coordinators. They transfer knowledge gained during the product development stage and participate in the decision-making processes concerning materials, manufacturing, marketing strategy, etc.

Students at any level and from any department may participate.

The Innovation Center is located in W91-208.

Department of Chemical Engineering

James Wei, Sc.D.
Warren K. Lewis Professor of Chemical Engineering
Head of the Department

John Ploeger Longwell, Sc.D.
Edwin R. Gilliland Professor of Chemical Engineering
Executive Officer of the Departm

Professors

Raymond Frederick Baddour, Sc.D.
Lammot du Pont Professor of Chemical Engineering

János Miklós Beér, Sc.D.
Professor of Chemical and Fuel Engineering

Clark Kenneth Colton, Ph.D.
Bayer Professor of Chemical Engineering

John Frank Davidson, Sc.D.
Professor of Chemical Engineering
(Visiting)

Lawrence Boyd Evans, Ph.D.
Professor of Chemical Engineering

Jack Benny Howard, Ph.D.
Professor of Chemical Engineering

Edward Wilson Merrill, Sc.D.
Carbon P. Dubbs Professor of Chemical Engineering

Robert Clark Reid, Sc.D.
Chevron Professor of Chemical Engineering

Adel Fares Sarofim, Sc.D.
Joseph R. Mares Professor of Chemical Engineering

Charles Nelson Satterfield, Sc.D.
Professor of Chemical Engineering

Kenneth Alan Smith, Sc.D.
Professor of Chemical Engineering
Associate Provost

Johnson Edward Vivian, Sc.D.
Professor of Chemical Engineering, Emeritus
Senior Lecturer

Glenn Carber Williams, Sc.D.
Professor of Chemical Engineering
Graduate Officer

Associate Professors

Robert Calvin Armstrong, Ph.D.
Associate Professor of Chemical Engineering

Charles Harry Byers, Ph.D.
Associate Professor of Chemical Engineering
Director of the School of Chemical Engineering Practice, Oak Ridge
(Visiting)

Robert Edward Cohen, Ph.D.
Associate Professor of Chemical Engineering
(On leave)

William Murray Deen, Ph.D.
Associate Professor of Chemical Engineering

Wayne Douglas Erickson, Sc.D.
Associate Professor of Chemical Engineering
(Visting)

Christos Georgakis, Ph.D.
Associate Professor of Chemical Engineering

Michael Patrick Manning, Sc.D.
Associate Professor of Chemical Engineering

Michael Modell, Sc.D.
Associate Professor of Chemical Engineering
(Absent)

Frederick Asahel Putnam, Ph.D.
Associate Professor of Chemical Engineering

Ulrich Werner Suter, Dr.Sc.Techn.
Associate Professor of Chemical Engineering

Jefferson William Tester, Ph.D.
Class of 1942 Associate Professor of Chemical Engineering
Director of the School of Chemical Engineering Practice

Costas George Vayenas, Ph.D.
Associate Professor of Chemical Engineering
(Absent)

Preetinder Singh Virk, Sc.D.
Associate Professor of Chemical Engineering

Assistant Professors

John Francis Brady, Ph.D.
Assistant Professor of Chemical Engineering

Robert Arthur Brown, Ph.D.
Joseph R. Mares Assistant Professor of Chemical Engineering

Fred Morris Gelbard, Ph.D.
DuPont Assistant Professor of Chemical Engineering

Trevor Alan Hatton, Ph.D.
Assistant Professor of Chemical Engineering

George Albert Huff, Jr., Sc.D.
Assistant Professor of Chemical Engineering
Director of the School of Chemical Engineering Practice, Albany

Herbert Harold Sawin, Ph.D.
DuPont Assistant Professor of Chemical Engineering

Selim Mehmet Senkan, Sc.D.
Assistant Professor of Chemical Engineering

Adjunct Professors

Alan Sherman Michaels, Sc.D.
Adjunct Professor of Chemical Engineering

Joseph Lee Russell, Sc.D.
Adjunct Professor of Chemical Engineering

Administrative Officer

Robert Choate Morrow, B.S.

Senior Lecturers

Morton Mace Denn, Ph.D.
(Visiting)
Charles Michael Mohr, Sc.D.
William Caubu Rousseau, M.S.
(Visiting)

Lecturers

Samuel Wright Bodman, Sc.D.
(Visiting)
Edmund Gale Lowrie, M.D.
(Visiting)
Barry Alan Solomon, Ph.D.
(Visiting)
Warren Myron Zapol, M.D.
(Visiting)

Instructors

Ralph Allen Hulseman, M.S.
Assistant Director of the School of Chemical Engineering Practice, Oak Ridge

George Harry Kemker, Jr., M.S.
Assistant Director of the School of Chemical Engineering Practice, Albany

Herbert Marc Wood, B.S.
Director of the School of Chemical Engineering Practice, Albany

Technical Instructors

Reed Campbell Fulton
Stanley Robert Mitchell

Visiting Engineer

Amitava Mitra, M.Sc.

Visiting Scientists

Al Kemal Dincer, Ph.D.
Edwin W. Salzman, M.D.
Michael Bernard Stemerman, M.D.
Youqi Yang, B.S.
Wei-Kang Yuan, B.S.

Visiting Scholar

Zhao-Sheng Tian, Dipl.

Professors Emeriti

Thomas Bradford Drew, S.M.
Professor of Chemical Engineering, Emeritus

Hoyt Clarke Hottel, A.B., S.M.
Professor of Chemical Engineering, Emeritus

Herman Paul Meissner, D.Sc.
Professor of Chemical Engineering, Emeritus

Johnson Edward Vivian, Sc.D.
Professor of Chemical Engineering, Emeritus
Senior Lecturer

Harold Christian Weber, D.Sc.
Professor of Chemical Engineering, Emeritus

Department of Chemical Engineering

Undergraduate Study

Chemical engineering is the most broadly based of all engineering disciplines. This breadth results from a very deep involvement with chemistry in addition to the applications of physics and mathematics which are common to all engineering disciplines. In its broadest sense, chemical engineering is the creative application of chemistry to the solution of significant problems. Chemical engineering is making unparalleled contributions to the development of clean energy sources, to the provision of adequate food supplies, to the recreation of proper ecological balances, to the advancement of medical/engineering science, and to the economic production of material goods. In order to participate meaningfully in these activities, the engineer requires a thorough grounding in chemistry, mathematics, and physics. At MIT, the Department of Chemical Engineering achieves this objective in two undergraduate programs. One is Course X, leading to the Bachelor of Science in Chemical Engineering. This program is accredited by the Engineers' Council for Professional Development and the American Institute of Chemical Engineers. The other program is the Course X-C leading to the Bachelor of Science without specification. The latter is not accredited and requires less study in formal chemical engineering subjects and results in additional elective time. In the past, Course X-C has proven to be especially attractive to students who wish to specialize in chemistry, physics, biology, patent law, or management while simultaneously gaining a broad exposure to the engineering approach to solving problems.

The Department offers a wide selection of graduate subjects and research leading to advanced degrees in chemical engineering. Important subject areas include fuels and energy, polymer chemistry, surface and colloid chemistry, biomedical engineering, chemical process development, transport processes, and environmental engineering. Many of our current undergraduates find it attractive in the upperclass years to take a variety of these graduate-level subjects. This exposure is invaluable in identifying potential independent research interests for the student. Other students find these subjects to be fruitful as terminal technical subjects prior to moving on to work in teaching, government, or management. Students interested in the various areas of graduate study in Chemical Engineering should consult the graduate section which follows Undergraduate Study.

The School of Chemical Engineering Practice, also described in detail in the graduate section, involves one term of work under the direction of Institute staff resident at the Practice School Stations. There each student has a unique opportunity to develop the ability to apply basic professional principles to the solution of practical problems in industry. Study at the field stations is generally included in a program for a Master of Science degree and is normally required for the Chemical Engineer degree.

The undergraduate subjects provide basic studies in physics and mathematics, a major concentration in chemistry, and a strong core of chemical engineering. The four-year undergraduate programs, designed to develop judgment, initiative, and responsibility, give students considerable latitude in arranging a selection of subjects that best fits their needs and develops their aptitudes. Those who expect to go on to graduate school may therefore elect subjects which strengthen their preparation for advanced work.

In addition to work in science and engineering, students take an integrated sequence of subjects in the humanities and social sciences. The chemical engineer's progress and accomplishments are not determined solely by technological competence; fully as important are a breadth of outlook and an understanding of society. The curriculum is designed to give undergraduates a sound basis for further developing their aptitudes and interests through industrial work, independent study, or graduate work.

Chemical engineering also provides an ideal preparation for careers in medicine and related fields of health science and technology. The Department's strong emphasis on chemistry provides excellent training toward medical school. A suitable program of study may be arranged within the regular curricula of Course X or X-C. Interested students should consult with their faculty advisor.

Bachelor of Science in Chemical Engineering
Course X

	General Institute Requirements	Total Units
	Specific science and humanities and social science subjects	132
	The subjects 10.13, 18.03 and 5.41 which are required in the Departmental Program, appear on the list of Science Distribution Subjects and can be used to satisfy the Science Distribution Requirement.	
	The subjects 5.310 (5.311) which are required in the Departmental Program appear on the list of Laboratory Subjects and can be used to satisfy the Laboratory Requirement.	
	Departmental Program	
	Required Subjects	**138**
5.310	Laboratory Chemistry	2 8 2
	or	
5.311	Introductory Chemical Experimentation	2 8 2
5.41	Introduction to Structure, Bonding and Mechanism[1]	5 0 7
5.42	Organic Chemistry	5 0 7
5.62	Physical Chemistry	4 0 8
10.13	Mass and Energy Processing	4 0 8
10.14	Chemical Engineering Thermodynamics	3 0 6
10.26	Chemical Engineering Laboratory	2 8 2
10.301	Fluid Mechanics	3 0 6
10.302	Transport Processes	3 0 6
10.32	Separation Processes	3 0 6
10.36	Process Design	3 0 6
10.37	Chemical Kinetics and Reactor Design	3 0 6
18.03	Differential Equations	4 0 8
	Restricted Electives	
	Chemistry, Materials Science, Biology	**at least 18**
	Chemical Engineering[2]	**at least 18**
	Laboratory Work, 18 units selected from among subject offerings in the above categories. Thesis may be elected to satisfy 12 units. The subjects 10.UR, 10.91 or equivalent may be elected to satisfy no more than 6 units.	
	Unrestricted Electives[3]	**60**
	Total Units Required for the S.B. Degree	**366**

1
Students who take 5.41 to fulfill the General Institute Requirements in Chemistry/Biology must take 12 additional units of Unrestricted Elective.

2
The 18 units of restricted electives in Chemical Engineering must not include 10.801, 10.802J, 10.803, 10.804, 10.805J, 10.806, 10.808J, or 10.816.

3
It is always possible for second-year students in Course X to arrange their course of study so that they have 12 units of elective freedom each semester.

Electives in chemistry normally are selected from the following: 5.61 Physical Chemistry; 5.03 Principles of Inorganic Chemistry I; and relevant laboratory subjects. Electives in chemical engineering normally include the following: 10.21 Structures and Properties of Matter and 10.18 Industrial Chemistry.

Additional opportunity for experimental research, with considerable flexibility in scheduling, is provided in 10.91 Experimental Research Problem. Students with a strong interest in a professional minor may satisfy this interest by use of the unrestricted elective time.

Freshmen who want an early initial exposure to chemical engineering should take 10.10 Process Synthesis which is designed for freshmen and may be used to satisfy the restricted electives in Chemical Engineering.

The student who decides early to major in chemical engineering is encouraged to begin taking professional subjects at once. For example, 5.41 Introduction to Structure, Bonding and Mechanism satisfies the Institute requirement in chemistry. It is required in the Departmental Program and may be taken in the freshman year. In the second year, the chemical engineering subjects, 10.13 Mass and Energy Processing and 10.14 Chemical Engineering Thermodynamics; 5.62 Physical Chemistry; and additional mathematics may be taken. The student is then in an excellent position for professional work in some depth in the third and fourth years.

Some students may wish to defer choice of a major field until the end of two years; or they may decide upon chemical engineering early but still wish, because of strong secondary interest in other engineering or scientific areas, to exercise maximum freedom in the first two years. They have 12 units of elective time in the first year and, if their second year includes two subjects in humanities and a third term of mathematics, 60 units remain to be chosen. If two of the Science Distribution Subjects chosen are in the field of fluid mechanics, thermodynamics, chemistry, biology, or chemical engineering (examples: 2.40 Thermodynamics, 3.00 Thermodynamics of Materials, 5.41 Introduction to Structure, Bonding and Mechanism, 5.60 Chemical Thermodynamics, 7.01 General Biology, 10.10 Process Synthesis, or 10.13 Mass and Energy Processing) students can generally complete the requirements for a degree in chemical engineering in two more years. This leaves 36 hours to their own choosing in the second year, but they have sacrificed some of their elective freedom in the third and fourth years. Students are advised to discuss their proposed program with a Course X faculty advisor as soon as they become interested in a degree in chemical engineering.

Bachelor of Science
Course X-C

Students in Course X-C are permitted to plan programs involving basic subjects in chemistry and chemical engineering, but instead of continuing in depth in these areas, can study in other fields, such as other engineering disciplines, biology, biomedical engineering, economics, or management.

Students planning to follow this curriculum should discuss their interests with a member of the faculty of the Department. At the time they decide to enter the Course X-C program, preferably by the first term of their senior year, they should submit to the Department a statement of goals and a program of subjects which achieves their objectives. Students are assigned a member of the Department faculty as an advisor.

Graduate Study

Bachelor of Science Course X-C

	General Institute Requirements	Total Units
	Specific science and humanities and social science subjects	132
	The Science Distribution Requirement can be satisfied by 10.13 and 5.41 which are required in the Departmental Program, plus appropriate subjects totaling	12
	Laboratory Requirement	12
	Departmental Program	
	Required Subjects	42
5.41	Introduction to Structure, Bonding and Mechanism[1]	5 0 7
10.13	Mass and Energy Processing	4 0 8
10.14	Chemical Engineering Thermodynamics	3 0 6
10.301	Fluid Mechanics	3 0 6
	Restricted Electives	at least 102
	A coherent program of subjects, with at least 30 units in chemical engineering,[2] in addition to those in the Departmental Program, designed to achieve a specific educational goal. The program is to be planned by the student in consultation with a designated faculty advisor in the Department of Chemical Engineering.	
	Unrestricted Electives[3]	up to 60
	Total Units Required for the S.B. Degree	360

1
Students who take 5.41 to fulfill the General Institute Requirement in Chemistry/Biology, must take 12 additional units of Unrestricted Elective.

2
The 30 units of restricted electives in Chemical Engineering must not include 10.801, 10.802J, 10.803, 10.804, 10.805J, 10.806, 10.806J, or 10.816.

3
The Unrestricted Electives must be at least 36 units.

Five-Year Programs

In addition to offering separate programs leading to the Bachelor of Science and Master of Science in Chemical Engineering, the Department offers a program leading to the simultaneous award of both degrees at the end of five years. A detailed description of this program is available from the Graduate Registration Officer.

For chemical engineering students interested in nuclear applications, the Department of Chemical Engineering and the Department of Nuclear Engineering offer a five-year program leading to the joint Bachelor of Science in Chemical Engineering and Master of Science in Nuclear Engineering. Such Programs are approved on an individual basis between the registration officers of the two departments.

Inquiries

Additional information concerning undergraduate academic and research programs, admissions, financial aid, etc. may be obtained by writing to Professor J. B. Howard, Executive Officer, Department of Chemical Engineering, Room 66-350, MIT, Cambridge, Massachusetts 02139, (617) 253-4561.

Fields of Graduate Study

The technology of chemical engineering in the process industries falls loosely into two categories: physical and chemical. While both types are encountered in many industrial problems, graduate subjects of instruction and research are logically grouped in the corresponding fields of engineering operations and applied chemistry. Most graduate students take some work in each field, and in the School of Chemical Engineering Practice the problem assignments involve fundamentals in both areas.

Applied Chemistry. The Department offers a diversified program in applied chemistry, designed for students who wish to broaden their competence in the chemical aspects of chemical engineering. This program provides subjects in industrial chemistry and chemical thermodynamics; chemical kinetics and reactor engineering, with emphasis on heterogeneous and catalytic processes; and the physical chemistry of ion exchange, adsorption, and chromatography. The subjects listed under Materials Science and Engineering also include several on applied chemistry. Much of the Department's research activity falls into these areas, and unique laboratory facilities are provided. Specific subjects offered by the Department include:

10.25	Industrial Chemistry
10.47	Ion Exchange
10.56	Chemical Engineering in Medicine
10.59	Properties of Gases and Liquids
10.60	Heterogeneous Catalysis and Catalytic Processes
10.61J	Surface and Colloid Chemistry
10.62	Electrochemistry
10.63	Adsorption and Catalysis
10.65	Chemical Reactor Engineering
10.655	Multiphase Chemical Reactors

A well-rounded program in applied chemistry might also include subjects given by other departments in advanced organic, inorganic, or physical chemistry; biochemistry, enzymology, or bacteriology; and physical metallurgy, electrochemistry, corrosion, or ceramics.

Biochemical Engineering. The past two decades have witnessed major scientific breakthroughs in the fields of biochemistry and biology. Practical application of these developments is virtually untapped; they represent natural and fertile areas of activity for chemical engineers with strong backgrounds in applied chemistry. Among these are analytical techniques (enzyme-coated electrodes, automated chemical analysis), medical therapy (cancer chemotherapy, artificial kidney) and catalysts for industrial processes. The Department has an active research program focusing upon the use of enzymes in a wide range of applications. Students interested in the field have the opportunity to draw upon a variety of relevant subjects offered by the Department including:

10.25	Industrial Chemistry
10.50	Heat and Mass Transfer
10.56	Chemical Engineering in Medicine
10.58J	Artificial Internal Organs
10.60	Heterogeneous Catalysis and Catalytic Processes
10.61J	Surface and Colloid Chemistry
10.641	Structure and Properties of Polymers
10.65	Chemical Reactor Engineering

Well-rounded programs also should include introductory and advanced subjects in biology, biochemistry, bacteriology, biochemical engineering, or microbiology offered in other departments.

Biomedical Engineering. The application of chemical engineering to problems in the life sciences and medicine has become an increasingly important and meaningful area of research. The broad backgrounds of chemical engineers, spanning both fundamental and applied aspects of chemistry and physics, makes them uniquely qualified to handle such tasks.

Students interested in this area have the opportunity to draw upon the Department's diverse offering of subjects in the chemical engineering sciences. Relevant subjects offered include:

10.21	Structures and Properties of Matter
10.33	Analytical Treatment of Chemical Engineering Processes
10.40	Chemical Engineering Thermodynamics
10.49J	Biomedical Transport Phenomena
10.50	Heat and Mass Transfer
10.51	Macromolecular Hydrodynamics
10.52	Mechanics of Fluids
10.54	Advanced Topics in Mass Transfer
10.56	Chemical Engineering in Medicine
10.58J	Artificial Internal Organs
10.61J	Surface and Colloid Chemistry
10.641	Structure and Properties of Polymers
10.65	Chemical Reactor Engineering
10.67	Polymer Science Laboratory
10.681	Physical Chemistry of Polymers

The Department's active graduate research program in biomedically related areas is characterized by an interdisciplinary approach to both fundamental and applied problems. Many projects involve collaboration with physicians, surgeons, and life scientists in other departments and in local hospitals associated with Harvard Medical School. Research topics include the rheology of non-Newtonian biological fluids, mass transfer in blood and in artificial organs, such as the artificial kidney and blood oxygenator, synthesis of blood-compatible synthetic biomaterials, membrane transport phenomena, synthetic replacement of the lung surfactant, physical properties of biopolymers, and ultrafiltration of solutions of biological macromolecules.

Environmental Engineering. Most processes which generate pollutants are chemical in nature. A broad chemical engineering background therefore provides an excellent preparation for attacking many aspects of environmental engineering. Problems in air and water pollution control and in solid waste disposal can be analyzed and modified by applying chemical engineering fundamentals. Furthermore, the versatility of the chemical engineer, in terms of an understanding of both chemical and physical aspects of engineering, makes him or her particularly well-qualified to handle the more complex interrelationships which are part of the broader environmental problems.

In addition to graduate subjects in thermodynamics, industrial chemistry, and transport phenomena, students interested in pursuing graduate programs in environmental engineering are encouraged to take some additional subjects in process design, kinetics, catalysis, combustion, and separation processes. Specific subjects in environmental problem areas include:

10.17	Air Pollution Fundamentals
10.72	Seminar in Air Pollution Control
10.75	Principles of Chemical Waste Management

Also recommended are subjects in water resources (Civil Engineering), mesometeorology (Meteorology and Physical Oceanography), microbiology (Biology), and biochemical engineering (Nutrition and Food Science).

Chemical Engineering Systems. The Department offers a program for the student who wishes to apply a broad chemical engineering background to the analysis and synthesis of chemical process systems. Increased use of the digital computer for process design and control and the development of improved mathematical and computational methods has

made possible the modeling, simulation, and optimization of complex chemical engineering systems, operating in the non-steady state, with interaction of operating units and components. There are increased opportunities for graduates who have augmented a solid background in chemical engineering fundamentals with an understanding of the tools and language of modern systems analysis.

Relevant subjects offered by the Department include:

10.33	Analytical Treatment of Chemical Engineering Processes
10.34	Numerical Methods Applied to Chemical Engineering
10.341	Finite Element Methods for Problems in Transport Phenomena
10.35	Chemical Process Dynamics and Control
10.38	Analysis and Simulation of Chemical Processing Systems
10.53	Chemical Engineering Design

Well-rounded programs also may include introductory and advanced subjects in applied mathematics, control theory, operations research, and systems analysis offered by other departments.

Graduate research activities in these fields include work on process simulation, modeling, and system optimization, real-time control, computer aided design and automatic process synthesis. Research is carried out in collaboration with students and faculty in electrical engineering to bring an interdisciplinary approach to the program.

Engineering Operations (Process Engineering). The variety of graduate offerings provides opportunity for programs in heat transfer, fluid mechanics, and the separation processes based on mass transfer — subjects which are basic in process engineering. Opportunities for research of an advanced nature in these areas are available. Relevant subjects offered by the Department include:

10.33	Analytical Treatment of Chemical Engineering Processes
10.35	Chemical Process Dynamics and Control
10.38	Analysis and Simulation of Chemical Processing Systems
10.40	Chemical Engineering Thermodynamics
10.41	Distillation
10.47	Ion Exchange
10.50	Heat and Mass Transfer
10.51	Macromolecular Hydrodynamics
10.52	Mechanics of Fluids
10.53	Chemical Engineering Design
10.54	Advanced Topics in Mass Transfer
10.615	Integrated Circuit Processing
10.651J	Fluidization
10.70	Principles of Combustion

Programs also may include advanced subjects in mathematics, instrumentation, fluid mechanics, metallurgy, and others offered in other departments.

Fuel and Fossil Energy Engineering. The problem of supplying energy economically while meeting environmental constraints is growing in importance and complexity thus providing opportunities for major research and engineering contributions in the fields of combustion and fuel conversion. Combustion involves all the basic chemical engineering skills and a knowledge of high temperature chemistry and complex radiative heat transfer. Fuel conversion processes such as coal pyrolysis, gasification, and liquefaction involve the problems of the chemistry of complex mixtures with an important requirement for selective production of the desired products.

An integrated program in the field typically includes subjects in heat, momentum and mass transfer, thermodynamics, kinetics, combustion, radiation, and a research problem in combustion or fuel processing. The Department's Fuels Research Laboratory provides excellent facilities for research on a wide range of problems; through cooperative programs with the Energy Laboratory, it offers the opportunity to work in facilities of sufficient size to address many of the pressing problems of fluidized bed and conventional combustion of difficult fuels on a realistic scale. Control of pollutants in both fuel manufacture and combustion is a major thrust of the research program. Relevant subjects include:

10.39	Energy Technology
10.40	Chemical Engineering Thermodynamics
10.50	Heat and Mass Transfer
10.52	Mechanics of Fluids
10.60	Heterogeneous Catalysis and Catalytic Processes
10.63	Adsorption and Catalysis
10.65	Chemical Reactor Engineering
10.651J	Fluidization
10.70	Principles of Combustion
10.72	Seminar in Air Pollution Control
10.73	Seminar in Fuel Conversion and Utilization
10.74	Radiative Transfer
10.79J	Introduction to Nuclear Chemical Engineering

Materials Engineering and Polymers. The Department maintains an active and diversified graduate research program in surface and colloid chemistry, polymer chemistry, and polymer physics and offers a coordinated instructional program in these areas. Students whose interests lie in the direction of surface phenomena or polymeric materials thus have a rare opportunity to develop specialized skills in these areas in an atmosphere where the focus of attention is on the applied, as well as the basic, scientific aspects. Specific subjects offered are:

10.51	Macromolecular Hydrodynamics
10.57J	Polymer Processing
10.61J	Surface and Colloid Chemistry
10.615	Integrated Circuit Processing
10.641	Structure and Properties of Polymers
10.642	Molecular and Phenomenological Interpretation of Polymer Viscoelasticity
10.66	Polymer Rheology Laboratory
10.67	Polymer Science Laboratory
10.681	Physical Chemistry of Polymers
10.682	Chain Structure, Conformation and Morphology of Synthetic Polymers
10.691	Synthetic Chemistry of Polymers

Graduate research activities in these fields include topics such as the rheology of bulk polymers, polymer solutions and particulate dispersions, molecular transport phenomena in polymers, structure and properties of elastomers and microcrystalline thermoplasts, permselective membranes, chemisorption on semiconductors, fluid transport in microporous solids, crystal growth kinetics and wetting processes. Collaboration between chemical engineering and many other departments in the supervision of these research projects brings an interdisciplinary approach to the entire program.

For students with strong interest in materials and an adequate background in chemistry or chemical engineering, the Department offers special graduate curricula leading to the degrees of Materials Engineer, Doctor of Science, or Doctor of Philosophy. These curricula are designed to provide a properly integrated background in the science and engineering of the major classes of materials (metals, ceramics, and polymers) and also to specialize in some depth in a selected area of the field. Specific graduate programs are suggested by, and subject to the approval of, an interdepartmental committee on materials engineering. Further details may be obtained by consulting the Department's Graduate Registration Officer.

School of Chemical Engineering Practice

Since its inception in 1916 the School of Chemical Engineering Practice has been a major feature of the graduate education in the Department. In this unique program students receive intensive instruction to broaden their education, not only in the technical aspects of the profession, but also in communication skills and human relations, which are frequently decisive in the success of an engineering enterprise.

Every student accepted into the program spends half a semester at each of the two Practice School stations under the full time supervision of resident MIT Staff members. Presently, one station is located at the Oak Ridge National Laboratory, Oak Ridge, Tennessee, which is operated by the Nuclear Division of the Union Carbide Corporation for the Department of Energy. The other station is at the General Electric Company's plastics and silicone production facilities near Albany, New York. At Oak Ridge, students receive training in the research and development aspects of the profession in a government funded laboratory. At Albany the emphasis is on technical and economic feasibility, design, operation, and optimization of chemical processes in a profit-motivated organization. The widely different, yet complementary operations of these plants provide a good basis for problem solving and the opportunity for exposure to a large variety of technical activities.

The operation of the Practice School is quite similar to a small consulting company. The resident staff work closely with the technical personnel of the host companies in identifying project assignments with significant educational merit, and with solutions that result in worthy contributions to the operation of the host plants.

At Practice School, students work on three or four different projects. Groups and designated group leaders change from one project to another, giving every individual an opportunity to be a group leader at least once.

Students interested in attending Practice School are advised to take subjects from the following list:

10.25	Industrial Chemistry
10.33	Analytical Treatment of Chemical Engineering Processes
10.40	Chemical Engineering Thermodynamics
10.50	Heat and Mass Transfer
10.60	Heterogeneous Catalysis and Catalytic Processes
10.65	Chemical Reactor Engineering

Advanced Degrees

The following advanced degrees are offered in chemical engineering: Master of Science in Chemical Engineering; Master of Science in Chemical Engineering Practice; Chemical Engineer; Environmental Engineer; Materials Engineer; Doctor of Science or Doctor of Philosophy. Preparation equivalent to 5.62 Physical Chemistry and 5.42 Organic Chemistry is normally essential for any graduate work in chemical engineering.

Master of Science in Chemical Engineering. Programs for the Master of Science in Chemical Engineering usually are arranged as a continuation of undergraduate professional training, but on a more mature basis. The general requirements for a Master's program are given in Chapter IV of this catalogue. To complete the requirements of at least 66 subject units, of which 42 units must be in "A" subjects, together with an acceptable thesis generally takes one academic year.

Master of Science in Chemical Engineering Practice. The requirements for the Master of Science in Chemical Engineering Practice (Course X-A) are the same as those for the Master of Science in Chemical Engineering, except that 24 units of practice school experience (10.82, 10.83, 10.84, 10.85, 10.86, 10.87, 10.88 or 10.89) may be accepted in lieu of the Master's thesis.

Bachelor of Science graduates of this Department ordinarily meet the requirements for the Master of Science in Chemical Engineering Practice (Course X-A) in two terms. Beginning in the September following graduation, students are at the field stations until the end of December, and then return to the Institute to complete the program during the spring term. A similar Practice School field program begins in February and extends to the end of May.

For students who have graduated in chemical engineering from other institutions, the usual program of study for the Master of Science in Chemical Engineering Practice involves one or two terms at the Institute followed by the field station work in the Practice School. Graduates in chemistry from other institutions normally require an additional term. Enrollment is limited and students usually are not admitted to the Practice School until they have spent at least one term at the Institute.

Master of Science in Technology and Policy. Students interested in applying their chemical engineering background to problems of policy and socioeconomic assessment of technology may apply for the interdepartmental Master of Science Program in Technology and Policy. This program combines subjects in advanced technology in the particular field of the student's choosing with subjects in economics, systems analysis, political science, and law. It engages the student in significant project work integrating technology and policy. Well-qualified students may complete this program in one calendar year. General requirements and application procedures are described in Chapter V.

Chemical Engineer. The Engineer's degree is offered as an advanced degree in chemical engineering for those students who desire a graduate education in depth but who are not interested primarily in research. The program of advanced study and research normally includes attendance at the Practice School, completion of an approved integrated minor consisting of at least 24 units outside the Department, and a 10.90 Experimental Research Problem (of approximately 10 units) completed under the supervision of a faculty member in the Department of Chemical Engineering. Variations in the program are approved on an individual basis. A detailed description of the Chemical Engineer's program may be obtained from the Graduate Registration Office.

Environmental Engineer. The Environmental Engineer goes beyond the Master's program but without the research focus of the doctorate. It prepares students for careers in government, industry, and private practice where technical decision making is integrated with environmental planning and management functions. Detailed requirements, suggested subjects, and sample programs may be obtained from the Graduate Registration Office.

Materials Engineer. Candidates interested in studying materials engineering in the Department of Chemical Engineering should have training equivalent to that offered by the Institute in its undergraduate programs in chemistry or chemical engineering. In general, two years are required for completion of the Materials Engineer. A detailed description of the Materials Engineer program may be obtained from the Graduate Registration Office.

Doctor of Science or Doctor of Philosophy. Admission to the doctoral program is granted only after the candidate has passed a general examination consisting of written and oral parts. The general examination is given in January and May. It is usually taken at the end of the second term in residence as a graduate student although students with good preparation may attempt the exam after one term. It is not necessary to complete a Master's program in order to obtain a doctorate.

The requirements for the doctoral degree include a program of advanced study, a minor program, and a thesis. The program of advanced study and research is normally carried out in one of the fields of chemical engineering under the supervision of one or more faculty members in the Department of Chemical Engineering. The object of the minor program is to broaden the student's knowledge. The minor consists of completing satisfactorily two or more related subjects, totaling at least 24 credit units, in a field other than chemical engineering and of a more advanced character than would have been required for the student's undergraduate degree. The minor program should be arranged in consultation with and approved by the student's registration officer.

Joint MIT-WHOI Program
Course X-W

A joint program with the Woods Hole Oceanographic Institution is intended for students whose primary career objective is oceanographic engineering. Students divide their academic and research efforts between the campuses of the two institutions. While in residence at MIT, students enrolled in this course follow a program similar to that of other students in this Department. The program is described in more detail under the section on MIT's Joint Program in Oceanographic Engineering with the Woods Hole Oceanographic Institution.

Financial Support

The Department has a wide variety of financial support for graduate students, including teaching and research assistantships, fellowships, and loans. Information about financial assistance may be obtained by writing to the Graduate Registration Officer, but consideration for awards cannot be given before students have been admitted to the Graduate School.

Inquiries

Additional information concerning graduate programs, admissions, financial aid, assistantships, etc. may be obtained by writing to Professor Glenn C. Williams, Graduate Registration Officer, Department of Chemical Engineering, Room 66-366, MIT, Cambridge, Massachusetts 02139, (617) 253-4587.

Department of Civil Engineering

Joseph Martin Sussman, Ph.D.
Professor of Civil Engineering
Head of the Department

Professors

John Melvin Biggs, S.M.
Professor of Civil Engineering

Jerome Joseph Connor, Jr., Sc.D.
Professor of Civil Engineering

Carl Allin Cornell, Ph.D.
Professor of Civil Engineering
(Absent, fall)

Richard Lawrence de Neufville, Ph.D.
Professor of Civil Engineering
Chairman, MIT Technology and Policy Program
(Absent, fall)

Themistocles Dracos, Ph.D.
Professor of Civil Engineering
(Visiting)

Peter Sturges Eagleson, Sc.D.
Professor of Civil Engineering

Ann Fetter Friedlaender, Ph.D.
Professor of Civil Engineering and Economics

Ralph A. Gakenheimer, Ph.D.
Professor of Civil Engineering and Urban Studies and Planning

Donald R.F. Harleman, Sc.D.
Professor of Civil Engineering
Ford Professor of Engineering

Charles Cushing Ladd, Sc.D.
Professor of Civil Engineering

Robert Daniel Logcher, Sc.D.
Professor of Civil Engineering

Marvin Lee Manheim, Ph.D.
Professor of Civil Engineering

David Hunter Marks, Ph.D.
Professor of Civil Engineering

Frederick Jerome McGarry, S.M.
Professor of Civil Engineering and Polymer Engineering

Chiang Chung Mei, Ph.D.
Professor of Civil Engineering
(Absent)

Fred Moavenzadeh, Ph.D.
Professor of Civil Engineering
Director, Technology Adaptation Program

Francois M.M. Morel, Ph.D.
Professor of Civil Engineering

Amedeo Rodolfo Odoni, Ph.D.
Professor of Civil Engineering and Aeronautics and Astronautics

Hugo Perez La Salvia, S.M.
Professor of Civil Engineering
(Visiting)

Frank Edward Perkins, Sc.D.
Professor of Civil Engineering
Associate Provost

Paul Osborne Roberts, Ph.D.
Professor of Civil Engineering
(Absent)

Daniel Roos, Ph.D.
Professor of Civil Engineering
Director, Center for Transportation Studies

Erik Hector Vanmarcke, Ph.D.
Professor of Civil Engineering

Robert Van Duyne Whitman, Sc.D.
Professor of Civil Engineering

Associate Professors

David Brian Ashley, Ph.D.
Associate Professor of Civil Engineering

Mohsen Mohamed Baligh, Ph.D.
Associate Professor of Civil Engineering
(Absent)

Gregory Bert Baecher, Ph.D.
Associate Professor of Civil Engineering

Moshe Emanuel Ben-Akiva, Ph.D.
Associate Professor of Civil Engineering
(Absent)

Rafael Luis Bras, Sc.D.
Associate Professor of Civil Engineering
Gilbert W. Winslow Career Development Professor

Oral Buyukozturk, Ph.D.
Associate Professor of Civil Engineering

Sallie W. Chisholm, Ph.D.
Henry L. Doherty Professor in Ocean Utilization

Herbert Heinrich Einstein, Sc.D.
Associate Professor of Civil Engineering
(Absent)

Hilary Max Irvine, Ph.D.
Associate Professor of Civil Engineering

Henry G. Irwig, Ph.D.
Associate Professor of Civil Engineering

Eduardo Kausel, Ph.D.
Associate Professor of Civil Engineering

Steven Richard Lerman, Ph.D.
Associate Professor of Civil Engineering

Ole Secher Madsen, Sc.D.
Associate Professor of Civil Engineering

Wallace Kendall Melville, Ph.D.
Associate Professor of Civil Engineering

Masaki Sawamoto, Ph.D.
Associate Professor of Civil Engineering
(Visiting)

Yosef Sheffi, Ph.D.
Associate Professor of Civil Engineering

Keith Densmore Stolzenbach, Ph.D.
Associate Professor of Civil Engineering

Daniele Veneziano, Ph.D.
Associate Professor of Civil Engineering
(Absent, spring)

John Loyd Wilson, Ph.D.
Associate Professor of Civil Engineering

Nigel Henry Moir Wilson, Ph.D.
Associate Professor of Civil Engineering

Assistant Professors

Michael Nicholas Fardis, Ph.D.
Assistant Professor of Civil Engineering

Harold Field Hemond, Ph.D.
Esther and Harold E. Edgerton Assistant Professor of Civil Engineering

Achi Mohamen Ishaq, Ph.D.
Assistant Professor of Civil Engineering
(Visiting)

Roman Krzysztofowicz, Ph.D.
Assistant Professor of Civil Engineering

Michael D. Meyer, Ph.D.
Class of 1922 Career Development Assistant Professor of Civil Engineering

Marie-Elisabeth Paté, Ph.D.
Assistant Professor of Civil Engineering

Clifford Winston, Ph.D.
Assistant Professor of Civil Engineering

Senior Lecturers

Edward Emmet Newman, S.M.
Carl M. Sapers, LL.B.
Mary Elizabeth Schumacker, S.B.
William Walther Seifert, Sc.D.
Harry Sutcliffe, M.S.
(Visiting)

Lecturers

E. Eric Adams, Ph.D.
Mark Ladner, Ph.D.
(Visiting)

Senior Administrative Officer

Trond H. Kaalstad, M.S.

Administrative Assistants

Stephanie Demeris-George
Victoria H. Murphy, B.A.

Senior Research Associate

Robert T. Martin, Ph.D.

Principal Research Associate

Carl D. Martland, C.E.

Research Associates

Amr S. Azzouz, Sc.D.
Michael J. Markow, M.S.
W. Allen Marr, Ph.D.
Jean S. Savy, Ph.D.

Research Engineer

Brian D. Brademeyer, M.S.

Department of Civil Engineering

Postdoctoral Associates

Gail I. Harrison, Ph.D.
Robert J. Olsen, Ph.D.
Anthony V. Palumbo, Ph.D.
Carl J. Watras, Ph.D.

Visiting Engineers

Masashi Nagao, Ph.D.
Elicho Taniguchi, S.M.

Research Affiliates

Donald M. Anderson, Ph.D.
Jose E. Fernandez, Ph.D.
Janet K. Koch, Ph.D.
Craig E. Philip, Ph.D.

Professors Emeriti

John Brazer Babcock III, S.B.
Professor of Railway Engineering, Emeritus

Robert Joseph Hansen, Sc.D.
Professor of Civil Engineering, Emeritus

Myle Joseph Holley, Jr., S.M.
Professor of Civil Engineering, Emeritus

Thomas William Lambe, Sc.D.
Edmund K. Turner Professor of Civil Engineering, Emeritus

William Edward Stanley, C.E.
Professor of Sanitary Engineering, Emeritus

John Benson Wilbur, Sc.D.
Professor of Engineering, Emeritus

Civil engineering is the principal instrument for focusing humanity's scientific and technical skills on the creation of constructed facilities which advance a society toward the attainment of basic objectives such as economic development, environmental protection, and social well-being.

The essence of the profession, as we view it, is to bring about a symbiosis of the constructed facility with the natural environment on the one hand, and with the social environment on the other. Creating this accommodation between humans and the environment requires recognition and formulation of complex problems when the objectives are multiple; when human and institutional, as well as technical, constraints are operative; and when both our understanding and the available information are imperfect. It requires problem solution in a manner which reveals an array of technically feasible, economically justifiable, and socially desirable alternatives, and it demands that we involve the affected public in the process of final choice. It calls for design which incorporates the best technology. It includes ensuring that the physical process of construction is sensitive to social and environmental constraints. It requires that management, operation and maintenance of the completed facility can be effectively performed and are responsive to changing objectives over time.

Civil engineering professionals are concerned with the critical problems of today's society. For example, our energy needs require projects of extraordinary scope and potential environmental impact (e.g., the Trans-Alaska Pipeline, offshore extraction facilities, the development of synthetic fuels). The efficient transport of goods and people require innovative systems planning and implementation of infrastructure as well as a basic understanding of the economic, organizational, and political factors that govern our transport needs. The availability and effective utilization of water for human consumption, irrigation, and power generation, and protection of society from the potential disaster of floods or droughts requires careful planning and design of facilities as well as an understanding of the demands of society for the resource. Civil engineers play a leadership role in the conception, planning, realization, and operation of facilities and systems in all the above areas and others concerned with basic human and societal needs.

This broad scope of civil engineering activities, embracing planning, analysis, design, construction, management, operations and maintenance of a variety of facility types, requires a diverse set of practitioners — those with the breadth of perspective to assess needs and to evaluate impacts, and the specialists who design the system and make it work. In this light, it is our belief that the education of civil engineers for future leadership positions should provide 1) a rigorous perspective on the latest technology and analytic methods, and 2) opportunities to develop the social science and management skills which are required to assess needs, evaluate social and environmental impacts, and operate the engineering enterprise. Such opportunities are ensured through a broad curriculum and the encouragement of interactions with other departments at MIT and neighboring universities.

The Department of Civil Engineering is organized into three functional Divisions: Constructed Facilities, Transportation Systems, and Water Resources and Environmental Engineering. These Divisions

Undergraduate Study

represent the major professional thrusts of the Department, and much of our educational and research efforts are focused in these areas. Detailed descriptions of these programs are contained in the following pages. At the same time, many problems within civil engineering transcend any one of these Divisions. This is reflected in the Department's educational and research programs, which integrate the techniques and concepts of these major functional areas. Also, many of our educational programs are disciplinary in nature, and some of our faculty and students have interests which are primarily disciplinary. Therefore, three Department working groups — Physical Systems, Systems Methodology, and Social and Management Systems — have responsibility for activities which are discipline-oriented.

The undergraduate program of the Department of Civil Engineering is designed to balance the problem-formulation and problem-solving needs for a broad range of careers. The core of the program is designed to provide the fundamental analytic methods for formulating, solving, and evaluating problems of physical behavior and of complex system performance, as well as an overall appreciation for the issues and structure of civil engineering problems and for the skills required to achieve solutions. The program also requires the study of an applications area in some depth, both for the development of particular specialized knowledge and skills embodied in the functional Divisions mentioned above, and for the self-discipline and self-confidence to be gained from thoroughness of understanding.

At the graduate level, research and education go hand-in-hand. Recognizing the continuing demand for pioneering technology while responding to the new need for an understanding of broad interactions, two basic tracks are provided. Some students may be interested in physical processes or in the analysis and design of component facilities and hence work in a fundamental area such as soil, water, or structures. Others may study the planning, design, construction, and operations of large-scale systems of facilities in fields such as transportation, water resources, and other public services.

The functional Divisions of the Department have responsibility for graduate admissions, research and teaching assistant awards and assignments, fellowship and traineeship assignments, and the administration of those research and academic programs which are functionally oriented. Prospective graduate students must indicate their choice of divisional affiliation when applying for admission. Because of the broad spectrum of career opportunities open within each functional area, students may pursue graduate studies in one of these three areas from an analytically oriented undergraduate base in such fields as urban planning, science, or management, as well as from other branches of engineering.

The Department of Civil Engineering offers two undergraduate curricula for students seeking a strong base for careers in civil engineering or related fields. The first curriculum, Course I, which leads to the Bachelor of Science in Civil Engineering, is designed for students having educational goals which fall substantially within the scope of civil engineering. The second curriculum, Course I-A, which leads to the Bachelor of Science without designation, is designed for students having a well-defined educational goal, the attainment of which requires a specially formulated program of study.

Each of these curricula provides sufficient flexibility to permit students to develop their own special interests by taking subjects offered by the Department of Civil Engineering and by other departments. Undergraduates are encouraged to participate in the research and development activities of the Department and in many cases obtain degree credit for such work.

Students often find there are academic advantages in planning their programs for the third and fourth years so they dovetail with possible graduate study. This is readily accomplished for those students who embark on the Departmental Program in their second year. Under certain circumstances students are permitted to work toward undergraduate and graduate degrees to be received simultaneously.

Bachelor of Science in Civil Engineering
Course I

The curriculum for this degree is designed to help the student develop problem-solving and decision-making abilities which can be brought to bear on civil engineering problems. The aim is to provide the student with the basic techniques for exercising these abilities, and with a useful knowledge of one area of civil engineering in depth, while at the same time providing an understanding of the interrelationship of the various disciplines which comprise it. The seven-subject core of this curriculum introduces the student to the issues, problems, and methods of

civil engineering. It provides a foundation of applied mechanics, applied probability, economic analysis, and systems engineering, and stresses the common nature of their application to problems which arise in the many different kinds of engineering projects which come within the scope of civil engineering. Planned electives provide the student with useful knowledge of some particular area of civil engineering in depth. This program (including the Internship Option below) is accredited by the Engineers' Council for Professional Development.

Bachelor of Science in Civil Engineering
Course I — Internship Option

Students who wish to gain industrial experience as part of their undergraduate and graduate programs may do so by applying to participate in the School of Engineering's Internship Program through enrollment in the Course I — Internship Option. The Engineering Internship Program is described in detail in the School of Engineering section of this catalogue; however, the salient points of the Course I — Internship Option will be presented here.

The Course degrees and curricular requirements are the same as for Course I. In addition, provision is made for students to be employed in the offices, plants, or construction sites of participating companies. The undergraduate work assignment consists of two consecutive summers, starting after the sophomore year. These work assignments are together considered equivalent to a 12-unit subject and may, by petition, be used toward the planned elective requirement in the appropriate divisional option.

The program is expected to be particularly attractive to students who wish to study for the combined S.B.-S.M. degree, requiring five years for completion. Such students, if they satisfy the requirements, apply for admission to the graduate school during the senior year. They then complete two further work assignments, consisting of a summer and the subsequent fall term. A thesis is ordinarily based on the industrial experience, and is submitted after the final work assignment, for the S.M. degree. An attempt is made to issue early admission decisions for students desiring to continue for the fifth year of this program. Twelve units of graduate credit is awarded for these two work assignments, in addition to regular thesis credit for preparation of the S.M. thesis.

Students desiring to participate in the Internship Option should apply early in the second term of their sophomore year. Admission to the Option is conditional upon selection by a participating company in an interview conducted for this purpose. Salaries are negotiated between the student and the company.

Bachelor of Science in Civil Engineering
Course I

	General Institute Requirements	Total Units
	Specific science and humanities and social science subjects. (1.01J, required in the Departmental Program, satisfies one humanities and social science subject requirement.)	123
	The Science Distribution Requirement can be satisfied by 1.00 or 1.04, and 18.03 which are required in the Departmental Program, plus appropriate subjects totaling	12
	The Laboratory Requirement can be satisfied by subjects required in the Departmental Program, plus an appropriate subject totaling	6
	Departmental Program	
	Required Subjects	84
1.00	Principles of Computer-Based Engineering Problem Solving[1] 3 1 8	
1.01J	Engineering Aspects of Economic Analysis 4 0 8	
1.02	Civil Engineering Systems Analysis I 3 1 8	
1.03	Civil Engineering Systems Analysis II 3 1 8	
1.04	Behavior of Physical Systems I 3 1 8	
1.05	Behavior of Physical Systems II 3 1 8	
18.03	Differential Equations 4 0 8	
	Planned Electives	78 or 69
	One of the following options:	
	Transportation Option	
1.102	Transportation Laboratory 0 3 3	
1.211	Analysis of Transportation Systems 5 0 7	
1.218	Case Study in Transportation Planning 3 3 9	
	Plus *three* of the following:	
1.212	Transportation and the Environment 4 0 8	
1.213	Introduction to Freight Transportation 3 0 9	
1.214	Public Transportation 4 0 8	
1.215	Traffic Flow: Theory and Engineering Application 3 0 9	
	OR	
	Water Resources and Environmental Engineering Option	
1.106	Laboratory Projects in Environmental Fluid Mechanics 0 3 3	
1.60	Fluid Dynamics 4 0 8	
1.70	Design of Water Resource Systems 3 0 9	
1.80	Fundamentals of Ecology 3 1 8	
	Plus *three* of the following:	
1.107	Laboratory Projects in Aquatic Biology and Chemistry 2 6 4	
1.62	Free Surface Hydraulics 3 1 8	
1.71	Introduction to Hydrology 3 1 8	
1.85/1.86	Introduction to Wastewater Treatment Engineering 4 0 8	
1.ThU	Thesis 0 12 0	
	OR	
	Constructed Facilities Option	
1.30	Soil Mechanics 3 0 9	
1.40	Project Management 3 2 7	
1.50	Introduction to Structural Engineering 3 2 7	
1.59J	Materials of Construction 3 0 9	
	Plus *one* of the following Laboratory subjects:	
1.103	Geotechnical Engineering Laboratory 0 3 3	
1.104	Materials of Construction Laboratory 0 3 3	
1.105	Structural Engineering Laboratory 0 3 3	
	Plus *one* of the following *sets of subjects* from specialized areas listed below:	
	Geotechnical Engineering	
1.311	Geotechnical Engineering 2 0 4	
1.312	Geotechnical Laboratory 0 3 3	
1.32	Introduction to Engineering Geology 3 3 6	
	or	
	Construction Engineering and Management	
1.412J	Design of Building Systems 3 2 7	
1.413	The Design-Construction Interface 3 0 6	
	or	
	Structural Engineering	
1.502	Structural Analysis and Design 3 1 8	
1.503	Engineering Mechanics 4 0 8	
	Unrestricted Electives[2]	**at least 57 up to 66**
	Total Units Required for the S.B. Degree	**360**

1 2.10 or 6.030 may be accepted by petition as substitution for 1.00.

2 Schedules of students in Course I may be arranged to leave available 15 units of Unrestricted Electives in the second year.

Bachelor of Science Course I-A

The programs which lead to this degree are provided for those students whose interests and educational goals fall within the field of civil engineering in its broadest sense, but who cannot achieve their goals by meeting the requirements for the undergraduate degree with designation.

The programs leading to this degree are not accredited by the Engineers' Council for Professional Development. This may be a consideration for students, who at some future time may seek professional registration.

Students whose interest is divided between one of the functional areas of civil engineering and such fields as control of the environment, urban affairs, project management, and public systems, for example, may satisfy the requirements for the degree Bachelor of Science (without designation) by planning a program which conforms to the requirements outlined under Option 1 below. Option 1 is also intended for students who want to pursue interdisciplinary studies in the mineral resources area and particularly in mining engineering.

Students whose interest is in civil engineering and urban planning may satisfy the requirements for the degree Bachelor of Science (without designation) by planning a program which conforms to the requirements outlined under Option 2. This program is offered jointly by the Departments of Civil Engineering and Urban Studies and Planning.

Bachelor of Science Course I-A — Option 1

	General Institute Requirements	Total Units
	Specific science and humanities and social science subjects. (1.01J, required in the Departmental Program, satisfies one humanities and social science subject requirement.)	123
	The Science Distribution Requirement can be satisfied by either 1.00 or 1.04, and 18.03 which are required in the Departmental Program, plus appropriate subjects totaling	12
	Laboratory Requirement[1]	12
	Departmental Program	
	Required Subjects	**60**
1.00	Principles of Computer-Based Engineering Problem Solving[2] 3 1 8	
1.01J	Engineering Aspects of Economic Analysis 4 0 8	
18.03	Differential Equations 4 0 8	
	plus either	
1.02	Civil Engineering Systems Analysis I 3 1 8	
1.04	Behavior of Physical Systems I 3 1 8	
	or	
1.02	Civil Engineering Systems Analysis I 3 1 8	
1.03	Civil Engineering Systems Analysis II 3 1 8	
	or	
1.04	Behavior of Physical Systems I 3 1 8	
1.05	Behavior of Physical Systems II 3 1 8	
	Planned Electives	**at least 72**
	At least seven subjects, three of which are offered by the Department of Civil Engineering, which will lead to a well-defined educational goal.	
	Unrestricted Electives[3]	**at least 81**
	Total Units Required for the S.B. Degree	**360**

1
Recommended subjects: 1.102, 1.103, 1.104, 1.105J, 1.106, 1.107 (Laboratory projects in various areas).

2
2.10 or 6.030 may be accepted by petition as substitution for 1.00.

3
Schedules of students in Course I-A may be arranged to leave available 9 units of Unrestricted Electives in the second year.

Bachelor of Science Course I-A — Option 2

	General Institute Requirements	Total Units
	Specific science and humanities and social science subjects. (1.01J, required in the Departmental Program, satisfies one humanities and social science subject requirement.)	123
	The Science Distribution Requirement can be satisfied by 1.00 and 18.03 which are required in the Departmental Program, plus appropriate subjects totaling	12
	Laboratory Requirement[1]	12
	Departmental Program	
	Required Subjects	**81**
1.00	Principles of Computer-Based Engineering Problem Solving[2] 3 1 8	
1.01J	Engineering Aspects of Economic Analysis 4 0 8	
1.02	Civil Engineering Systems Analysis I 3 1 8	
1.03	Civil Engineering Systems Analysis II 3 1 8	
11.001	Introduction to Urban and Environmental Planning and Development 3 0 9	
	or	
11.002	Introduction to Public Policy Analysis and Governmental Action 3 0 9	
11.190	Senior Colloquium 2 0 7	
18.03	Differential Equations 4 0 8	
	Planned Electives	**at least 72**
	Subjects which assure breadth and depth in the area of specialization	**at least 18**
	Civil Engineering subjects	**at least 18**
	A Special Studies project or thesis, the content of which requires a synthesis of the knowledge within the scope of the joint program	**at least 12**
	Unrestricted Electives[3]	**at least 60**
	Total Units Required for the S.B. Degree	**360**

1
Recommended subjects: 1.102 or 11.188.

2
2.10 or 6.030 may be accepted by petition as substitution for 1.00.

3
Schedules of students in Course I-A may be arranged to leave available 9 units of Unrestricted Electives in the second year.

The student interested in pursuing either option first defines his or her educational goal, and then finds a member of the faculty in the department who agrees to serve as the program advisor, and to assist the student in outlining a program and obtaining its approval from the Undergraduate Academic Officer, on behalf of the Departmental Undergraduate Committee. Programs conforming to the requirements outlined for Option 2 must be approved by a joint committee made up of faculty members from the Departments of Civil Engineering and of Urban Studies and Planning.

Undergraduate Electives

1.UR	Research in Civil Engineering (Arr.)
1.102	Transportation Laboratory[1] (0-3-3)
1.103	Geotechnical Engineering Laboratory[1] (0-3-3)
1.104	Materials of Construction Laboratory[1] (0-3-3)
1.105J	Structural Engineering Laboratory[1] (0-3-3)
1.106	Laboratory Projects in Environmental Fluid Mechanics[1] (0-3-3)
1.107	Laboratory Projects in Aquatic Biology and Chemistry[1] (2-6-4)
1.12J	Ethics and Technocrats (4-0-8)
1.16	Computer Models of Physical and Engineering Systems[2] (3-0-9)
1.19	Introduction to Technology and Law (3-0-9)
1.211	Analysis of Transportation Systems (5-0-7)
1.212	Transportation and the Environment (4-0-8)
1.213	Introduction to Freight Transportation (3-0-9)
1.214	Public Transportation (4-0-8)
1.215	Traffic Flow: Theory and Engineering Application (3-0-9)
1.218	Case Study in Transportation Planning (3-3-9)
1.219	Field Experience in Transportation (Arr.)
1.30	Soil Mechanics (3-0-9)
1.311	Geotechnical Engineering (2-0-4)
1.312	Geotechnical Laboratory (0-3-3)
1.32	Introduction to Engineering Geology[2] (3-3-6)
1.384J	Introduction to Mining and Mineral Technology (3-0-6)
1.40	Project Management (3-2-7)
1.411J	Basic Building Construction (3-3-6)
1.412J	Design of Building Systems (3-2-7)
1.50	Introduction to Structural Engineering (3-2-7)
1.502	Structural Analysis and Design (3-1-8)
1.503	Engineering Mechanics (4-0-8)
1.59J	Materials of Construction[2] (3-0-9)
1.60	Fluid Dynamics (4-0-8)
1.61	Engineering and Management of Water Related Projects (0-4-8)
1.62	Free Surface Hydraulics (3-1-8)
1.70	Design of Water Resources Systems (3-0-9)
1.71	Introduction to Hydrology (3-1-8)
1.80	Fundamentals of Ecology (3-1-8)
1.85	Introduction to Wastewater Treatment Engineering (2-0-4)
1.86	Element Cycles in the Environment[2] (2-0-4)
1.991 1.992	Special Undergraduate Studies in Civil Engineering (Arr.)
1.999	Undergraduate Studies in Civil Engineering (Arr.)

[1] Satisfies Institute Laboratory Requirement
[2] Satisfies Institute Science Distribution Requirement.

By the fourth year, students usually have the prerequisites for a variety of graduate subjects offered by the department.

Students wishing to work closely with a member of the faculty on research may obtain permission to register for thesis, or to enroll in 1.999, Undergraduate Studies in Civil Engineering.

Students registered in the Department are encouraged to consider appropriate subjects offered by other departments as part of their elective programs.

Graduate Study

Constructed Facilities

The Department of Civil Engineering grants the following advanced degrees: Master of Science; Master of Science in Civil Engineering; Civil Engineer; Environmental Engineer; Doctor of Science; and Doctor of Philosophy. For the Institute's general requirements for the various degrees, see Chapter IV of this catalogue. Detailed information regarding the requirements of the department for these degrees, may be obtained from the Academic Programs Office, Room 1-281.

Fields of Advanced Study

Integrated programs of advanced study are available in the following areas: geotechnical engineering, structural engineering and mechanics, construction engineering and project management, transportation systems, hydrodynamics and coastal engineering, hydrology and water resource systems, water quality control and the aquatic environment, and environmental engineering. Major fields available for doctoral theses are included in the Civil Engineering list in Chapter IV. Fields other than those listed must be approved by the Department Registration Officer and the Dean of the Graduate School.

Geotechnical Engineering. The interaction of soil and rock with constructed facilities and the use of soil and rock as construction material is the domain of the geotechnical engineer. The graduate program in geotechnical engineering leads to an understanding of advanced mechanical and geological principles that control the behavior of soil and rock. The program emphasizes the familiarization of the student with geotechnical analysis and design techniques and with the incorporation of geotechnical aspects in planning of civil engineering projects.

The teaching program offers comprehensive treatment of theoretical soil mechanics, soil properties, exploration and instrumentation, earth dams and foundations, and advanced subjects in the areas of soil dynamics, reliability, engineering geology and rock mechanics. Thesis research and other studies utilizing the unique laboratory and field facilities of the Department complement the graduate program in geotechnical engineering and offer students excellent opportunities to work closely with the faculty. The major areas of research are: soft ground construction, earthquake engineering; underground construction; stability of earth dams and natural slopes in soil and rock; behavior of sands under cyclic loading; negative skin friction on piles; in-situ testing, especially for offshore exploration; and application of probability and decision theory to geotechnical problems. Many research projects are, and the individual student's academic program can be, of an interdisciplinary nature involving, for instance, structural engineering and project management.

Structural Engineering and Mechanics. Society today has a great demand for constructed facilities, particularly buildings. In some cases, such as facilities to meet the needs for new energy sources, the challenge is to devise new ways to provide functional and safe structures. Usually, however, the challenge is to reduce both the direct and indirect costs of the facilities. Engineers who are prepared to improve design practice in the face of changing needs and values, and to better integrate structural design into total project planning, will be required to meet these challenges.

The educational program in structural engineering is based upon study of the fundamentals of structural mechanics, analysis of structural systems, dynamic analysis, and structural planning and design. Advanced areas of study include finite element techniques, the theory of probability and reliability applied to structural design, and engineering for earthquake and wind loadings.

A cooperative effort within the School offers a special opportunity to study structural mechanics for nuclear power engineering. This effort, while serving a major current need, is directed toward the solution of problems of materials and mechanics of future energy systems. A joint subject with the Department of Nuclear Engineering introduces the engineering problems. Students studying in this and other aspects of mechanics and materials may take advantage of subject offerings in all departments of the School.

Students wishing to focus upon the overall problems of building design and planning may take advantage of the Department's program in construction engineering and project management. The combination of fundamental subjects in structural engineering, plus subjects from the management program, provides a very strong base for professional work in the building field.

The research program, in which students become involved, includes projects in the following areas: earthquake engineering including seismic risk analysis, nonlinear response of structures, soil-structure interaction, seismic resistance of pre-cast panel buildings; statistically based loading and serviceability criteria for building design; three-dimensional models for failure of concrete, computational strategies for complex concrete structures; offshore structures including dynamic response, stochastic modeling of ocean storms, effect of foundation stiffness degradation on response characteristics, fatigue analysis.

Transportation

Construction Engineering and Project Management. Forces inside and outside the construction industry are bringing about rapid changes, causing corresponding changes in its organization and management. As construction problems become more complex, the industry must meet, more reliably than ever, the demands for control of time, cost, and performance, cope with new technologies and means of production, and be concerned with increasingly complex human relations. A growing public awareness of the direct influence that constructed facilities have upon the public welfare is forcing close scrutiny and control by public agencies. As a result, there is increasing interdependence between the inception, feasibility determination, design, and production phases of development, with a corresponding need for greater sophistication in planning, organization and management.

The Department has developed a program responsive to this need. It is not limited to the physical construction phase of a project. Rather, it encompasses the totality of activities from the initial identification of the need for a facility, through economic and technical feasibility analyses, environmental and social impact analyses, design, construction, and operation.

The academic component of the program is designed to promote an understanding of the construction industry and its relevant management and operational disciplines. At the same time, it enables students to concentrate in depth on specific aspects of the industry which are of particular interest. The research component is directed toward improving the knowledge and understanding of interrelationships and interactions of various actors and processes within the industry and toward developing ways to improve both the efficiency and effectiveness of constructed facilities projects.

Transportation Systems. The focuses of teaching and research in transportation are on systems planning and analysis, management, and policy and institutional issues, particularly for multimodal systems. The approaches utilized include economics, analysis techniques such as mathematical and computer models, and the tools of management and the social sciences as well as traditional engineering disciplines. Explicit attention to the political and social factors which must be considered when making transportation decisions is a central element of the approaches utilized. The program builds upon basic knowledge of the properties of transportation system components, and the ability to analyze interactions among these components and between the transportation system and its environment. The academic program benefits from an extensive body of research which provides support and stimulation. Subjects of instruction include transportation systems analysis, transport systems design, urban transportation systems, freight transportation, transportation management, transportation planning, transportation technology, transportation in developing countries, institutional and policy analysis, decision theory, mathematical optimization, economic analysis, probabilistic analysis, statistical analysis and substantive applications to highway, transit, air, rail, and sea transport, and both the freight and passenger sectors. The Transportation Systems Division actively participates in the work of the Center for Transportation Studies and the Flight Transportation Laboratory.

Water Resources and Environmental Engineering

The programs of graduate study and research lie in the broad field of engineering in the water environment. These include both departmental and interdisciplinary programs in the analytical and managerial aspects of water resources. A joint degree program between MIT and Woods Hole Oceanographic Institution exists.

The educational and research programs are broadly grouped in three areas: **Hydrodynamics and Coastal Engineering.** A wide selection of subjects is offered including theoretical and applied fluid mechanics, hydrodynamics of wave motion, beach erosion and coastal sediment problems, wave interaction in harbors and offshore structures, estuary and coastal circulation and water quality, energy extraction from waves and the ocean thermal gradient, economic development and environmental impact assessment in the coastal zone. Related subjects in Oceanography and Ocean Engineering are offered by other departments at MIT and at Woods Hole Oceanographic Institution.

Hydrology and Water Resource Systems. Emphasis is on both deterministic and stochastic representations of hydrologic processes in the surface and ground water regimes. Particular attention is given to the integration, in a systems analysis framework, of hydrologic criteria and optimization methods for multi-objective and multi-purpose urban and river basin development schemes with environmental, economic and public policy issues. Opportunities may exist for summer fieldwork in developing countries. Related subjects in statistics and systems methodology are also offered in the Civil Engineering Department.

Water Quality Control, Aquatic Science, and Environmental Engineering. Teaching and research activities are conducted in the fields of environmental fluid mechanics, aquatic chemistry and biology, limnology, the assessment of environmental impact of energy development and the fate of pollutants in natural water bodies including lakes, reservoirs, rivers, estuaries and the coastal zone. Opportunities are available for in-depth study in

Disciplinary Groups

one of these areas or for an interdisciplinary program drawing upon the full range of offerings at MIT. Emphasis is on the integration of hydrodynamic and hydrothermal transport and mixing processes with biogeochemical transformation processes including effects of heavy metals ad hydrocarbons.

Research includes waste heat management, harbor and coastal modeling, local and regional water quality, resource and land use management and facility siting, phytoplankton/trace metal interactions, chemical equilibrium models, and phytoplankton growth dynamics.

Extensive research facilities are provided in the Ralph M. Parsons Laboratory for Water Resources and Hydrodynamics which houses the Water Resources and Environmental Engineering Division of the Department. Laboratory facilities are provided for hydrodynamic studies involving wave motion, jet turbulence and diffusion by means of laser-Doppler instrumentation, flows with thermal and density stratification and flows in porous media. Research facilities are available for aquatic biological and chemical interactions.

We have divided the disciplinary dimension of the Department into three Groups; Physical Systems, Systems Methodology, and Social and Management Systems. Each member of the faculty belongs to one of these groups which are responsible for the establishment and maintenance of the requisite disciplinary capability and for guiding and assisting in program formulation those students whose educational interests are not met through the degree programs of the functional Divisions.

Education and research which is focused on the functional problems of Transportation, Water Resources, and Constructed Facilities requires the integration of contributions from many applied science disciplines. Civil engineering education traditionally has had its base in the classical physical sciences in preparation for understanding physical behavior and for the design of facilities. Of primary interest are applied earth science, mathematics, mechanics, chemistry, and biology. Then came the digital computer which gave birth to the systems sciences, making possible the planning and analysis of large-scale systems. From these we draw applied probability and statistics, decision analysis, optimization, mathematical programming, simulation, and computer systems. More recently has come the need to appreciate the interactions of our facilities and systems with the people and institutions they are designed to serve. For this we draw upon the social and management sciences of economics, law, political science, and group psychology.

Each member of the faculty of the Department has specialized training in one or more of the disciplines listed above, in addition to an overriding interest in a particular functional application.

Physical Systems

Understanding the physical behavior of structures and the natural environment with which they interact is a prerequisite to safe, economical, and meaningful construction. Proper use of physical sciences when planning, designing, constructing, and evaluating engineering systems has, therefore, always been a major part of the endeavor of civil engineers. Academic offerings in the Physical Systems area include basic subjects in mechanics, materials, and mathematical methods. A wide spectrum of subjects deals with applications in coastal and offshore engineering, earthquake and geotechnical engineering, structural engineering, hydrology and water resources engineering, and environmental science.

Research currently in progress requires an understanding of physical systems which in some instances transcends the functional Division boundaries. Examples are the mathematical modeling of physical processes; design of offshore facilities such as gravity storage structures and artificial islands; interaction between structures and foundations and/or fluids; design of future nuclear power facilities with special regard for safety provisions; improved design of waste heat facilities such as cooling towers; hydrology of rainfalls, surface runoff, and groundwater; more efficient use of materials and resources; understanding and predicting the fate and effects of pollutants in water and the dynamics of aquatic ecosystems.

Systems Methodology

Over the past decade the Department of Civil Engineering has been a leader in the development and application of systems analysis. Initially these applications were oriented toward the solution of problems which arose in the engineering sector. ICES, a computer-aided design software package now in use throughout the world, was developed here in response to our initial concern. More recently our attention and efforts have centered around how these new techniques can be successfully applied in the solution of problems in the public sector.

Special Programs and Facilities

At this time, students whose interests are centered primarily in one of the functional areas of civil engineering have come to recognize the part systems analysis plays in the successful practice of their professions, and members of the faculty encourage them to explore the use of a systems methodology approach in problem solving.

The Systems Methodology Group offers a series of subjects in such areas as simulation, optimization, systems analysis, and statistics, each with a distinct engineering focus, and a further series of subjects which deal with the application of these techniques to civil engineering in particular.

Social and Management Systems

What civil engineers do often has profound impact on society. Major water resource development projects and major changes in a region's transportation significantly shape the social and economic development of a region. The construction of any major project means significant direct economic impacts through jobs and materials purchases. These are only a few examples of the complex interactions between the technologies with which civil engineering deals, and the societies which those technologies serve.

Civil engineers today must be aware of, and be capable of dealing with, the interactions between technology and society, as well as having mastery of a specific technology such as constructed facilities, transportation, or water resources.

This awareness should have several dimensions:

The capability to identify the effects of technology on society; such as how transportation or water projects affect economic development or social mobility, or how changes in construction methods may affect the structure of the construction industry.

An understanding of the processes through which decisions may be reached about particular technologies; for example, the structure of institutional arrangements and political forces which influence the siting of major new facilities such as power plants, transit lines, highways, refineries, dams, etc.; or the processes through which national, regional, or urban investment policies are formulated; or how present decision processes can be restructured to enable social and environmental interests to participate in technological decisions more effectively.

A concern for values: what objectives should technology try to achieve? In developing a metropolitan transportation plan, should priority be given to low-income central city residents or to middle-income suburban commuters? In developing a regional energy plan, what levels of environmental risks are acceptable in order to gain local jobs and to achieve regional economic objectives? In introducing major innovations in the construction industry, how should the potential benefits be shared among labor, management, and facility owners?

A concern for what the role of the civil engineer should be: should the civil engineer work to change legal, economic, or institutional constraints? Should the objectives of a project be accepted as given, or should questions be raised about those objectives?

Civil engineers, whether in professional practice, or still students, have to decide for themselves what mix of skills and capabilities they wish to have in specific areas of technology and in these four areas of concern for the interactions between technology and society. The Social and Management Systems Group in the Department provides a base of resources through which students can develop their awareness and capabilities to the extent they wish.

Educational and research facilities and special programs within the Department are described below.

Interdisciplinary Programs

As new problem areas emerge, they increasingly fail to fall within the traditional interest area of a single academic department at MIT. The Department of Civil Engineering is responding to this situation in two ways: 1) The Department has added faculty with training and professional experience in law, management, economics, political science, and sociology, as well as in mechanical and electrical engineering, ecology, chemistry, and geology. Accordingly, departmental research and subject offerings have been developed in many interdisciplinary areas of current and future importance such as environmental engineering, environmental management and control, public service systems, urban engineering, engineering and public policy, project evaluation and management. Undergraduates and graduate students build educational programs in these and other areas, either through use of the liberal elective provisions of the curriculum leading to degrees designated as being in civil engineering, or by formulating a special program leading to a degree without designation. In any case, the subjects chosen may be selected from among the offerings of other departments of the Institute, such as Urban Studies and Planning, Architecture, Management, Mathematics, Economics, Political Science, the life and earth sciences, and the other fields of engineering. 2) Interdisciplinary programs at the graduate level are administered by special and standing interdepartmental committees. Those of particular interest to students from civil engineering are in environmental engineering, transportation, materials, applied earth sciences, operations research, computers and information systems, ocean engineering, public systems, the social applications of technology, management of technology, and mineral resources engineering and management.

In short, each student's educational and research program may be arranged to reflect his or her personal and professional goals, whether they are intensive or extensive in nature.

Master of Science in Technology and Policy

Students interested in applying their civil engineering background to problems of policy and socioeconomic assessment of technology may apply for the interdepartmental Master of Science Program in Technology and Policy. This program combines subjects in advanced technology in the particular field of the student's choosing with subjects in economics, systems analysis, political science, and law. It engages the student in significant project work integrating technology and policy. Well-qualified students may complete this program in one calendar year. General requirements and application procedures are described in Chapter V of this catalogue.

Master of Science in the Management of Technology

Students who would like to apply their civil engineering background and at least five years of technical work experience to issues in technical management may want to look into applying to the Joint Program in the Management of Technology. Jointly offered by MIT's School of Engineering and the Sloan School of Management, this Program entails a rigorous 12-month curriculum, developed and taught by faculty from both Schools, focusing on management principles for technical people in a technical environment. The Program is designed for scientists and engineers on a career path requiring increasing managerial responsibilities for technical activities. These are individuals planning to remain on the technical side of the organization rather than moving into general management positions in the near future. More information on general requirements and application procedures is included in Chapter V of this catalogue.

Joint MIT-WHOI Program Course I-W

A joint program with the Woods Hole Oceanographic Institution is intended for students whose primary career objective is oceanographic engineering. Students divide their academic and research efforts between the campuses of the two institutions. While in residence at MIT, students enrolled in this course follow a program similar to that of other students in this Department. The program is described in more detail under the section on MIT's Joint Program in Oceanographic Engineering with the Woods Hole Oceanographic Institution.

Master of Science in Transportation

The interdepartmental degree of Master of Science in Transportation is offered by participating departments (see above) in cooperation with the Center for Transportation Studies. Most Civil Engineering students studying transportation at the Master's level are enrolled in this interdepartmental program, although the Master of Science in Civil Engineering degree is still offered for those students whose educational objectives are better served by that program. Requirements for the Master of Science in Transportation are described in Chapter V of this catalogue.

Center for Transportation Studies

The Center for Transportation Studies (CTS) coordinates transportation research and educational activitities at MIT. Faculty from the following departments participate in CTS: Aeronautics and Astronautics, Civil Engineering, Economics, Mechanical Engineering, Ocean Engineering, Political Science, Sloan School of Management, and Urban Studies and Planning. The Transportation Systems Division of the Department of Civil Engineering plays a major role in both the academic and research programs of the Center. A primary goal of the Center is to encourage the interdisciplinary approach essential in dealing with transportation issues. Effective solution of transportation problems requires understanding the technological options and their social, economic, and political ramifications. The Center provides a framework within MIT for interdisciplinary exchange in this broadly based field of study. The current research program of the Center includes projects in diverse areas such as innovative transportation planning, railroad noetwork planning, urban transportation, transportation demand models, the Federal role in transportation planning, railroad regulation and technical change, transportation in developing countries, and an international evaluation of the future of the automobile. The Center currently is directed by Professor Daniel Roos, a faculty member of the Department of Civil Engineering. A more complete description of the Center is provided in Chapter V of this catalogue.

Mining and Mineral Resources Research Institute

The MMRRI coordinates academic and research activities in the mineral resources field. In addition to the Department of Civil Engineering, the Departments of Mechanical Engineering, Materials Science and Engineering, Earth and Planetary Sciences, Ocean Engineering, Economics, Management, and Political Science are involved, as is the Energy Laboratory. A consortium consisting of several other universities in Massachusetts and MIT ensures statewide interaction. Finding mineral resources, extracting and processing them economically and in an environmentally acceptable manner are some of the major problems facing us today, a problem area that includes reducing our need for mineral resources and substituting one for the other. The MMRRI makes use of MIT's strength in integrating many different disciplines toward the solution of these problems. Joint academic subjects and seminars and particularly the undergraduate and graduate interdisciplinary programs of study in "Mineral Resources Engineering and Management" represent the academic side of the MMRRI, while on the research side interdepartmental efforts are organized and individual projects coordinated. The MREM programs are described in Chapter V of this catalog.

Laboratories

The **Ralph M. Parsons Laboratory for Water Resources and Hydrodynamics** is a major unit for research in the water environment, containing more than 40,000 square feet of classrooms, laboratories, shops, computer facilities, and offices. A large collection of literature in this field is available for reference. The experimental equipment includes a number of wave tanks and channels for the study of wave deformation and breakwaters and for investigations of the transport of suspended sediment. A 40 ft. by 60 ft. basin is used for the study of waste heat disposal by submerged, multi-port diffusers in estuaries and coastal waters. Water temperature distributions are measured by a 100 probe, automatic scanning system connected to a computer controlled data acquisition facility. Additional specialized equipment and instrumentation is available for the study of turbulence, stratified flows, and dispersion in porous media.

Laboratory facilities are available for the study of aquatic biological and chemical interactions related to water quality. Current investigations include phytoplankton growth dynamics and effects of trace metal and toxic substances. A van with portable laboratory facilities is provided for field observations related to water quality and hydrology in lakes and wetlands.

The **Geotechnical Engineering Research Laboratory** conducts applied and fundamental research on the engineering properties of soil and rock, develops new methods of analysis, and measures and evaluates the field performance of structures during and after construction. The primary objective of the research is evaluation and improvement of methods for predicting the behavior of constructed facilities. The geotechnical laboratory, served by a computer based data acquisition system, includes plane strain and high pressure triaxial apparatus, controlled loading consolidation cells, freezing units, equipment for dynamic testing, and a rock mechanics laboratory.

The **Structures Laboratory** is an educational facility for the study of the behavior of structural elements and structural systems. The laboratory assists the student in relating theoretical predictions to actual response and in visualizing the behavior of complex systems.

Computation and information processing are essential tools of civil engineering. The use and advancement of these tools are important components of our academic program. In collaboration with several other Engineering departments, a well-equipped local computer facility is maintained for use by students and faculty in the Departments' academic and research programs, a 4MByte Digital Equipment Corporation VAX 11/780 supports more than 40 on-line character and graphics terminals. The **Joint Computer Facility** also provides a wide range of computer peripherals such as plotters and letter-quality printers, including analog and interactive graphics capabilities on a separate DEC PDP 11/34 which is connected by a network to the VAX 11/780. The Joint Computer Facility provides easy access to students to its facilities and provides consultants for assistance in hardware and software use.

Entrance Requirements for Graduate Study

Applicants do not need to have an undergraduate degree in civil engineering.

Numerous opportunities for graduate education in civil engineering exist for students with backgrounds in other branches of engineering, science, and certain social sciences. These arise through the growth of interdepartmental research and degree programs which are bringing people of diverse backgrounds together in search of solutions to the major problems of our society. Graduate students and faculty now in the Department have, for example, experience in economics, political science, sociology, architecture, urban and regional planning, management, biology, geology, and oceanography.

The primary requirements are for a keen intellect combined with capability and interest in quantitative approaches to real problems. Prerequisites for each subject are given in the subject descriptions. Students may make up deficiencies in prerequisites while pursuing a program of graduate study.

Financial Assistance for Graduate Students

The research of the Department is an integral part of the study program, and approximately 100 graduate students each year receive appointments as Research Assistants.

A limited number of Teaching Assistantships are available for advanced graduate students.

In addition to financial support, these appointments provide valuable educational experience and, in the case of Research Assistantships, thesis opportunities.

Inquiries

Detailed information about the academic policies and programs of the Department may be obtained by writing to the Academic Programs Office, Room 1-281, MIT, Cambridge, Massachusetts 02139, or by calling (617) 253-7106.

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Sosale Shankara Sastry, Ph.D.
Assistant Professor of Electrical Engineering

Robert Ronald Tenney, Ph.D.
Assistant Professor of Electrical Engineering

George C. Verghese, Ph.D.
Assistant Professor of Electrical Engineering

John L. Wyatt, Jr., Ph.D.
Assistant Professor of Electrical Engineering

Richard Eliot Zippel, Ph.D.
Assistant Professor of Computer Science and Engineering

Victor Waito Zue, Sc.D.
Assistant Professor of Electrical Engineering

Adjunct Professors

Robert Harmon Rediker, Ph.D.
Adjunct Professor of Electrical Engineering

Stanley R. Rich, B.E.E.
Gordon Adjunct Professor of Electrical Engineering

Gunter Stein, Ph.D.
Adjunct Professor of Electrical Engineering

Senior Lecturers

Jacques Cohen, Ph.D. (Visiting)
John Francis Reintjes, M.E.E.
John George Trump, Sc.D.
Henry Joseph Zimmermann, S.M.

Lecturers

Guy Octo Barnett, M.D.
Terrance Raymond Bourk, Ph.D.
Stephen Kent Burns, Ph.D.
Chathan M. Cooke, Ph.D.
Charles Freed, S.M.
Stanley B. Gershwin, Ph.D.
Bernard Gold, D.E.E.
Timothy Lee Johnson, Ph.D.
Nelson Yuan-Sheng Kiang, Ph.D.
Alexander Kusko, Sc.D.
Philip W. Lavori, Ph.D.
Richard S. Marcus, E.E.
Charles E. Miller, S.M.
Ronald S. Newbower, Ph.D.
Charles D. Paton, B.S.
Stephen A. Raymond, Ph.D.
Robert Harvey Rines, Ph.D.
John Avery Tucker, M.Engrg.
Bruce D. Wedlock, Sc.D.
Allen W. Weigner, Ph.D.

Technical Instructor

Charles D. Paton, B.S.
Lecturer

Director of Course VI-A

John Avery Tucker, M.Engrg.
Lecturer

Administrative Officer

Richard Joseph Caloggero

Facilities Officer

Anthony Colozzi, B.S.

Integrated Circuit Fabrication Facility Manager

Anthony Colozzi, B.S.

Administrative Assistants

Patrice M. Gunderson, B.S.
Paul Jerome McQuillen, B.S.
Eric M. Ostrom
Marilyn Andrea Pierce
Horace McNutt Smith, Jr., B.A.

Senior Research Scientists

Nathaniel Isaac Durlach, M.A.
Dennis H. Klatt, Ph.D.

Senior Research Associate

Arthur Linz, Ph.D.

Research Associates

Chathan M. Cooke, Ph.D.
John J. Guinan, Ph.D.
Edward W. Maby, Ph.D.
Stephen D. Umans, Ph.D.
William B. Westphal, S.B.

Visiting Engineer

Mark H. Douma, S.M.

Visiting Scientist

Zi-Yu Liu, Ph.D.

Research Affiliates

Robert P. Bishop, Sc.D.
George Edward Costey, B.E.E.
Kenneth J. Germeshausen, S.B.
Theodore C. M. Lo, M.D.
James T. O'Connor, V.M.D.
Robert Poss, M.D.
Ferdinand A. Salzman, M.D.
Robert S. Wenstrup, Jr., Ph.D.

Postdoctoral Associates

A. N. M. Masum Choudhury, Ph.D.
Hans Peter Christenson, Ph.D.
David R. Day, Ph.D.

Professors Emeriti

Gordon Stanley Brown, Sc.D., D.Ing., Tekn.D.
Institute Professor, Emeritus
Professor of Electrical Engineering, Emeritus

Murray Eden, Ph.D.
Professor of Electrical Engineering, Emeritus

Harold Eugene Edgerton, Sc.D., D.Eng., LL.D.
Institute Professor, Emeritus
Professor of Electrical Measurements, Emeritus

Richard Henry Frazier, S.M.
Professor of Electromechanics, Emeritus

Truman Stretcher Gray, Sc.D.
Professor of Engineering Electronics, Emeritus

Charles Kingsley, Jr., S.M.
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Yuk-Wing Lee, Sc.D.
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Claude Elwood Shannon, Ph.D.
Donner Professor of Science and Professor of Electrical Engineering and Mathematics, Emeritus

Alexander Smakula, Ph.D.
Professor of Crystal Physics, Emeritus

John George Trump, Sc.D.
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Arthur Robert Von Hippel, Ph.D.
Institute Professor, Emeritus
Professor of Electrophysics, Emeritus

Karl Leland Wildes, S.M.
Professor of Electrical Engineering, Emeritus

John McReynolds Wozencraft, Ph.D.
Professor of Electrical Engineering, Emeritus

Henry Joseph Zimmermann, S.M.
Professor of Electrical Engineering, Emeritus

Department of Electrical Engineering and Computer Science

Undergraduate Study

Many of the products and services upon which our modern industrial civilization is based are the work of electrical engineers and computer scientists. The large quantities of power which serve both developed and developing societies are provided by electric motors and generators and are controlled by complex electrical distribution systems. Similarly, our rapidly growing capacity for computation and manipulation of data structures is provided by electronic digital computers, their associated communication and switching networks, and software systems. Electrical engineers have developed conceptual models for detection, communication, and control, and have applied them not only to physical and biological systems but also to such fields as economics, management, and linguistics. In addition, they have developed complex instrumentation systems for observation and measurement which are used extensively in all branches of the physical and biological sciences and engineering. Much of this work in turn has drawn upon progress made in understanding and exploiting the fundamental electric and magnetic properties of materials in a variety of novel devices for processing energy, signals, and information.

In a field of rapidly changing technology no one can describe the systems and devices of only 15 years hence. What is certain, however, is that their development and understanding will require a firm grounding in the application of mathematics and physics to the design and analysis of "real" systems. "Real" systems include such obvious physical entities as motors, transistors, and lasers and the larger physical systems of which they are components: power systems, communications systems, and computers. Increasingly, the "real" systems with which the engineer must deal also include such abstract entities as algorithms, information structures, and computation schemata. An education in preparation for a professional career in the field of electrical science and engineering or in computer science and engineering requires both a solid preparation in fundamental mathematical and physical principles and practice in the application of these principles to real problems. The focus of the core curricula and of many of the subjects offered for graduate students is on the fundamental principles of electrical and computer science. Elective subjects, laboratory work, and thesis research complement this preparation by introducing specialized techniques of design, analysis, and experimentation in a variety of fields.

The Department's undergraduate programs provide the intellectual tools and skills needed for professional work and form a basis for the continuing study and learning that is characteristic of engineering leaders. The core curricula focus on mathematical and physical principles and the techniques used in their application to real problems. Elective subjects and laboratory work deal with the specialized techniques of a variety of fields. Each student's program is developed through personal discussion with and guidance from his or her faculty advisor.

The Department offers two undergraduate programs: Program 1, Electrical Science and Engineering; and Program 3, Computer Science and Engineering. Versions of these two programs combining study with industrial engineering practice are available under the designation VI-A. All of the programs are accredited by the Engineers' Council for Professional Development.

Each of the undergraduate degree programs in Course VI involves three distinct segments: lecture-recitation subjects, laboratory-project subjects, and undergraduate thesis. Classroom subjects provide organized arrangements of important knowledge and an introduction to the application of that knowledge through homework exercises and elementary design problems. Laboratory project work, on the other hand, provides an exposure to the design of experiments — the organization of procedures to achieve specified goals. Also, it provides experience with problems of implementation — the use of the hardware and software tools of the profession. Finally, it requires evaluation of results — the quantitative reconciliation of observations with appropriate conceptual models, or of performance with specified design goals. Because of the importance of this work, students are expected to complete one Departmental Laboratory subject in addition to the General Institute Laboratory Requirement.

Satisfactory completion of an undergraduate thesis is required in both Programs 1 and 3. The undergraduate thesis is the one part of the curriculum in which the responsibility for success is on the student's shoulders. He or she is to take the initiative in interviewing members of the staff, discussing possible research or engineering projects, and arranging for supervision. With guidance from the supervisor, students are responsible for determining methods of solving the problem, carrying out the indicated research or design work, and presenting their results both orally and in a formal written report. They are faced with a time limit for the completion of these tasks and are expected to organize their efforts accordingly. Students are encouraged to begin thinking about thesis interests early, since work may begin in the junior year.

Students in the VI-A program not entering the Course VI Master of Science program may substitute work done as part of Industrial Practice for the undergraduate thesis provided the work includes a written report in thesis format and an oral report either at MIT or at the company. Students in the VI-A program who continue in the Course VI S.B.-S.M. program may submit a single S.M. thesis to satisfy both the undergraduate and graduate thesis requirements.

The Departmental programs allow for a number of unrestricted elective subjects without overload. Students may choose these subjects as they see fit. Sequences of electives have been developed to provide an opportunity for specialization in several of the current disciplines in electrical engineering and computer science or for exposure to current research in these areas. Elective sequences are currently available in digital systems, electronic materials and devices, and bioengineering. A series of elective subjects has also been established to provide an opportunity for undergraduates to develop a close working relationship with an active research group. Participation may extend over several terms and occur in a variety of forms: project work under faculty or staff supervision, independent study of relevant literature, assisting graduate students in thesis research, or individual research or design work. Students should consult their faculty counselors about the choice of appropriate electives.

All undergraduates are encouraged to acquire industrial experience during their program at MIT. Many aspects of engineering education can be more effectively accomplished on the job than in a classroom. Further, most students gain a great deal of pleasure from discovering that the knowledge they have gained at MIT, which may have seemed rather abstract, does in fact help to solve real and important engineering problems. This experience may be acquired either through participation in the VI-A program or through appropriate summer jobs.

Additional information concerning the Department's undergraduate programs may be obtained from Professor L. A. Gould, Electrical Engineering and Computer Science Undergraduate Office, Room 38-476, MIT, Cambridge, Massachusetts 02139, (617) 253-7329.

Bachelor of Science in Electrical Engineering
Course VI
Program 1: Electrical Science and Engineering

Program 1 prepares students for electrical engineering careers in industry, research, or the academic world. Through a proper selection of elective subjects students may get a good start on an industrial career in one of the specialized branches of electrical engineering or prepare themselves for the graduate study needed for an academic or research career in engineering or such related fields as physics, mathematics, management, or the social sciences. Program 1 requires at least one term of mathematics including differential equations and one term of quantum physics or thermodynamics beyond the General Institute Requirements. This background forms the basis for the core of the curriculum: seven subjects in circuit theory, electronics, electromagnetic fields, electrodynamics, signals and systems, computer programming languages, and computation structures. An additional set of restricted electives allows the student to choose from the fields of statistical physics, probability, or advanced mathematics, including complex variables, modern algebra, or analysis, depending on interest.

The **Bioelectrical Engineering Option** is a variant of Program 1 that prepares students for a variety of careers in biomedical engineering and medicine. The curriculum differs from the normal Program 1 curriculum primarily in that three subjects in quantitative physiology replace several advanced subjects in mathematics and physical science. In addition, students in the Bioelectrical Engineering Option are free to make other substitutions that may be more appropriate to their career objectives, and are particularly encouraged to study more deeply the life sciences and chemistry through electives.

The curriculum requirements for Program 1 are given on the next page. The requirements listed are not rigid. Some variations are routinely permitted, while others are considered on an individual basis. Well-motivated substitutions of substantially equivalent subjects are routinely approved. Departmental approval of requests for substantial changes generally is granted only to well-prepared students whose proposed programs are comparable to the listed curricula in breadth, depth, and integrated approach to a well-defined educational objective.

Bachelor of Science in Electrical Engineering
Course VI
Program 1: Electrical Science and Engineering

	General Institute Requirements	Total Units
	Specific science and humanities and social science subjects.	132
	The Science Distribution Requirement can be satisfied by taking 6.002, 18.03 and either 2.40, 5.60,[1] or 8.211, as required by the Departmental Program.	
	Laboratory Requirement	12
	Departmental Program	

	Required Subjects[2]		117
6.001	Structure and Interpretation of Computer Programs	4 3 8	
6.002	Circuits and Electronics	4 2 9	
6.003	Signals and Systems	4 2 9	
6.012	Electronic Devices and Circuits	4 0 8	
6.013	Electromagnetic Fields and Energy	4 0 8	
6.014	Electrodynamics	4 0 8	
6.032	Computation Structures	4 0 8	
18.03	Differential Equations	4 0 8	
	Thesis[3]	12	
	Restricted Electives		48
	1. Either		
2.40	Thermodynamics	4 0 8	
	or		
5.60	Chemical Thermodynamics	4 0 8	
	or		
8.211	Introduction to Quantum Physics	5 0 7	
	2. One subject from each of two of the following groups:		
	Group A. Statistical Physics		
6.018	Statistical Mechanics and Thermodynamics	4 0 8	
	Group B. Probability Theory		
6.041	Probabilistic Systems Analysis	4 0 8	
18.313	Probability	3 0 9	
18.440	Probability and Random Variables	4 0 8	
	Group C. Advanced Mathematics		
18.04	Complex Variables with Applications	12	
18.063	Introduction to Algebraic Systems	4 0 8	
18.100	Analysis I	3 0 9	
	Restricted Electives (continued)		
	3. Departmental Laboratory: Subjects selected from the list below (in addition to the General Institute Laboratory Requirement)	12	
6.100	Electrical Engineering and Computer Science Laboratory	Arr.	
6.101	Introductory Electronics Laboratory	3 8 1	
6.111	Introductory Digital Systems Laboratory	3 7 2	
6.114	Real-Time Computing and Control Laboratory	3 7 2	
6.115	Microcomputer Project Laboratory	2 8 2	
6.121	Bioelectronics Project Laboratory	2 8 2	
6.141	Power Systems Project Laboratory	0 10 2	
6.142	Microcomputer Controlled Energy Systems	3 6 3	
6.151	Semiconductor Devices Project Laboratory	0 12 0	
6.161	Modern Optics Project Laboratory	2 8 2	
6.162	Image Transmission Systems Project Laboratory	0 12 0	
6.163	Strobe Project Laboratory	2 8 2	
6.170	Laboratory in Software Engineering	3 6 3	
6.182	Psychoacoustics Project Laboratory	3 4 5	
	Unrestricted Electives[4,5]		54
	Total Units Required for the S.B. Degree		363

1
5.60 cannot be used to satisfy both the Science Distribution Requirement and the Chemistry/Biology Requirement.
2
Substitution for 6.012, 6.013, or 6.014 by subjects of similar content may be permitted upon petition to the Department.
3
A thesis of at least 12 units is required. Up to 18 additional units of thesis may be used as elective units.
4
Students are encouraged to consider elective subjects in the areas of science and public policy, engineering management, inventions, entrepreneurship, finance, or managerial economics.
5
Schedules of students in Course VI, Program 1 can always be arranged to leave available 12 units of Unrestricted Elective in the second year.
6
Most students in the Bioelectrical Engineering Option will wish to include a variety of chemistry and biology subjects in their programs. Note that, although 5.41 Introduction to Structure, Bonding, and Mechanism, 5.60 Chemical Thermodynamics, and 7.01 General Biology are not specifically required in the Departmental Program, these subjects are prerequisites for many advanced chemistry and biology subjects. Only those students with a good high school preparation in chemistry and biology should elect not to take 5.41 and 7.01. Students who may be interested in applying for admission to medical school probably will want to elect additional chemistry and biology subjects, such as 5.310 Laboratory Chemistry, 5.42 Organic Chemistry, and 7.011 Introduction to Experimental Biology or 20.002 Laboratory in Applied Biology.

Bachelor of Science in Electrical Engineering
Course VI
Program 1: Bioelectrical Engineering Option

	General Institute Requirements	Total Units
	Specific science and humanities and social science subjects	132
	The Science Distribution Requirement can be satisfied by taking 6.002 and 18.03, which are required by the Departmental Program, plus appropriate subjects totaling	12
	Laboratory Requirement	12
	Departmental Program	

	Required Subjects		153
6.001	Structure and Interpretation of Computer Programs	4 3 8	
6.002	Circuits and Electronics	4 2 9	
6.003	Signals and Systems	4 2 9	
6.012	Electronic Devices and Circuits	4 0 8	
6.013	Electromagnetic Fields and Energy	4 0 8	
6.014	Electrodynamics	4 0 8	
6.021J	Quantitative Physiology: Cells and Tissues	4 2 6	
6.022J	Quantitative Physiology: Organ Transport Systems	3 2 7	
6.023J	Quantitative Physiology: Sensory and Motor Systems	3 2 7	
6.032	Computation Structures	4 0 8	
18.03	Differential Equations	4 0 8	
	Thesis[3]	12	
	Restricted Elective		12
6.041	Probabilistic Systems Analysis	4 0 8	
	or		
18.313	Probability	3 0 9	
	or		
18.440	Probability and Random Variables	4 0 8	
	Unrestricted Electives[4,5,6]		42
	Total Units Required for the S.B. Degree		363

Bachelor of Science in Computer Science and Engineering
Course VI
Program 3: Computer Science and Engineering

Program 3 is designed to give students a background in computer science and related fields, upon which they may build careers in advanced computer systems development, in sophisticated applications of computers to technical or organizational problems, and in the further development of computer science.

The Program 3 curriculum has three major components. The first deals with the design and use of computer languages and systems, and with the role of computers in problem solving. It includes the study of algorithms and information structures, the organization of programs and information processing systems, and the methods of artificial intelligence. The second component broadens the student's experience by providing an introduction to the description and analysis of linear systems and electronic circuits. The concepts involved in this component underlie a wide range of computer applications and are prerequisite to the successful integration of computers with a variety of physical systems and processes. The third component, which consists of subjects in linear algebra, modern algebra, and computational models, introduces the student to certain fundamental areas of mathematics that support and supplement the first two components.

For some students, particularly those whose interests are centered on the hardware aspects of computation, a program of studies involving a combination of subjects from the Program 1 and 3 curricula may be appropriate. Such programs should be arranged through the student's faculty advisor.

The curriculum requirements are listed at the right. Although they are intended to meet the needs of most students whose major interest lies in computers and computation, these requirements are not rigid. Well-motivated substitutions of essentially equivalent subjects are normally approved. Substantial changes may also be approved provided they result in a program of comparable breadth and depth and serve a well-defined educational objective.

Bachelor of Science in Computer Science and Engineering
Course VI
Program 3: Computer Science and Engineering

	General Institute Requirements	Total Units
	Specific science and humanities and social science subjects	132
	The Science Distribution Requirement is satisfied by 6.034, 18.700 and 18.063, which are required in the Departmental Program.	
	Laboratory Requirement	12
	Departmental Program	
	Required Subjects[1]	141
6.001	Structure and Interpretation of Computer Programs	4 3 8
6.002	Circuits and Electronics	4 2 9
6.003	Signals and Systems	4 2 9
6.032	Computation Structures	4 0 8
6.034	Artificial Intelligence	4 0 8
6.035	Computer Language Engineering	4 0 8
6.045J	Computability, Automata, and Formal Languages	3 0 9
6.170	Laboratory in Software Engineering	3 6 3
18.063	Introduction to Algebraic Systems	4 0 8
18.700	Linear Algebra	3 0 9
	Thesis[2]	12
	Restricted Electives	24
	Two of the following subjects:	
6.033	Computer System Engineering	4 0 8
6.036	Problem-Solving Paradigms	4 0 8
6.046	Introduction to Algorithms	3 0 9
6.088	Machine Vision and Manipulation	3 0 9
	Unrestricted Electives[3,4]	54
	Total Units Required for the S.B. Degree	363

1
Substitution for 6.034, 6.035, 6.045J, 6.170, 18.700 or 18.063 by subjects of similar content may be permitted upon petition to the Department.

2
A thesis of at least 12 units is required. Up to 18 additional units of thesis may be used as elective units.

3
Students are encouraged to consider elective subjects in the areas of science and public policy, engineering management, invention, entrepreneurship, finance, or managerial economics.

4
Schedules of students in Course VI, Program 3 can always be arranged to leave available 12 units of Unrestricted Elective in the second year.

VI-A Program

The VI-A Program combines industrial and research experience with academic work through a series of organized assignments at affiliated companies interwoven with the regular course of study at MIT. Although students may stop at the Bachelor's degree, the Program encourages the simultaneous completion of the Bachelor's and Master's at the end of the fifth year with only the Master's Thesis required for the two degrees. Usually the work of the two final VI-A Company Assignments serves as the basis for this thesis. As the VI-A Program ensures a continuing liaison between the participating companies and the professional staff of the Department, students receive job assignments more professionally rewarding than typical summer jobs. In addition to receiving academic credit for these Company Assignments, students receive pay which helps to defray educational expenses.

Second-year students who are registered and in good standing in any of the regular programs of Course VI may apply for admission to the VI-A Program. Application should be made at the VI-A Office, Room 38-473, early in the second term. The Department cannot guarantee the acceptance of a student into the Program, however, since the cooperating companies make the final selections.

Students in the VI-A Program usually complete the Bachelor's requirements in the normal four years, including a minimum of two, but occasionally three, Company Assignments. Academic credit is earned, while on Assignment, by registering for 6.921 Industrial Practice and, when appropriate, 6.922. Additional academic credit may also be earned while at the company by taking subjects after hours at nearby colleges and obtaining transfer credit at MIT. VI-A students stopping at the S.B. degree may substitute work done as part of Industrial Practice for the undergraduate thesis provided the work includes a written report in thesis format and an oral report either at MIT or at the company, and is approved by a faculty member.

Students in the VI-A Program who are admitted to the combined Course VI S.B.-S.M. program normally are expected to complete four Assignments with their cooperating company. Formal application must be made to the MIT Graduate School for participation in this combined program. Since the third and fourth contiguous Assignments generally involve projects of appropriate calibre, these projects are often developed into Master's theses to satisfy both the undergraduate and graduate thesis requirements. The S.B. and S.M. degrees are awarded simultaneously at the end of the fifth year.

The companies and laboratories participating in the VI-A Program provide a wide spectrum of assignments in the various fields of electrical science and engineering and computer science and engineering. Students are individually associated with only one company while in the Program. Company Assignments are arranged to provide a broad exposure to the kinds of activities in which engineers are currently engaged. Further, the technical sophistication and responsibility involved in the Assignments progresses with the developing technical competence, academic achievement, and maturity of the participating students.

Companies or laboratories currently cooperating with MIT in the VI-A Program include AVCO-Everett Research Laboratory, Bell Laboratories, Codex Corp., Comsat, C. S. Draper Laboratory, Digital Equipment Corporation, Fairchild Camera and Instrument Corporation, General Electric Company, Gen Rad Company, Hewlett-Packard Company, Honeywell, Inc., IBM Corporation, Lincoln Laboratory, Medtronic, Inc., Motorola, Inc., Naval Surface Weapons Center, Naval Underwater Systems Center, Raytheon Company, RCA, Tektronix, Inc., Texas Instruments, Inc., and Xerox Corporation.

While on assignment, students are subject to the usual company regulations and receive regular financial compensation. In all cases, VI-A students must remain with the company with which they start the Program. At the conclusion of the Program, students are not obligated to accept employment with their company, nor is the company obligated to offer such employment.

Additional information about the VI-A Program can be obtained from the Director, John A. Tucker, VI-A Office, Room 38-473, MIT, Cambridge, Massachusetts 02139, (617) 253-4644.

Engineering Internship Program

Sophomore students in good standing in the Department may apply for admission to the schoolwide Engineering Internship Program. A general description of this program is provided in the School of Engineering section of this catalogue. Like the Department's VI-A Program, the Internship Program provides a way to combine industrial experience with the Course VI academic program.

Electrical Engineering and Computer Science students who are accepted for the Engineering Internship Program register for the usual program of study in either Program 1 or Program 3. They receive academic credit for their two undergraduate work assignments by registering for 6.925.

Participants in the Program are encouraged to apply for admission to graduate school. If they are accepted to and enter graduate school, they complete their work experience with a seven-month assignment at their internship company. They receive graduate academic credit for this assignment by registering for 6.955. In many cases they also satisfy thesis requirements for both the S.B. and the S.M. during the graduate work assignment.

Additional information about the Engineering Internship Program as it applies to Electrical Engineering and Computer Science students can be obtained from Professor James K. Roberge, Room 38-494, MIT, Cambridge, Massachusetts 02139, (617) 253-5994.

Graduate Study

The program of graduate education in the Department of Electrical Engineering and Computer Science has three aspects. First, a variety of classroom subjects in physics, mathematics, and fundamental fields of electrical engineering and computer science is offered to permit students to develop strong theoretical backgrounds. Second, more specialized classroom and laboratory subjects and a wide variety of colloquia and seminars introduce the student to the problems of current interest in many fields of research, and to the techniques which may be useful in attacking them. Third, each candidate for any advanced degree conducts research under the direct supervision of a member of the faculty and reports the results in a thesis.

Three advanced degree programs are offered. A well-prepared student may obtain a Master of Science in one calendar year, including completion of a course of formal studies and the presentation of a satisfactory thesis. Students who need more classroom subjects before beginning thesis work, or who want to carry out a more substantial research or teaching program while gaining further graduate experience, may choose to complete their theses by the end of a two-year program and receive the Electrical Engineer and the Master of Science degrees concurrently. The doctoral programs usually take four to five years beyond the Bachelor's level to complete. Most doctoral students complete the Master of Science requirements in the course of their doctoral programs.

There are no fixed programs of study for these degrees. Each student plans a program in consultation with a Graduate Counselor, a member of the faculty whose professional field is related to the student's interest. As the program moves toward thesis research, it usually centers in one of a number of areas, each characterized by an active research program. Areas of specialization in the Department which have active research programs and related graduate subjects include: systems, communication and control; computer science; electronics, computers and systems; electromagnetics and dynamics; energy conversion devices and systems; materials and devices; VLSI system design and technology; communication and probabilistic systems; operations research; bioelectrical engineering; high-voltage radiation engineering; stroboscopic photography and underwater sound.

In addition to graduate subjects in electrical engineering and computer science, many students find it profitable to study subjects in other departments such as Biology, Economics, Foreign Literatures and Linguistics, Management, Mathematics, Physics, and Psychology.

The informal seminar is an important mechanism for knitting together members of the various research groups. There are about 16 that meet every week. In these, graduate students, faculty, and visitors report their research in an atmosphere of free discussion and criticism. For the new graduate student, these open seminars are excellent places to learn about the various research activities in the Department.

Research activities in electrical engineering and computer science are carried on by students and faculty in laboratories of extraordinary range and strength, including the Laboratory for Information and Decision Systems, the Research Laboratory of Electronics, the Laboratory for Computer Science, the Artificial Intelligence Laboratory, the Center for Materials Science and Engineering, the Electric Power Systems Engineering Laboratory, the Energy Laboratory, the Center for Space Research, the Continuum Electromechanics Group, Lincoln Laboratory, the High Voltage Research Laboratory, the Francis Bitter National Magnet Laboratory, the Operations Research Center, and the Stroboscopic Light and Pulsed Sonar Laboratory. Full descriptions of many of these laboratories, including a list of current projects, may be found in Chapter V of this catalogue.

Joint MIT-WHOI Program Course VI-W

A joint program with the Woods Hole Oceanographic Institution is intended for students whose primary career objective is oceanographic engineering. Students divide their academic and research efforts between the campuses of the two institutions. While in residence at MIT, students enrolled in this course follow a program similar to that of other students in this Department. The program is described in more detail under the section on MIT's Joint Program in Oceanographic Engineering with the Woods Hole Oceanographic Institution.

Master's Degree Program for Students in Industry

A course of study leading to the degree of Master of Science in Electrical Engineering and Computer Science may be pursued by well-qualified students while employed by approved firms in the Greater Boston area. Much of the work is done on a part-time basis and the thesis project is done at the student's place of employment with the help and supervision of both MIT faculty and a company supervisor. This program requires one term as a full-time student. The academic course requirements to earn the Master's degree in this program are the same as those for a regularly enrolled full-time graduate student. Enrollment is limited.

Requirements for Graduate Study

Because the undergraduate backgrounds of applicants to the Department are varied (electrical engineering, computer science, physics, mathematics, biomedical engineering, for example), no specific admissions requirements are listed. The backgrounds of all applicants are studied carefully to assure that they meet the principal prerequisites necessary for their graduate programs. Applicants with unusual academic backgrounds are encouraged to communicate directly with faculty members in their proposed area of study for advice. In any case, superior achievement in undergraduate sciences is considered particularly important.

Master of Science in Electrical Engineering and Computer Science

The general requirements for the degree of Master of Science are given in the graduate education chapter of this catalogue. The Department requires that the program include at least four formal graduate-level classroom or laboratory subjects (listed as "A" subjects in this catalogue). Students working full time for the Master of Science degree may take as many as four classroom subjects per term. The subjects are wholly elective and are not restricted to those given by the Department. The program of study must be well balanced, emphasizing one or more of the theoretical or experimental aspects of electrical engineering or computer science. A thesis is required.

Electrical Engineer[1]

Able students who desire more extensive training than is possible within the Master of Science program are encouraged to study for the degree of Electrical Engineer. The course of studies for this degree is elective, and a thesis is required. The program ordinarily requires at least four terms of graduate study beyond the Bachelor of Science level. The general requirements for the Engineer's degree are given in the graduate education chapter. The Department also requires that the program include at least eight approved graduate "A" subjects.

Doctor of Philosophy and Doctor of Science

The general requirements for the degree of Doctor of Philosophy or Doctor of Science are given in the graduate education chapter. Only students who have shown promise of performing truly creative work are encouraged to study for the doctoral degree. Doctoral candidates are expected to perform thesis work which is a significant contribution to knowledge and to participate in the educational program of the Department. Students beginning graduate work in the Department are required to qualify first for the Master of Science or the Electrical Engineer degree; the quality of the thesis submitted for these degrees is a major component in the decision to qualify a student for the doctoral program. Students who have completed a Master's degree elsewhere are required to submit evidence of research accomplishment before being qualified for the doctoral program.

All regular graduate students who intend to enter a doctoral program are required to complete a written examination early in their graduate study. Two forms of the examination currently exist. For students not specializing in computer science, the examination occurs in January of their first year of graduate study and is designed to explore students' undergraduate preparation for graduate study. In addition to its role in the decision on qualification for doctoral study, this examination helps students to evaluate their preparation and helps faculty members counsel them with respect to their graduate programs. For students specializing in computer science, the examination occurs in January of their second year of graduate study and is based on material covered in a set of graduate core subjects in computer science. This form of the examination is designed to evaluate student preparation in those areas of computer science which the faculty believe to be fundamental to graduate study in this field at MIT.

The General Examination consists of the written examination described above and two oral examinations. One oral examination is normally taken in the third term of graduate study and the other in the fifth term. When the doctoral thesis research is completed, a thesis examination is held. A Minor Program is required by the Department and must have departmental approval.

Fellowships and Research and Teaching Assistantships

Studies toward an advanced degree can be supported by personal funds, by an award such as the National Science Foundation Fellowship which the student brings with him or her to MIT, by a fellowship or traineeship awarded by MIT, or by a graduate assistantship. Assistantships require participation in research or teaching in the Department or in one of the associated laboratories. Assistants normally register for two or three scheduled classroom or laboratory subjects, depending upon the terms of their appointments, and may receive additional academic credit for their participation in the teaching or research program. Many assistants spend two years in a program leading to the simultaneous award of the degrees of Master of Science and Electrical Engineer; the Department encourages assistants to pursue such programs. A brochure on *Research and Graduate Study in Electrical Engineering and Computer Science at MIT* describing research and teaching opportunities in detail, may be obtained from the Department.

Inquiries

Additional information concerning graduate academic and research programs, admissions, financial aid, assistantships, etc. may be obtained from Horace M. Smith, Jr., Room 38-444, MIT, Cambridge, Massachusetts 02139, (617) 253-4605.

[1]This degree may be awarded for work in either Electrical Engineering or Computer Science.

Department of Materials Science and Engineering

Walter Shepherd Owen, Ph.D., D.Eng.
Professor of Materials Science and Engineering
Head of the Department

Professors

Benjamin Lewis Averbach, Sc.D.
Professor of Materials Science

Robert Weierter Balluffi, Sc.D.
Professor of Physical Metallurgy

Michael Berliner Bever, Dr. Jur., M.B.A., Sc.D.
Professor of Materials Science and Engineering, Emeritus
Senior Lecturer

Harvey Kent Bowen, Ph.D.
Professor of Ceramic Engineering and Electrical Engineering
Faculty Coordinator, Energy Laboratory
Associate Director, Materials Processing Center

Robert Louis Coble, Sc.D.
Professor of Ceramics

Morris Cohen, Sc.D., D.Tekn.
Institute Professor, Emeritus
Professor of Materials Science and Engineering, Emeritus

John Frank Elliott, Sc.D.
Professor of Metallurgy
Director, Mining and Minerals Resources Research Institute

Merton Corson Flemings, Sc.D.
Ford Professor of Engineering
Director, Materials Processing Center

Harry Constantine Gatos, Ph.D.
Professor of Electronic Materials and Molecular Engineering

Nicholas John Grant, Sc.D.
Professor of Metallurgy

Keith Huber Johnson, Ph.D.
Professor of Materials Science

Roy Kaplow, Sc.D.
Professor of Materials Science and Education

Thomas Burness King, Ph.D.
Professor of Metallurgy

William David Kingery, Sc.D.
Professor of Ceramics

Ronald Michael Latanision, Ph.D.
Professor of Materials Science and Engineering

Heather Nan Lechtman, M.A.
Professor of Archaeology and Ancient Technology
Director, Center for Materials Research in Archaeology and Ethnology

Koichi Masubuchi, D.Eng.
Professor of Materials Science and Ocean Engineering

Frederick Jerome McGarry, S.M.
Professor of Polymer Engineering and Civil Engineering

Robert Edward Ogilvie, Sc.D.
Professor of Metallurgy

Regis Marc Noel Pelloux, Sc.D.
Professor of Materials Engineering

Robert Michael Rose, Sc.D.
Professor of Materials Science and Engineering

Kenneth Calvin Russell, Ph.D.
Professor of Metallurgy and Nuclear Engineering

Julian Szekely, D.Sc., Ph.D.
Professor of Materials Engineering

Donald Robert Uhlmann, Ph.D.
Professor of Glass and Polymer Science

John Bruce Vander Sande, Ph.D.
Professor of Materials Science

August Ferdinand Witt, Ph.D.
Professor of Materials Science

Bernhardt John Wuensch, Ph.D.
Professor of Ceramics

Asscciate Professors

Rowland Morrell Cannon, Jr., Sc.D.
Associate Professor of Ceramics

Joel Phillip Clark, Sc.D.
Associate Professor of Materials Systems

Thomas Waddy Eagar, Sc.D.
Associate Professor of Materials Engineering

Linn Walker Hobbs, Ph.D.
Associate Professor of Ceramics

David Kaye Roylance, Ph.D.
Associate Professor of Materials Engineering

Chong Sook Paik Sung, Ph.D.
Associate Professor of Polymerics

Harry Louis Tuller, D.Eng.Sc.
Associate Professor of Ceramics

Gregory John Yurek, Ph.D.
Associate Professor of Metallurgy

Assistant Professors

Samuel M. Allen, Ph.D.
Assistant Professor of Physical Metallurgy

Alan Bleier, Ph.D.
Assistant Professor of Ceramics

I-Wei Chen, Ph.D.
Assistant Professor of Nuclear Materials and Nuclear Engineering

Terry A. Ring, Ph.D.
Assistant Professor of Minerals Engineering

Donald Robert Sadoway, Ph.D.
Assistant Professor of Materials Engineering

Gary E. Wnek, Ph.D.
Assistant Professor of Polymers

Adjunct Professor

Richard Joseph Charles, Sc.D.
Adjunct Professor of Ceramic Engineering

Lecturers

Joseph Tibor Blucher, Sc.D.
(Visiting)
Simon David Strauss
(Visiting)
Pamela Bowren Vandiver, M.A.

Technical Instructors

Arthur Jeremiah Gregor
Anthony Joseph Zona

Administrative Officer

Joseph Mitti Dhosi, S.M.

Administrative Assistants

Patricia Ellen Gavagan
Marguerite A. Meyer
I. Carol Willwerth

Senior Research Associates

John Haggerty, Sc.D.
Jacek Lagowski, Ph.D.

Principal Research Associate

Gregory Bruce Olson, Ph.D.

Research Associates

Harold Jefferson Frost, Ph.D.
Hung Chi Ling, Sc.D.
John Forbes Mandell, Ph.D.
Louis Harold Strong, Ph.D.

Postdoctoral Associates

Manoj Choudhary, Ph.D.
Alexander King, Ph.D.
Yoko Suyama, Ph.D.
Tooru Tsuru, Ph.D.
R. Scott Wallace, Ph.D.
Hanan Yinnon, Ph.D.

Research Affiliates

David A. Colling, Sc.D.
Bill Cormann Glessen, Ph.D.
Robert H. Liss, Ph.D.

Visiting Scientists

Lars Arnberg, Ph.D.
Piotr Becla, Sc.D.
Paul David Bristowe, Ph.D.
Avner Brokman, M.Sc.
Kuo-chih Chou
Nagy El Kaddah, Ph.D.
Chih-Yao Fang, M.Sc.
Robert Irving Frank, M.S.
Kazutaka Fujii, B.S.
Evelyne Fries, M.S.
Ibrahim Gaballah, D.Sc.
Filippo Gabrielli, M.S.
Joel Lee Goodrich, B.S.
Yigal Gefen, Sc.D.
Friedrich J. Hunkeler, Sc.D.
Lei Hwang, Ph.D.
Kyoko Isozumi, B.S.
Shoji Isozumi, Ph.D.
Walter Klemperer, Ph.D.
Iwao Kohatsu, Ph.D.
Bingzke Lou, M.S.
John W. McKelliget, Ph.D.
Richard Paul Messmer, Ph.D.
Susumu Mizuta, Ph.D.
Tetsu Narutani, M.Eng.
Leighton Hartwell Peebles, Jr., Ph.D.
Ram P. Tandon, Ph.D.
Kazumi Wada, M.S.
Boqun Wu, M.S.
Xiong-Feng Yang, Ph.D.
John-Ku Yoon, Ph.D.
Jiai-yun Zhang, M.S.
Shi-Xun Zhang
Qui-Min Zhou, Ph.D.

Department of Materials Science and Engineering

Professors Emeriti

Michael Berliner Bever, Dr.Jur., M.B.A., Sc.D.
Professor of Materials Science and Engineering, Emeritus

John Chipman, Ph.D., Sc.D.
Professor of Metallurgy, Emeritus

Morris Cohen, Sc.D., D Tekn.
Institute Professor, Emeritus
Professor of Materials Science and Engineering, Emeritus

Carl Frederick Floe, Sc.D.
Professor of Metallurgy, Emeritus

Frederick Harwood Norton, Sc.D.
Professor of Ceramics, Emeritus

John Torrey Norton, Sc.D.
Professor of the Physics of Metals, Emeritus

Cyril Stanley Smith, Sc.D.
Institute Professor, Emeritus
Professor of Metallurgy, Emeritus
Professor of the History of Technology and Science, Emeritus

Herbert Henry Uhlig, Ph.D.
Professor of Metallurgy, Emeritus

John Wulff, D.Sc.
Professor of Metallurgy, Emeritus

The Department of Materials Science and Engineering is concerned with the extraction, production, and use of engineering materials; with how they can be produced economically in the shapes required and with the properties demanded by modern applications. The performance of all machines and structures is limited by the properties of the materials from which they are made; thus materials engineering is at the heart of all engineering. Almost all of the properties of importance to an engineer are structure-sensitive; that is, they can be modified in significant ways by changing the chemical composition, the arrangement of the atoms or molecules in crystalline or amorphous configurations, or the size, shape, and orientation of the crystals or other macroscopic units of a solid. To understand how the useful properties of a material can be modified, it is necessary to understand the relationships between structure and properties and how the structure can be changed and controlled by the various chemical, thermal, or mechanical treatments to which a material is subjected during manufacture and in use. All materials are used in a gaseous or fluid environment which is to some degree hostile. The environment may affect the performance of the material and, when it does, the effect is usually detrimental. The losses due to surface chemical attack of building materials and to the corrosion of metals are enormous. Thus, surface reactions and surface protection are important areas of study. The study of the structure, the control of the structure, and the relationships between the structure and the properties of a material in a gaseous or fluid environment are the essential components of materials science. It is physics and chemistry applied to real materials.

Some materials have been used as structural materials for centuries. Gradually, the properties have been improved by trial and error methods using empirical knowledge. Materials science in its modern form is a very young discipline within the range of applied sciences. It is no more than 50 years old, and more important scientific developments have occurred in the last three decades than in the preceding 300 years. At first the materials scientist concentrated on trying to understand the empirical ideas about materials which had evolved over the centuries, but this stage was quickly replaced by one in which it became possible to successfully apply solid-state science to real materials. To do this, much relevant science had to be developed in parallel with the rapid improvement in our understanding of engineering materials, and these parallel developments continue at an accelerating pace. In recent years most of the major improvements in materials have resulted from the applications of scientific knowledge. The days when the materials engineer had only empiricism and intuition as guides are nearly over. In addition to marked improvements in the properties of traditional engineering materials, whole classes of new materials, such as semiconductors and modern magnet materials, have developed out of the great surge in activity in materials science.

All recent achievements in materials have depended as much on developments in materials engineering as they have on materials science. When developing processes for extracting and processing materials, and when designing materials for specific applications, the modern materials engineer must have a proper concern for economic, social, and environmental factors. Materials technology is only one, although an essential component, of a total materials system. Students wishing to specialize in materials engineering are provided with many opportunities to obtain an understanding of the economic and societal components of materials systems in association with the technological aspects of materials design.

The links between materials engineering and materials science are very strong, and the two activities are interwoven in the Department of Materials Science and Engineering. There are some subjects which it is necessary for all students of materials to know — most important are thermodynamics, and certain aspects of solid mechanics, physics, and chemistry. Suitable core subjects in these areas are provided at the undergraduate and grad-

Undergraduate Study

uate levels. In addition, subjects covering a wide variety of topics from solid-state physics to the analysis of materials systems are offered. By the selection of appropriately grouped subjects, the student can follow many different paths through the science and engineering of materials, with emphasis on engineering, science, or a mixture of the two.

Materials science and materials engineering disciplines seek to identify and understand the principles, phenomena, and ideas which are basic to all materials. For example, there are important differences in details in the fracture of ceramic, metallic, and polymeric materials, but the basic physics of fracture is the same in each case. Extruding a polymeric fiber and a metal wire may, at first sight, appear to be unrelated processes, but careful study reveals many interesting similarities. Many large industries today manufacture products containing a large variety of different materials. Their materials engineers must acquire a working understanding of the basic behavior of all of them. However, there are also many large industries in which a single class of material (e.g., steel, polymers, glasses, etc.) is manufactured and processed. In these circumstances, the materials expert must have a knowledge of various aspects of the science and engineering of one class of material. It is for this reason that programs are provided in the Department which enable a student to specialize in the science and engineering of ceramics, metals, or polymers.

Materials engineers and materials scientists, whether generalists or specialists in a particular class of material, are of vital importance to modern industry. The design and operation of propulsion units such as gas turbines and rocket motors; energy producers such as nuclear reactors; energy converters such as magnetohydrodynamic generators, semiconductor or superconductor devices and machines, laser communication systems, or any one of dozens of other developments of modern engineering, are critically dependent upon the availability of materials with the requisite blend of properties. Scientists and engineers with the knowledge and skills to carry out imaginative research on new materials, on the development of new methods of producing and processing, or the design of materials for specific applications are in great demand by industry and government. They find challenging opportunities in a variety of positions in operations, development and research in the basic materials-producing industries, in consumer and construction industries, and in the space and electronics industries.

Bachelor of Science in Materials Science and Engineering
Course III

The undergraduate program caters to the diverse needs of students who intend to pursue graduate work, to those who are more inclined toward engineering application, and to those who prefer solid-state science. The decision to concentrate on either the science or the engineering of materials may be reached by students as late as the sophomore year or even during the junior year.

For these reasons, the curriculum is flexible. Understanding of materials is developed from a foundation of physical and engineering science and a core of subjects in mechanics, thermodynamics, crystal structure, and structure-property relations. These essential subjects are taught within the Department so that meaningful examples can be used to illustrate the material. However, appropriate substitutions of subjects taken in other departments are permitted and, indeed, encouraged when a student has somewhat different educational objectives. The degree programs in Course III and Course III-B are accredited by the Engineers' Council for Professional Development. The degree programs in Course III-A are not accredited by the Engineers' Council for Professional Development.

The elective program is chosen, with the help of an advisor, to give depth in one or more technical areas such as the extraction, preparation, and purification of materials including: chemical process technology; the processing and fabrication of materials by deformation; heat treatment and phase change; the study and control of structure-property relations in ceramic, metallic, and polymeric materials, and the physics of solid materials in general. Many graduate subjects are open to undergraduates with the necessary preparation.

Other choices under the elective program are, of course, possible. A student may concentrate elective time on modern production or research management techniques in the materials industry, or on the

technology appropriate to a specific industry, or the student may choose a program which provides a sound basis in materials science and engineering from which an effective graduate program can be developed.

Participation in laboratory work by undergraduates is an integral part of both an engineering and a research experience. Laboratories are not associated with particular subjects, and, especially in thesis work, the undergraduate student has access to extensive facilities for research in materials.

The teaching facilities, some of which are located in the Center for Materials Science and Engineering, include an electron-optics laboratory with X-ray and electron diffraction equipment; electron microscopes and microanalyzers; laboratories for microscopic studies, heat treatment, and physical testing of materials; and complete test apparatus for the study of mechanical, thermal, electrical, and magnetic properties. In the ceramics laboratories most types of refractory as well as electrical ceramics and glasses can be prepared and their properties studied. Facilities for the growth and characterization of metallic and nonmetallic crystals are available in several laboratories. The chemical metallurgy laboratories contain equipment for the study of heat and mass flow and for thermodynamic and kinetic investigations at high temperatures, as well as for the processing of minerals, metals, and other materials. The materials processing laboratories are equipped for work on deformation, solidification, joining, and vapor deposition as processing techniques. Laboratories in polymer structure and properties, surface chemistry, and corrosion are also open to undergraduates. Other services include a complete analytical laboratory and computation facilities with a remote console.

Bachelor of Science in Materials Science and Engineering Course III

	General Institute Requirements	Total Units
	Specific science and humanities and social science subjects.	132
	The Science Distribution Requirement can be satisfied by 3.00, or 3.11 and 18.03 which are required in the Departmental Program plus appropriate subjects totaling	12
	The subject 3.081, which is required in the Departmental Program, appears on the list of Laboratory Subjects and can be used to satisfy the Laboratory Requirement.	
	Departmental Program	
	Required Subjects[1]	**108**
3.00	Thermodynamics of Materials	4 0 8
3.01	Physical Chemistry of Materials	4 0 8
3.02	Phase Transformations and Structure Development	3 0 5
3.081	Materials Laboratory I	1 6 5
3.082	Materials Laboratory II	1 6 5
3.11	Mechanics of Materials I	4 0 8
3.12	Mechanics of Materials II	3 0 5
3.13	Crystallography	3 0 5
18.03	Differential Equations	4 0 8
3.041	Thesis Seminar	2 0 1
	Thesis	9 to 15
	Restricted Electives[1]	**at least 40**
	Five subjects chosen from the following:	
3.03	Chemical Metallurgy	3 0 5
3.06	Engineering of Glasses and Polymers	3 0 5
3.061J	Introduction to Polymer Science and Engineering	3 0 9
3.07	Introduction to Ceramics	4 0 8
3.10	Chemical Physics of Materials	3 0 5
3.14	Physical Metallurgy	3 0 5
3.15	Electrical, Optical, and Magnetic Materials and Devices	3 0 5
3.16	Applied Surface Chemistry	3 0 6
3.18	Materials Processing	3 0 5
	Unrestricted Electives	**up to 68**
	Total Units Required for the S.B. Degree	**360**

1
Substitution of similar subjects may be permitted by petition.

Students who decide during the first year at MIT to study materials science and engineering can facilitate their later progress by ensuring that their second-year subjects include additional mathematics and physics, as well as 3.00 Thermodynamics of Materials and 3.11 Mechanics of Materials I, or their equivalents. The third and fourth years may then be devoted to study, in some depth and with adequate preparation, of areas such as ceramics, metallurgy, or polymerics through appropriate use of upperclass elective time.

Some students, on the other hand, do not wish to make a course choice until their junior year or may wish to use their elective time to the fullest possible extent in the second year rather than in later years. Generally, it is possible to complete the Departmental Program and Institute Requirements in two more years, especially if one of the second-year Science Distribution subjects is in mechanics of solids; however, some elective freedom, particularly in the fourth year, is sacrificed.

Bachelor of Science Course III-A

Major problems that our society must solve are the development, optimization, and exploitation of energy, environment, human resources, and materials. Many aspects of materials science and engineering involve diverse considerations which no single department is qualified to handle; suitable programs often require both a depth of knowledge in particular engineering techniques and a knowledge of the characteristics which these techniques require. A National Academy of Sciences study has shown that while only a small fraction of scientists and engineers receive degrees in Materials Science and Engineering, fully a third of all scientists and engineers are professionally involved in materials-related problems. One of the basic objectives of Course III-A is to provide an opportunity for students to become familiar both with the characteristics of materials and methods used to control and evaluate their properties in parallel with the study of a particular set of engineering techniques.

However, students may wish to combine materials science and engineering with other branches of study and, generally, a program can be set up to satisfy individual student goals.

The curriculum requirements are intended as a guide for students. Individual programs generally can be developed if the student informs the department of his or her intentions at the beginning of the junior year. By doing this, there will be sufficient time for the student and a faculty advisor to plan a coherent program with a list of planned electives and submit it to the Department for approval. Such a program is more effective if the student's aims are discussed as early as possible with appropriate faculty members. The program should in all cases be presented no later than the beginning of the second term of the junior year.

Bachelor of Science Course III-A

	General Institute Requirements	Total Units
	Specific science and humanities and social science subjects	132
	Science Distribution Requirement	36
	The subjects 3.00, or 3.11 and 18.03 which are among the Restricted Electives, appear on the list of Science Distribution subjects and can be used to satisfy part of the Science Distribution Requirement.	
	Laboratory Requirement	12
	The subject 3.081, which is among the Restricted Electives, appears on the list of Laboratory Subjects and can be used to satisfy the Laboratory Requirement.	
	Departmental Program	
	Restricted Electives[1]	
	A. Four of the following subjects	**36 to 48**
3.00	Thermodynamics of Materials	4 0 8
3.01	Physical Chemistry of Materials	4 0 8
3.02	Phase Transformations and Structure Development	3 0 5
3.11	Mechanics of Materials I	4 0 8
3.12	Mechanics of Materials II	3 0 5
3.13	Crystallography	3 0 5
18.03	Differential Equations	4 0 8
	Restricted Electives (continued)	
	B. Three of the following subjects	**24 to 32**
3.03	Chemical Metallurgy	3 0 5
3.06	Engineering of Glasses and Polymers	3 0 5
3.061J	Introduction to Polymer Science and Engineering	3 0 9
3.07	Introduction to Ceramics	4 0 8
3.10	Chemical Physics of Materials	3 0 5
3.14	Physical Metallurgy	3 0 5
3.15	Electrical, Optical, and Magnetic Materials and Devices	3 0 5
3.16	Applied Surface Chemistry	3 0 6
3.18	Materials Processing	3 0 5
	C. One of the following subjects:	**12**
3.081	Materials Laboratory I	1 6 5
3.082	Materials Laboratory II	1 6 5
	Planned Electives	**at least 72**
	At least six subjects (without Department specification) selected by the student and faculty advisor, together with the restricted electives, should make up a program intended to attain the goal defined by the student.	
	Unrestricted Electives[2]	**36 to 16**
	Total Units Required for the S.B. Degree	**360**

Examples of Planned Elective Programs are:

Program 1: Materials for Electronic Applications
18.03, 6.002 (SD), 6.012, 6.013, 6.014, 6.301, 6.151J (LAB) **87 units**

Program 2: Materials for Mechanical Applications
18.03, 2.02 (SD), 2.03J, 2.20 (SD), 2.34J, 2.51, 2.70, 2.73 **90 units**

Program 3: Materials for Biomedical Applications
7.01 (SD), 7.05 (SD), 3.082, 5.42, HST 010, HST 030 **85 units**

Note: In this program, Unrestricted Electives may be planned to meet pre-med requirements if that is desired.

Program 4: Materials and Archaeology
21.50, 21.502, 21.503, 21.552, 21.553, 21.554, 21.550, 12.01 (SD) or 12.061 **90 units**

1 Substitution of similar subjects may be permitted by petition.

2 Up to 36 additional units of Unrestricted Electives are available if 3.081, which is among the list of Restricted Electives, is used to satisfy the Laboratory Requirement, and 18.03 and 3.00 or 3.11 or 3.061J or 3.07, which are among the Restricted Electives, are used to satisfy a portion of the Science Distribution Requirement.

Bachelor of Science in Materials Science and Engineering Course III-B

This program provides a student with industrial experience concurrently with academic work through cooperative work assignments matched to the student's capabilities. A faculty advisor is assigned to each student to act, together with a company representative, as co-supervisor during his or her work assignments. The company suggests the nature of the work assignment, but care is taken to ensure a more challenging and rewarding experience than is typical of most summer jobs. Students are able to earn a salary during their work periods and also receive academic credit. Growth in job responsibility is expected as the student progresses.

Admission to the program is preferably obtained during the second year so that the work periods follow during that summer and the summer of the third year. A suitable work program, properly reported, may be used to satisfy the undergraduate thesis requirement. Students who are admitted to the program in the junior year can complete only one work term and are generally expected to do a senior thesis.

The program is expected to be particularly attractive to students who wish to study for the combined S.B.-S.M. degree, requiring five years for completion. Such students, if they satisfy the requirements, apply for admission into the graduate school during the senior year. They then complete two further consecutive work terms, not necessarily at the same company as the earlier work term or terms. A single thesis, which is ordinarily based on the industrial experience, suffices for the combined degrees.

Arrangements with companies are such that both company and student agree to complete the program. There are no obligations on either side regarding further employment.

Students electing the Engineering Internship Program, which is described at the beginning of the School of Engineering in this chapter, would register in Course III-B.

Graduate Study

Bachelor of Science in Materials Science and Engineering Course III-B

	General Institute Requirements	Total Units
	Specific science and humanities and social science subjects.	132
	The Science Distribution Requirement can be satisfied by 3.00, or 3.11 and 18.03 which are required in the Departmental Program, plus appropriate subjects totaling	12
	The subject 3.081, which is required in the Departmental Program, appears on the list of Laboratory Subjects and can be used to satisfy the Laboratory Requirement.	
	Departmental Program	
	Required Subjects[1]	**108**
3.00	Thermodynamics of Materials	4 0 8
3.01	Physical Chemistry of Materials	4 0 8
3.02	Phase Transformations and Structure Development	3 0 5
3.081	Materials Laboratory I	1 6 5
3.11	Mechanics of Materials I	4 0 8
3.12	Mechanics of Materials II	3 0 5
3.13	Crystallography	3 0 5
3.930	Industrial Practice	12
3.931	Industrial Practice[2]	12
18.03	Differential Equations	4 0 8
	Restricted Electives[1]	**at least 40**
	Five subjects chosen from the following:	
3.03	Chemical Metallurgy	3 0 5
3.06	Engineering of Glasses and Polymers	3 0 5
3.061J	Introduction to Polymer Science and Engineering	3 0 9
3.07	Introduction to Ceramics	4 0 8
3.082	Materials Laboratory II	1 6 5
3.10	Chemical Physics of Materials	3 0 5
3.14	Physical Metallurgy	3 0 5
3.15	Electrical, Optical, and Magnetic Materials and Devices	3 0 5
3.16	Applied Surface Chemistry	3 0 6
3.18	Materials Processing	3 0 5
	Unrestricted Electives	**up to 68**
	Total Units Required for the S.B. Degree	**360**

1 Substitution of similar subjects may be permitted by petition.

2 Thesis, 12 units, may be substituted for 3.931.

The Department offers the following graduate degrees: Doctor of Philosophy, Doctor of Science, and Master of Science in Ceramics, Materials Engineering, Materials Science, Metallurgy, or Polymerics; also the degrees of Materials Engineer and Metallurgical Engineer.

Programs of advanced study and research in the Department are organized in five fields. It is useful to think of them in a 3x2 matrix.

The three fields in the columns are concerned with the integrated science and engineering of a single class of material. The two rows are fields which deal with either the science or the engineering of all materials. Thus, the coverage of each of the graduate fields is:

	Ceramics	Metallurgy	Polymerics
Materials	Science	Science	Science
Materials	Engineering	Engineering	Engineering

Ceramics. The field of ceramics is concerned with the science and engineering involved in the manufacturing, processing, and utilization of a wide range of inorganic materials which include oxides, nitrides, carbides, silicates, and more complex compounds. Some, such as refractory alumina, are crystalline and others, such as soda glass, are used in the amorphous form. Ceramic materials are essential to many diverse industries. In recent years a large research and development effort has resulted in important extensions of the useful properties of traditional ceramics and has led to the development of many exciting new materials.

	Recommended Subjects
3.06	Engineering of Glasses and Polymers
3.07	Introduction to Ceramics
3.20	Thermodynamics of Materials
3.21	Kinetic Processes in Materials
3.22J	Solid-State Surface Science
3.23	Physics and Chemistry of Materials
3.25J	Physics of Deformation and Fracture of Solids I
3.26J	Physics of Deformation and Fracture of Solids II
3.27	Diffraction and Structure
3.271	Structure of Materials
3.60	Material and Tensor Properties of Ceramics
3.601	Electrical, Optical, and Magnetic Properties of Ceramics
3.603	Advanced Topics in Mechanical Properties of Ceramics
3.604	Problems in Nonstoichiometry
3.61	Glass Structure and Properties
3.611	Polyphase Ceramics
3.63	Ceramic Processes

Materials Engineering. Materials engineering is concerned with technically and economically feasible solutions to problems of materials production and utilization. It involves the synthesis of fundamental and practical knowledge to develop, produce, modify, and apply materials to meet specific needs. Research within the field involves issues relating to physical and chemical aspects of materials extraction, production and utilization, to problems of innovation, costs, quality, and reliability, and to societal and environmental concerns.

	Core Subjects
3.20	Thermodynamics of Materials
3.21	Kinetic Processes in Materials
3.55	Macroscopic Transport in Materials Processing
3.56	Engineering Systems Analysis

	Elective Subjects
3.35	Solidification Processing
3.37	Deformation Processing
3.38	Behavior of Metals at Elevated Temperatures
3.39	Mechanical Behavior of Materials
3.51	Process Metallurgy
3.53	Electrochemical Processing of Materials
3.54	Corrosion—The Environmental Degradation of Materials
3.551J	Gas-Solid Reactions
3.561	Materials Systems Analysis
3.63	Ceramic Processes
3.71J	Physical Metallurgy Principles for Engineers
3.76J	Electronic Materials
3.91J	Mechanical Behavior of Plastics
3.94	Polymer Processing
14.04	Intermediate Microeconomic Theory
15.572	Systems Simulation

Materials Science. The field of materials science has evolved as an independent discipline only in the last few decades. It is the science concerned with the discovery, analysis, and understanding of the nature of materials. The objectives are to provide coherent descriptions or models of the structure of materials and to explain how this structure relates to composition, properties, and behavior.

	Core Subjects
3.20	Thermodynamics of Materials
3.23	Physics and Chemistry of Materials
3.271	Structure of Materials
3.28	Statistical Mechanics of Materials
3.29	Structure-Properties Relationships in Materials

	Elective Subjects
2.072	Mechanics of Continuous Media
2.301	Advanced Mechanical Behavior of Materials
3.22J	Solid-State Surface Science
3.25J	Physics of Deformation and Fracture of Solids I
3.26J	Physics of Deformation and Fracture of Solids II
3.30	Electron Microscopy: Image Interpretation
3.32	Introduction to Electron Optics and Electron Microscopy
3.35	Solidification Processing
3.39	Mechanical Behavior of Materials
3.54	Corrosion—The Environmental Degradation of Materials
3.60	Material and Tensor Properties of Ceramics
3.601	Electrical, Optical, and Magnetic Properties of Ceramics
3.61	Glass Structure and Properties
3.71J	Physical Metallurgy Principles for Engineers
3.76J	Electronic Materials
3.93J	Materials Science of Polymers
3.96	Electrical and Optical Properties of Polymers

Metallurgy. This well-established discipline encompasses the study of metallic materials, elemental, alloy, and composite. It includes the processing of ores and minerals; refining of metals by chemical processes; the melting, alloying, and casting of metals; and control of structure by techniques such as heat treatment and mechanical working. The relations between composition, structure, and properties of metallic materials and the study of the behavior of metals under service conditions are important parts of the field. Metallurgy is viewed as a coherent discipline and all candidates are expected to have a working knowledge of both chemical and physical areas — though not usually to the same depth. Suitable programs are likely to be individualistic, and may be constructed in a number of ways from the subjects listed below.

	Core Subjects
3.20	Thermodynamics of Materials
3.21	Kinetic Processes in Materials
3.50	Physical Chemistry of Metallurgical Processes
3.71J	Physical Metallurgy Principles for Engineers

	Elective Subjects
2.55	Advanced Heat Transfer
3.22J	Solid-State Surface Science
3.25J	Physics of Deformation and Fracture of Solids I
3.26J	Physics of Deformation and Fracture of Solids II
3.31	Phase Transformations
3.35	Solidification Processing
3.37	Deformation Processing
3.38	Behavior of Metals at Elevated Temperatures
3.39	Mechanical Behavior of Materials
3.51	Process Metallurgy
3.52	Dynamic Behavior of Metallurgical Systems
3.53	Electrochemical Processing of Materials
3.54	Corrosion—The Environmental Degradation of Materials
3.55	Macroscopic Transport in Materials Processing

Polymerics. Polymeric materials are working substances of modern technology, similar to metals and ceramics as essential components of engineering systems and processes. The program covers structure-property relationships, improvement of properties by control and modification of structure and composition, processing techniques and applications of polymers. Numerous opportunities exist to concentrate on specific areas of polymer technology: physical properties; mechanical behavior; chemical synthesis and modification; surface characteristics; environmental interactions; combinations with other substances are a few examples. Each student pursues a particular program of study and research consistent with individual interests, thus the following subjects are intended to be guides rather than requirements.

	Core Subjects
3.20	Thermodynamics of Materials
3.21	Kinetic Processes in Materials
3.93J	Materials Science of Polymers
10.691	Synthetic Chemistry of Polymers

	Elective Subjects
2.820J	Polymer Processing
2.921	Polymer Deformation and Fracture
2.922	Fiber Processing Mechanics
2.924	Structural Mechanics of Fiber Assemblies
2.925	Textile Fibers: Structure and Chemical Modification
3.142	Introduction to Electron Microscopy
3.26J	Physics of Deformation and Fracture of Solids II
3.27	Diffraction and Structure
3.30	Electron Microscopy: Image Interpretation
3.60	Material and Tensor Properties of Ceramics
3.91J	Mechanical Behavior of Plastics
3.92J	Composite Materials
3.94	Polymer Processing
3.95	Environmental Properties of Polymers
3.96	Electrical and Optical Properties of Polymers
10.641	Structure and Properties of Polymers
10.642	Molecular and Phenomenological Interpretation of Polymer Viscoelasticity
10.67	Polymer Science Laboratory
10.681	Physical Chemistry of Polymers

The various graduate fields are not separated by sharp boundaries. Each member of the departmental faculty works in at least two of these fields. In many instances the same graduate subject appears on the lists of electives of several different fields. In this way the total departmental effort in materials is well integrated and a great deal of interaction between the fields exists. The graduate fields are also coupled to other activities on materials within the Institute. Faculty from other departments participate in the work of the departmental graduate fields. Subjects offered by other departments are, whenever appropriate, included in the recommended electives, and many students registered in one of the fields participate in multidisciplinary research projects with students and faculty from various parts of the Institute.

Students are expected to learn the fundamentals of their chosen field and to develop a deep understanding of one or more significant aspects of it. The general examinations are designed accordingly. A full range of advanced-level subjects is offered in each graduate field. In addition, arrangements can be made for private study of any topic by directed reading, individual programs, or participation in informal seminars. Students are not required to take any specified subjects. It is strongly recommended that they take appropriate core subjects unless they have taken equivalent subjects earlier in their careers. The selection of subjects from the list of electives and decisions about combinations of subjects which constitute a minor are matters which usually require much thought by the student. Faculty advisors offer experienced help with these selection problems.

A large and active research program on the structure and properties, preparation, and processing of materials, with emphasis on ceramics, metals, polymers, and electronic materials, is conducted by faculty and students in the Department. Graduate research is an important part of the educational process and much emphasis is placed on the preparation, presentation, and defense of a research thesis. Students choose research projects from many alternative opportunities which exist within the Department. All students work closely with an individual faculty member throughout the time the research is under way. In addition to providing the contents of a thesis, the results of the research must be of sufficient significance to warrant publication in the scientific literature. There are a large number of well-equipped research laboratories in the Department, and there is much interaction between them. Many formal and informal arrangements for sharing experimental facilities and equipment exist. Most members of the Department also are members of the Center for Materials Science and Engineering, which provides and maintains excellent central facilities including a machine and instrument shop. The Center promotes interdisciplinary research on materials, in which faculty and students from the different departments of the Institute participate.

Master of Science in the Management of Technology

Students who would like to apply their materials science and engineering background and at least five years of technical work experience to issues in technical management may want to look into applying to the Joint Program in the Management of Technology. Jointly offered by MIT's School of Engineering and the Sloan School of Managment, this Program entails a rigorous twelve-month curriculum, developed and taught by faculty from both schools, focusing on management principles for technical people in a technical environment. The Program is designed for scientists and engineers on a career path requiring increasing managerial responsibilities for technical activities. These are individuals planning to remain on the technical side of the organization rather than moving into general management positions in the near future. More information on general requirements and application procedures is included in Chapter V of this catalogue.

Master of Science in Technology and Policy

Students interested in applying their materials science and engineering background to problems of policy and socioeconomic assessment of technology may apply for the interdepartmental Master of Science Program in Technology and Policy. This program combines subjects in advanced technology in the particular field of the student's choosing with subjects in economics, systems analysis, political science, and law. It engages the student in significant project work integrating technology and policy. Well-qualified students may complete this program in one calendar year. General requirements and application procedures are described in Chapter V of this catalogue.

Mineral Resources Engineering and Management

Students in the Department with interests in the scientific, technical, and policy aspects of mineral resources can find programs of study and research in the areas of metallurgy, ceramics, and materials engineering. These activities are also coordinated with the interdisciplinary program at MIT in Mineral Resources Engineering and Management. Students seeking information on opportunities for careers in areas related to minerals resources, or to speak with faculty who have related programs, may obtain information from the Mining and Minerals Resources Research Institute of MIT, Room 4-140.

Simultaneous Award of Two Master of Science Degrees for Students from Other Departments

Graduate students may seek two Master of Science degrees simultaneously or in sequence, one awarded by the student's home department and the other by the Department of Materials Science and Engineering. The rules covering the matter are found in Chapter IV of this catalogue. The following requirements must also be met to obtain the Master of Science degree from the Department of Materials Science and Engineering:

a) Where a single, common thesis is submitted to fulfill the requirements for both Master of Science degrees, i) at least 48 subject units must be taken within the Department of Materials Science and Engineering, in addition to the thesis units; ii) there must be a thesis supervisor or cosupervisor from the Department of Materials Science and Engineering, and the candidate must provide a statement of the proposed thesis topic for approval by the Departmental Committee on Graduate Students.

b) Where two separate theses are submitted, one in each department, at least 30 subject units must be taken within the Department of Materials Science and Engineering, in addition to the thesis units.

Joint MIT-WHOI Program Course III-W

A joint program with the Woods Hole Oceanographic Institution is intended for students whose primary career objective is oceanographic engineering. Students divide their academic and research efforts between the campuses of the two institutions. While in residence at MIT, students enrolled in this Course follow a program similar to that of other students in this Department. The program is described in more detail under the section in this chapter on MIT's Joint Program in Oceanographic Engineering with the Woods Hole Oceanographic Institution.

Requirements for Completion of Graduate Degrees

The general requirements for completion of graduate degrees are described in the graduate education chapter. The Department requires that candidates for the doctoral degrees go through a qualifying procedure before continuing with their programs of study and research, and that they satisfy a minor requirement. Information on this examination and on the areas covered by the general examination is available from the Chairman of the Departmental Committee on Graduate Students.

Entrance Requirements for Graduate Study

The general admissions requirements are given in the graduate education chapter. Usually, there are no departmental requirements which are more restrictive than the General Institute Requirements. Programs are arranged on an individual basis depending upon the preparation and interests of the student. Those who have not studied some thermodynamics and kinetics at the undergraduate level are advised to take 3.01 Physical Chemistry of Materials and 3.02 Phase Transformations and Structure Development. Students wishing to do graduate work in ceramics are asked to take 3.07 Introduction to Ceramics unless they have had a similar subject in their undergraduate programs.

Teaching and Research Assistantships

The Department offers assistantships and fellowships for graduate study. Research and teaching assistantships are available in the fields in which the Department is active. Further information may be obtained from the Chairman of the Departmental Committee on Graduate Students.

Inquiries

Additional information regarding graduate programs, admissions, financial aid, etc., may be obtained by writing to the Chairman of the Departmental Committee on Graduate Students, Room 8-303, MIT, Cambridge, Massachusetts 02139, (617) 253-3329.

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Department of Mechanical Engineering

Engineering is a creative profession concerned with the combining of human, material, and economic resources to satisfy the needs of society. Mechanical engineering is one of the broadest and most versatile of the engineering professions, dealing generally with systems and devices for the conversion of energy and for the control of motions, forces, and material flows, including living systems.

Engineering is concerned with change as it utilizes basic scientific knowledge, human and material resources, and systems-type information to improve the quality of life, the standard of living, and the physical environment; and to provide such vital services as energy, food, manufactured goods, health care, transportation, and communication. As the priorities of society change, mechanical engineers can always find rewarding and challenging areas where their broad skills can be brought to bear.

The educational program in mechanical engineering prepares students for professional practice in an era of rapidly advancing technology. It combines a strong base in the engineering sciences (mechanics and materials, fluid and thermal sciences, and systems and control) with project-based laboratory and design experience. It strives to develop independence, creative talent, and leadership as well as the capability for continuing professional growth.

Since mechanical engineering is involved in virtually all physical systems, a simple description of the field is difficult. Rather, several broad areas of professional concentration are described here which offer rewarding career opportunities for mechanical engineering graduates in the years ahead. These include energy conversion and conservation, environmental engineering, biomedical engineering, manufacturing and materials processing, mechanics and materials, transportation, and systems, computers and control.

Energy Conversion and Conservation. This area includes the technology associated with the design, construction, and operation of equipment for energy conversion and conservation. Mechanical engineers are particularly concerned with the conversion of thermal, nuclear, chemical, mechanical, and electrical energy. The devices which accomplish these conversions include not only the traditional turbines, generators, boilers, and internal combustion engines, but also newer devices such as heat pumps, batteries, fuel cells, thermionic converters, solar heating systems, and nuclear power plants.

With both short- and long-term energy shortages ahead, as well as increasing pollution problems, this field is entering a new and exciting phase. Mechanical engineering provides a broad background for a career in almost all aspects of the power and energy industries.

Environmental Engineering. The mechanical engineer's approach to environmental problems reflects dual professional goals: to halt environmental degradation and to design technologies for conserving limited material and energy resources. For example, mechanical engineers are devising methods for diminishing noise associated with machinery vibrations and with fuel combustion; for modeling the transport of pollutants in air and in water; for increasing water supplies by desalinating salt water and by purifying waste waters; for collecting, processing, and recycling solid wastes; for increasing the durability of capital and consumer goods; for predicting and controlling the ecological impacts of thermochemical pollutants in aquatic and terrestrial ecosystems; for regulating thermal pollution by upgrading the heat-transfer technology of dry and wet-dry cooling towers; for improving food supplies by exploiting the agri- and aquacultural potentials of sewage and thermal wastes; and for detecting, modeling, and reducing the levels of toxic chemicals emitted from automobile and aircraft engines, incinerators, power plants, and waste-treatment plants.

In the Department of Mechanical Engineering, these diverse environmental engineering activities share a common commitment to seeking ways for removing environmental hazards while converting environmental liabilities into material and energetic assets. This commitment demands an understanding of the physical, chemical, and biological processes giving rise to pollution as well as of the ecological processes affected by pollution.

Biomedical Engineering. There is a growing recognition of the enormous potential of science and engineering for the advancement of human health. This includes deeper understandings of physiology, improved and new methods of medical diagnosis and therapy, more effective and economical health care systems, and the development and production of devices concerned with all the foregoing.

An undergraduate foundation in engineering can be directed either toward a career as a biomedical engineer, or toward medical school and practice and research in medicine. The Department of Mechanical Engineering, by reason of its offerings in the engineering sciences and in biomedical engineering, together with its project orientation and extensive research programs in medically related topics, provides an excellent undergraduate base for either of these directions. Many faculty members are involved in medically oriented research. Thus ample opportunity exists, through project laboratories and thesis, for engineering-based medical research and/or clinical experience.

Manufacturing and Materials Processing. Mechanical engineers have a continuing and growing interest in the production of equipment, components, and materials. Manufacturing industries comprise a major element of the economy and their productivity strongly influences domestic living standards and competitive positions in international trade.

Industrial production encompasses a range of subject areas from pure research to technical management, including physics of manufacturing processes; design and control of manufacturing processes and machinery; design, implementation, and operation of complex manufacturing systems; and optimization of processes and products relative to people, cost, and function. This field is now being extended to computer-controlled automation of complete manufacturing systems.

Mechanics and Materials. Now, more than ever, the modern mechanical engineer is required to wed the properties and behavior of the materials used to the increasingly stringent requirements of the structures of advanced engineering systems to assure optimum service performance. Such structures may range from nuclear reactor components to biosystems of living matter. Because of its general utility in many diverse applications of interest to mechanical engineers, students may wish to concentrate their professional education in a disciplinary program of mechanics and materials. Such a program may be made up of courses on dynamics and stability of structures, noise control, mechanics of continua, and mechanical behavior of engineering materials involving not only the more conventional metals and alloys but also ceramics, composite materials, fibers, polymers, and biological matter.

Mechanical Engineering Design. Design, in the engineering sense of deliberate creation of something new and useful, is at the heart of most engineering activity. Mechancial engineers in particular are involved in design in many and diverse fields. References to design are evident in most areas of professional concentration, but design in itself can be rewarding. Core courses in mechanical engineering provide the broad background upon which specific design courses are built, stressing problem definition and analysis, synthesis of creative solutions, and integration and application of the core material. Undergraduate and graduate experience includes courses ranging from introduction to design, through machine elements, design projects, and computer-aided design, to advanced design projects offering an opportunity to develop prototype equipment. In addition, among the range of thesis topics offered by the faculty each year, there are always several which are strongly oriented toward design, with ample opportunity to conceive, design, build, and test innovative solutions to "real world" problems.

Transportation. The transportation of people and goods vitally affects the economy and the quality of life. The growing need for better transportation services coupled with increasing emphasis on safety, environmental protection, and energy conservation creates many new and satisfying opportunities for mechanical engineering graduates to contribute to this important field.

Mechanical engineering encompasses the basic technologies of transportation, including structures (vehicles, guideways, and terminals), power and propulsion, and automation and control. The core program provides a sound background for entering almost any of the many transportation fields, but particularly those related to ground transportation.

Systems, Computers, and Control. This area includes the methodology for the analytical modeling, computer simulation and control of all types of engineering systems. It includes the application of computers to engineering analysis, optimization and design, and the use of feedback techniques and associated analog or digital hardware to automate or control physical devices or processes. The advent of the low-cost microprocessor is already revolutionizing the design of devices in such developing fields as automated manufacturing, power generation, energy conservation, transportation, pollution control, and health care.

Mechanical engineering provides the strong engineering-science base needed for professional work in this field combined with a range of basic and applied courses and laboratories in automatic control, system dynamics, computers, and computer hardware design.

Educational opportunities are enhanced by local computer facilities which allow students "hands-on" experience in digital, analog, and hybrid computers along with interactive graphics.

Research Areas

Another way to illustrate the wide range of the mechanical engineer is to list the areas in which active research at the forefront of technological problems is currently conducted in the Department. Some of these research areas are listed below in the three divisions in which the Department is organized.

Mechanics and Materials

Continuum mechanics: elasticity, plasticity, rheology
Machine computation, instrumentation
Physics, mechanics and materials science of deformation and fracture in materials
Environmentally assisted failure of materials
Mechanical behavior and processing of polymeric materials
Dynamics, vibrations, acoustics

Research Laboratories and Programs

Surface studies, wear, lubrication, friction, electric contacts, tribology
Manufacturing processes, machines, materials and systems
Fibers, polymers, textiles
Biomechanics
Biomaterials
Noise and vibration control
Nondestructive evaluation

Thermal and Fluid Sciences
Thermodynamics, kinetic theory, statistical mechanics
Heat and mass transfer
Fluid mechanics
Combustion and fire control
Cryogenics
Power generation and transmission
Automotive research
Internal-combustion engines
Biomedical fluid mechanics and heat transfer
Air- and water-pollution control
Water desalination and purification

Systems and Design
Modeling, analysis, synthesis, and management of systems
Control-system theory and design
Man-machine systems
Instrumentation and measurement systems
Transportation-system dynamics
Automotive engine control
Rail and highway vehicle dynamics
Electromechanics
Biomechanics
Hyperthermia
Cancer therapy
Biomedical ultrasonics
Ultrasonic imaging
Sensory aids and prostheses
Societal-systems design: transportation, underdeveloped technologies, urban problems, product safety
Fluidics and fluid-power control
Computer-aided engineering: computer graphics, information storage and retrieval
Power and propulsion systems
Solar- and fossil-fuel energy systems

The educational opportunities afforded students in mechanical engineering are enhanced by a wide variety of research laboratories and programs, many of which are interdepartmental in nature. Among the more important are the following.

Acoustics and Vibrations Laboratory. This laboratory deals with wide-band random vibration, acoustical scale modeling, wave-number filtering of boundary-layer pressure fluctuations, transmission of rail vibration in soil, noise transmission in machines, effect of sound upon boundary layer transition, dynamics of flexible rotors in fluid-filled journal bearings, sound propagation in urban areas, cavitation noise, acoustics of wall partitions, dynamics of offshore structures, and vibration of marine cables.

Eric P. and Evelyn E. Newman Laboratory for Human Mechanics and Rehabilitation. Technology appropriate to human rehabilitation is one of the major foci of biomedical engineering research in the Mechanical Engineering Department. Current programs include development of artificial limbs and hip implants, basic studies of human mobility, and aids to the blind.

Center for Transportation Studies.[1] This interdepartmental center facilitates research and provides a focal point for educational programs Institute-wide. It covers a wide spectrum ranging from broad conceptual planning through operation and management of transportation problems to new methods of transportation analysis, planning, and decision making.

Chemical Dynamics Research Laboratory. The goal of this laboratory is to provide basic information on the mechanism and rates of chemical reactions and excitation processes occurring in reacting gas mixtures and at gas-surface interfaces needed for dealing with applied problems in the fields of power generation and energy conversion.

Combustion and Propulsion Laboratory. This is a basic research-oriented facility engaged in a variety of urgent combustion-fluid mechanics problems arising from fire, explosion hazards, and energy conversion.

Cryogenic Engineering Laboratory. The Cryogenic Engineering Laboratory is conducting research in two exciting areas: superconducting electric generators and preserving living biomaterials by freezing.

Energy Laboratory.[1] The Energy Laboratory is an Institute-wide facility devoted to research in the energy field. The Department participates in the laboratory in the areas of fluidized-bed combustion, cooling towers, end-use energy conservation, internal and external-combustion engines, energy-policy studies, and emergency cooling of nuclear reactors.

Fibers and Polymers Laboratories. These laboratories focus on fiber physics, textile processing dynamics, polymer engineering, and the development of biological materials such as artificial skin.

Fluid Mechanics Laboratory. Research in this laboratory currently is concentrated in the areas of biofluid mechanics (particularly blood flow), environmental and energy systems (liquid-fuel-spill hazards and nuclear-power-plant containment systems), water purification and wavelength-tunable lasers.

Heat Transfer Laboratory. Current work is directed toward a range of important applications including: heat transfer in nuclear reactors, turbine-blade cooling, power-plant boilers and condensers, radiation in furnaces, heat exchangers, refrigeration condensers, geothermal energy, fusion-reactor cooling systems, fluidized-bed combustors, thermal modeling of biological tissue, thermal stress cracking of rocks, optimized heat-exchanger design, and energy conservation.

[1] See Chapter V of this catalogue for further details.

Man-Machine Systems Laboratory. The emphasis of this laboratory is on interactions between people and the systems which they control. The principal laboratory activity is experimentation, using human subjects and computer-based simulation of various systems to be studied.

Laboratory for Manufacturing and Productivity.[1] This interdepartmental laboratory was established in 1977 to provide a new focus for research and education. The laboratory seeks to establish a rational foundation for productivity increase by providing innovative methods and devices, a systematic understanding of the complex interactions among the many facets of manufacturing, and an important new talent base in manufacturing. The laboratory also is committed to addressing the issues of the impact of technology on workers, the role of labor in a technology-based society, and the impact of new manufacturing technology on society.

Associated with this laboratory is the **MIT-Industry Polymer Processing Program,** which is a cooperative effort between MIT and industrial firms in polymer processing. Since its founding in 1973, the program has provided a new focus in polymer processing by becoming a major source of new ideas, innovations, scientific and technological development, and manpower.

Mechanical Behavior of Materials Laboratory. This laboratory has for its central theme the understanding of the mechanisms of deformation and fracture processes in engineering materials by a combined approach of microstructural studies and the appropriate solid mechanics. In addition to a large number of specialized research equipment, the facilities include a scanning electron microscope and several testing machines, complete with computer controls and specimen chambers for conducting experiments in vacuum or special environments, and at high temperatures.

Laboratory for Medical Ultrasonics. This laboratory draws students and staff from various MIT departments, Harvard Medical School, and Boston area hospitals. Research involves the application of ultrasonic (non-ionizing) radiation to surgery, diagnosis, and to the treatment of tumors through hyperthermia.

Mining and Minerals Resources Research Institute.[1] The use of the earth's depleted resources is demanding new approaches to extraction. Mechanical engineers are contributing significantly to the search for methods which show high extraction efficiencies with low environmental impact and reduced energy use. Some of the directions being explored at present include improved methods of drilling and cutting; utilization of methane combined with more efficient mine ventilation; and new methods of coal gasification. Within MIT's interdepartmental Mining and Mineral Resources Research Institute program, the Department of Mechanical Engineering offers courses and thesis research opportunities ranging from study of the behavior of geologic materials to mining technology and, in particular, the innovative mechanization and automation of mining.

Sloan Automotive Laboratory. The Sloan Automotive Laboratory at MIT has been actively involved in internal combustion engine research for over 40 years. The current research interests of the laboratory fall into four general areas: fundamental combustion studies, internal combustion engine research, gas turbine and burner research, and policy and technology studies.

Surface Laboratory. This laboratory undertakes work in various aspects of tribology (which deals with rubbing surfaces), including high-speed friction, wear theory, lubrication, friction and adhesion, and sliding electric contacts.

Vehicle Dynamics Laboratory. The principal objectives of this laboratory are the development of analytical and experimental methods and design techniques to improve the dynamic performance characteristics of ground transport vehicles and their guideways with specific attention directed to dynamic performance, safety, ride quality, handling, and cost.

General Laboratories and Facilities

In addition, the Department has a number of general laboratories and shops used by faculty and students for work on topics not covered by the above laboratories.

In collaboration with several other departments, a well-equipped local computer facility is maintained for use by students and faculty in connection with research and the academic program. The facility includes analog, digital, and interactive computer graphics capabilities.

[1]See Chapter V of this catalogue for further details.

Undergraduate Study

The undergraduate program provides a broad intellectual horizon upon which may be built self-learning, part-time continuing education, formal graduate study, and practical experience.

A firm technical foundation is essential for a career as diversified and challenging as that open to the mechanical engineer. Beginning with mathematics, physics, and chemistry, students acquire proficiency in the engineering sciences: dynamics, mechanics, and properties of materials; fluid dynamics; heat and mass transport; thermodynamics; systems analysis; and control. Further, students experience the ways in which scientific knowledge can be put to use in the development and design of useful devices and processes. Mastering this art, largely by project-oriented work of a creative nature, is the primary object of subjects in laboratory and design. Laboratory experience, which takes many forms, is intended to help students achieve an understanding of how experimental methods may be used to help solve engineering problems. Design experience includes devising means to perform certain specified tasks, such as the design of a device or the synthesis of a system made up of many parts, and involves consideration of economic, social, legal, and political factors.

Bachelor of Science in Mechanical Engineering
Course II

The curriculum for the Bachelor of Science in Mechanical Engineering has been designed to provide alternatives — through the Restricted and Unrestricted Electives — for students who have quite different career goals. The Department recognizes in its departmental requirements and course offerings three categories of students it wishes to serve: 1) those who base their professional careers as mechanical engineers on the bachelor's degree with no further formal study; 2) those who proceed to formal graduate study in mechanical engineering or in an allied field; and 3) those for whom the undergraduate program provides a broad base — a base of intellectual style as well as intellectual content — for further professional study directed toward medicine, law, business, or industrial management.

The Department also provides many opportunities for undergraduates to establish a close relationship with faculty members and their research groups in the Department. Students interested in project work may consult their faculty counselors or approach other members of the faculty directly to discuss involvement with their research work.

The requirements for the Bachelor of Science in Mechanical Engineering have been selected to provide a balanced background in mechanical engineering while allowing students who defer entering the Department until the end of the second year to graduate in the normal four-year period. Students with a satisfactory academic record who have averaged 45 units per term, who have met the General Institute Requirements in chemistry, mathematics, and physics, and who also have taken 18.03 (Differential Equations) can graduate in four years. This program is accredited by the Engineers' Council for Professional Development.[1]

The following undergraduate program for the Bachelor of Science in Mechanical Engineering, Course II, begins with a basic background in mathematics, physics and chemistry, materials science, or biology. The Departmental program consists of three levels corresponding roughly to the second, third, and fourth years. The first and second levels constitute the universal core of subjects required of all candidates for the S.B. in Mechanical Engineering.

The first level provides an introduction to mechanical engineering through courses in system dynamics, including modeling and analysis (of fluid, thermal, electrical, and mechanical systems), solid mechanics, manufacturing and materials processing, instrumentation, and design. This sequence introduces early all of the basic elements in the engineering process and is an important characteristic of the curriculum. The second level emphasizes the basic engineering sciences and their integration through laboratory and design projects. The third level consists of professional electives and leads into areas of professional concentration, either in the engineering sciences, Group A; or the broader aspects of engineering systems and design, Group B. Courses in the latter category are of interest to other engineering departments and in most cases are interdepartmental offerings. In the former category students interested in the technology of fields such as bioengineering, pollution, energy, materials, automatic control, etc. may select additional courses from other engineering departments and the School of Science. Some students may place more emphasis on the humanities and social sciences than in the past, as preparation for graduate study in such fields as engineering of social systems, technology and policy, law, management, technology assessment, medicine, etc. Since the Department believes every student should pursue at least one engineering science in depth beyond that required in the "universal core," at least one restricted elective must be selected from Group A. In addition, all students are required to complete a thesis, working on an individual basis with a faculty or research-staff member.

[1] See discussion of significance of accreditation under "Degree Programs in Engineering" in the Dean's statement at the beginning of the School of Engineering section.

Bachelor of Science in Mechanical Engineering
Course II

	General Institute Requirements	Total Units
	Specific science and humanities and social science subjects	132
	The Science Distribution Requirement can be satisfied by 2.02 and 18.03, which are required in the Departmental Program, plus appropriate subjects totaling[1]	12
	Any combination of the subjects 2.671, 2.672 and 2.86 which are required in the Departmental Program, appear on the list of Laboratory Subjects and can be used to satisfy the Laboratory Requirement.	
	Departmental Program[2]	
	Required Subjects	**141**
2.01	Mechanics of Solids	4 0 8
2.02	Introduction to System Dynamics	4 0 8
2.03J	Dynamics	4 0 8
2.20	Fluid Mechanics	4 0 8
2.31	Mechanical Behavior of Materials I	3 1 5
2.32	Mechanical Behavior of Materials II	3 1 5
2.40	Thermodynamics	4 0 8
2.671	Measurement and Instrumentation	2 3 4
2.672	Project Laboratory	1 3 2
2.70	Introduction to Design	2 3 4
2.73	Design Projects	2 3 4
2.86	Manufacturing Processes	3 3 3
18.03	Differential Equations	4 0 8
	Thesis[3]	9
	Restricted Electives	**24**
	(Two subjects chosen from the following, at least one from Group A; additional subjects taken may be used for G (non-A) credit toward graduate degrees in mechanical engineering.)[4]	
	Group A	
2.06J	Mechanical Vibration	3 0 9
2.14	Control System Principles	3 2 7
2.21	Applications in Fluid Mechanics	3 0 9
2.34J	Deformation and Fracture Mechanics of Engineering Alloys	4 0 8
2.41J	Thermodynamics of Power Systems	3 0 9
2.51	Heat and Mass Transfer	3 0 9
	Group B	
1.02	Civil Engineering Systems Analysis I	3 1 8
2.72	Elements of Mechanical Design	3 3 6
2.96	Management in Engineering	3 0 9
15.001	Managerial Economics	4 0 8
	Unrestricted Electives[5]	**51**
	The Department recommends that all students elect an introductory digital-computing subject such as 2.10, as early as possible in their programs.	
	Total Units Required for the S.B. Degree	**360**

1
The Department suggests that 6.071 Introduction to Electronics be elected by all students to complete the Science Distribution Requirement.
2
Substitution of subjects of similar content may be permitted by petition to the Senior Registration Officer.
3
To foster substantial research and design achievement, the Department permits up to 6 units of additional thesis credit, subject to approval of the student's Faculty Counselor.
4
Certain graduate subjects may be substituted for restricted electives with permission of the senior registration officer.
5
Schedules of the students in Course II may always be arranged to leave available 24 units of Unrestricted Electives in the second year.

Recommended Elective Subjects

Students are urged to phone or visit the Undergraduate Office as soon as they have decided to enter mechanical engineering so that faculty advisors may be assigned. Students and their faculty advisors together plan a program that best utilizes the 24 units of Restricted Electives and the 51 units of Unrestricted Electives available in this degree program. Although the selection of elective courses is an individual decision, the faculty of the Department has developed several areas of professional concentration. For students wishing to follow one of these undergraduate concentrations, the following elective subjects are suggested. The fields described are not all-inclusive; students interested in other professional programs — including interdisciplinary programs — should consult their faculty advisor or the Department Head.

Power and Energy. In this field three areas in the core curriculum are particularly important: controls, materials, and thermal-fluid sciences. The following undergraduate electives are especially appropriate:

2.14	Control System Principles
2.34J	Deformation and Fracture Mechanics of Engineering Alloys
2.41J	Thermodynamics of Power Systems
2.51	Heat and Mass Transfer

Several graduate subjects in power and energy are appropriate for seniors with adequate background:

2.275	Turbomachinery Design (A)
2.301	Advanced Mechanical Behavior of Materials (A)
2.601J	Thermal Power Systems (A)
2.615	Internal Combustion Engines (A)
2.621	Gas-Turbine Design (A)
2.63	Energy Production from Renewable Resources (A)
2.649	Low Temperature Refrigeration (A)
3.38	Behavior of Metals at Elevated Temperatures (A)
6.685	Dynamics of Electric Machines (A)
10.39	Energy Technology (A)
22.211	Nuclear Reactor Physics I (A)
22.312	Engineering of Nuclear Reactors (A)

Mechanical engineering also provides an excellent undergraduate background for work in the nuclear power industry. The following two undergraduate courses are suggested:

22.02	Introduction to Applied Nuclear Physics
22.03	Engineering Design of Nuclear Power Systems

Other suitable undergraduate electives are management and economics.

Environmental Engineering. A career in environmental engineering requires a thorough understanding of the fundamental mechanisms underlying environmental problems. Understanding these mechanisms, whether they be physical, chemical, or biological in nature, is necessary to recognize environmental hazards and to devise ways to prevent or correct them. The following electives provide the depth and breadth in knowledge and know-how required to achieve these goals for environmental problems of concern to mechanical engineers.

	Mechanical Engineering Undergraduate Electives:
2.131	Ecodynamic Systems I
2.132	Ecodynamic Systems II
2.14	Control System Principles
2.41J	Thermodynamics of Power Systems
2.51	Heat and Mass Transfer

	Other Undergraduate Electives
1.107	Laboratory Projects in Aquatic Biology and Chemistry
7.01	General Biology
10.17	Air Pollution Fundamentals
12.20J	Environmental Chemistry of the Ocean-Atmosphere System
12.21	Physics of the Ocean
13.901	Ocean Engineering Laboratory I
13.902	Ocean Engineering Laboratory II
16.56	Noise Control Engineering (A)

For students who have taken the appropriate prerequisites, the following graduate courses permit a more advanced study of scientific and technological aspects of environmental problems of concern to mechanical engineers:

1.68	Physics of Natural Water Bodies (A)
2.284	Water Purification (A)

Manufacturing and Materials Processing. Specialization in manufacturing is dependent on a sound foundation in engineering science, which can be obtained from advanced courses in mechanics, materials, and heat transfer. The following are recommended:

2.04	Probability and Statistics in Mechanical Engineering
2.06J	Mechanical Vibration
2.14	Control System Principles
2.34J	Deformation and Fracture Mechanics of Engineering Alloys
2.51	Heat and Mass Transfer
2.841	Elements of Manufacturing
3.18	Materials Processing
6.071	Introduction to Electronics

Effective professional work in this area requires both an understanding of its technical facets and also its economic, human, and legal aspects. For this reason, we recommend that interested students select an economics sequence in satisfying part of their Humanities, Arts, and Social Sciences Requirement, e.g.:

14.01	Economic Principles I
14.02	Economic Principles II
14.03	Applied Microeconomics
14.63	Labor in Industrial Society

For those wishing to study manufacturing processes in greater depth, the following graduate courses are available:

2.800	Tribology (A)
2.810	Advanced Manufacturing Processes of Metals (A)
2.820J	Polymer Processing (A)
2.830	Control for Manufacturing Automation (A)
2.840	Productivity Analysis and Improvement
2.921	Polymer Deformation and Fracture (A)
2.922	Fiber Processing Mechanics (A)

Finally, we recommend that students seek experience on the manufacturing scene, either independently through summer employment or by participation in the Engineering Internship Program.

Biomedical Engineering. Students planning a medically related engineering program are encouraged to take the physics sequence providing biological examples: 8.013J Physics I, 8.023J Physics II, and 8.201J Statistical and Biological Physics.

Although Course II has sufficient flexibility to incorporate all the pre-medical requirements, some students find the additional freedom of Course II-A more adaptable to their goals (See the following section for full information). For such it is recommended that their restricted electives include:

2.01	Mechanics of Solids
2.02	Introduction to System Dynamics
2.20	Fluid Mechanics
2.40	Thermodynamics

Whether in Course II or Course II-A, medically oriented students are advised to take the following:

2.791J	Quantitative Physiology: Cells and Tissues
2.792J	Quantitative Physiology: Organ Transport Systems
2.793J	Quantitative Physiology: Sensory and Motor Systems
5.41	Introduction to Structure, Bonding and Mechanism
7.01	General Biology

Additional subjects recommended include:

2.14	Control System Principles
2.51	Heat and Mass Transfer
2.900J	Biomedical Materials

For undergraduates with sufficient background and interest, the Department offers the following graduate courses:

2.277	Biomedical Fluid Mechanics (A)
2.75	Physiology and Biomechanics of Human Movement (A)
2.76J	Ultrasound: Physics, Biophysics and Technology (A)
2.78	Seminar on Rehabilitation Engineering Research and Practice
2.907	Science and Engineering of Biological Membranes and Structural Tissue (A)

Transportation. The following two undergraduate electives are recommended for all students interested in transportation:

1.02	Civil Engineering Systems Analysis I
2.14	Control System Principles

Other undergraduate electives which are particularly appropriate include:

2.04	Probability and Statistics in Mechanical Engineering
2.06J	Mechanical Vibration
2.41J	Thermodynamics of Power Systems
2.96	Management in Engineering
15.001	Managerial Economics

A large selection of subjects relating to transportation are available in the graduate school to seniors with adequate background. The following basic subjects are especially recommended:

CTS 100J	Basic Concepts in the Analysis of Transportation Systems (A)
CTS 140J	Transportation Performance and Technology (A)

Interdisciplinary programs which combine a basic mechanical engineering background with a strong emphasis on the social, economic, planning, and institutional aspects of transportation may be arranged through Course II-A (See the following section).

Computers and Control. For students primarily interested in the application of computers to analysis and design the following undergraduate electives are suggested:

1.02	Civil Engineering Systems Analysis I
2.10	Elementary Programming and Machine Computation

Concentration in at least one engineering science, such as mechanics and materials, thermodynamics, heat transfer, fluid mechanics or dynamics beyond the core requirements is recommended; the subjects in Restricted Elective Group A are especially suitable. The following courses are also recommended:

1.562	Finite Element Methods (A) or
16.27	Finite Element Method (A)
2.092	Methods of Engineering Analysis (A)

For students wishing to concentrate in automatic control, the following undergraduate electives are recommended:

1.02	Civil Engineering Systems Analysis I
2.10	Elementary Programming and Machine Computation
2.14	Control System Principles
6.071	Introduction to Electronics

An extensive selection of graduate subjects is offered which are suitable for seniors with adequate background. The following are especially recommended:

2.141	Modeling and Simulation of Dynamic Systems (A)
2.151	Advanced System Dynamics and Control (A)
2.152	Modern Control Theory and Applications (A)
2.161	Computer-Controlled Experimentation (A)
2.171	Analysis and Design of Computer Control Systems
2.173	Instrumentation for Measurement, Analysis and Control (A)
2.18J	Man-Machine Systems (A)

Bachelor of Science
Course II-A

Many students have a defined goal which can best be met by organizing a curriculum specifically tailored to that goal. Such a curriculum may be significantly different from that required for the Bachelor of Science in Mechanical Engineering or, for that matter, different from that required for a degree in any specified field at MIT.

To meet such needs, the Department offers the Bachelor of Science, with a significant part of the curriculum made up of Planned Electives. These are chosen by agreement between the student and a departmental officer so that the complete curriculum is coherent and in pursuit of a clear objective.

For instance, some students may wish to penetrate more deeply into some field of mechanical engineering by choosing additional courses in one of the professional fields of concentration already mentioned, as well as introductory graduate courses from among the related engineering sciences. Others interested in electromechanical devices might combine advanced courses in dynamics, systems analysis, and vibrations with courses in electric circuits and electromagnetic field theory. Students interested in air pollution, fires, internal-combustion engines, and related fields involving chemical reaction might make up a package involving work in fluid mechanics, heat transfer, physical chemistry, reaction kinetics, and statistical mechanics. Some

combine subjects in mechanical engineering with subjects in economics and management. Students interested either in medical school or in a career in biomedical engineering may wish to develop backgrounds in biology, biochemistry, or physiology. Many other combinations are possible.

Students who wish to study for this degree must advise the Department's Undergraduate Officer by the beginning of their junior year in order that there be adequate opportunity for planning the complete curriculum. Registration for this degree program requires approval in writing from the Registration Officer in charge of Course II-A. This program leading to the undesignated Bachelor of Science is not accredited by the Engineers' Council for Professional Development.

Bachelor of Science
Course II-A

	General Institute Requirements	Total Units
	Specific science and humanities and social science subjects	132
	Science Distribution Requirement	36
	The subjects 2.01 and 18.03 which are among the Restricted Electives appear on the list of Science Distribution Subjects and can be used to partially satisfy the Science Distribution Requirement.	
	Laboratory Requirement	12
	Any combination of the subjects 2.671, 2.672 and 2.86 which are required in the Departmental Program, appear on the list of Laboratory Subjects and can be used to satisfy the Laboratory Requirement.	
	Departmental Program	
	Required Subjects	
	Thesis[1]	9
	Restricted Electives	**at least 78**
2.01	Mechanics of Solids	4 0 8
2.02	Introduction to System Dynamics	4 0 8
2.03J	Dynamics	4 0 8
2.06J	Mechanical Vibration	3 0 9
2.14	Control System Principles	3 2 7
2.20	Fluid Mechanics	4 0 8
2.21	Applications in Fluid Mechanics	3 0 9
2.31	Mechanical Behavior of Materials I	3 1 5
2.32	Mechanical Behavior of Materials II	3 1 5
2.34J	Deformation and Fracture Mechanics of Engineering Alloys	4 0 8
2.40	Thermodynamics	4 0 8
2.41J	Thermodynamics of Power Systems	3 0 9
2.51	Heat and Mass Transfer	3 0 9
2.671	Measurement and Instrumentation	2 3 4
2.672	Project Laboratory	1 3 2
2.70	Introduction to Design	2 3 4
2.72	Elements of Mechanical Design	3 3 6
2.73	Design Projects	2 3 4
2.86	Manufacturing Processes	3 3 3
18.03	Differential Equations	4 0 8
	Planned Electives A coherent selection of subjects which, together with the remaining portions of the student's program, is aimed at a well-defined educational goal. The planned electives are to be agreed upon between the student and a designated Faculty Counselor of the Department of Mechanical Engineering.	**at least 57**
	Unrestricted Electives[2]	**36**
	Total Units Required for the S.B. Degree	**360**

1
To foster substantial research and design achievement, the Department permits up to 6 units of additional thesis credit, subject to approval of the student's faculty counselor.

2
Schedules of students may always be arranged to leave 12 units of Unrestricted Electives in the second year. The Unrestricted Electives must be at least 18 units.

Engineering Internship Program in Mechanical Engineering
Course II-B

Students who wish to gain industrial experience during their undergraduate and graduate programs may do so by electing to participate in the Engineering Internship Program through enrollment in Course II-B.

The Course degrees and curricular requirements are the same as for Course II; however, in addition, provision is made for the students to be employed in the plants of the cooperating companies. The plant work at the undergraduate level consists of two summers, starting with the summer after the sophomore year. The plant work is considered as equivalent to a 12-unit elective subject: 2.951 Engineering Internship. This program is accredited by the Engineers' Council for Professional Development.

Students in this program interested in graduate study are encouraged to apply for early graduate-school admission under the combined Bachelor's and Master's program (See the following section). A student in this Program may spend an additional seven months (one summer and one term) at the cooperating company and write a single combined bachelor's and master's thesis. Subject to approval of the thesis supervisor, the thesis may be related to the work experience.

Additional information may be obtained from Professor Igor Paul, Room 3-451, MIT, Cambridge, Massachusetts 02139, (617) 253-4466.

The Second S.B. Degree in Mechanical Engineering

Undergraduates enrolled in other MIT departments may also earn the S.B. in Mechanical Engineering by satisfying the previously described Departmental requirements and completing a minimum of 90 units, acceptable to the Mechanical Engineering Senior Registration Officer, beyond the units required for the first S.B. Degree.

Graduate Study

If an S.B. thesis is completed in another MIT department, the Mechanical Engineering thesis requirement is waived. Subjects taken in other engineering departments which are similar to specific Mechanical Engineering requirements may be used to satisfy those requirements if approved by the Mechanical Engineering Department Senior Registration Officer. In some cases a student may require more than 90 additional units to satisfy the S.B. Degree requirements in Mechanical Engineering.

Combined Bachelor's and Master's Degree Program

Some students who obtain early admission to the graduate program may be permitted to delay satisfying all of the Bachelor's degree requirements until their fifth year, satisfying the requirements for both degrees simultaneously. This program permits students to complete some basic core graduate subjects in their senior year, leaving time to take more advanced subjects during the graduate year. With prior approval in their fourth year, students in this program may combine the work of the Bachelor's and Master's theses into a single thesis of scope comparable to both theses. The Master's study may be within the Department or in a cooperating department such as Nuclear Engineering. Students interested in these programs should consult the chairman of the departmental graduate committee early in the senior year.

The Department provides opportunities for graduate work leading to the Master of Science in Mechanical Engineering, the Master of Science, the Master of Science in Textile Technology, the Mechanical Engineer, the Materials Engineer, the Environmental Engineer, the Doctor of Science, and the Doctor of Philosophy.

Entrance Requirements for Graduate Study

Students beginning graduate study in mechanical engineering usually have received the equivalent of a Bachelor's degree in mechanical engineering at a recognized engineering school; however, in many cases they have had their undergraduate preparation in some other branch of engineering or science. Generally, their background includes preparatory studies in some or all of the following areas: applied mechanics, fluid mechanics, dynamics, thermodynamics, electric circuits, electromagnetic fields, and materials. The Department requirements for admission are not specific, since capable students with a more general preparation have the opportunity to establish their background in mechanical engineering by taking the most advanced undergraduate subjects which their abilities and preparation permit.

Fields of Graduate Study

The fields of advanced study and research are those listed briefly in Chapter II. As a guide to graduate students, the various avenues for forming a program of study and thesis research are described below.

Engineering Science. Some students elect to concentrate their studies in one or more of the various engineering sciences. Courses in the engineering science areas, in which a student may direct his or her studies, are listed in Chapter VII, grouped according to the following series of numbers:

2.0-	Mechanics, Dynamics, and Acoustics
2.1-	System Dynamics and Control
2.2-	Fluid Mechanics and Combustion
2.3-	Materials
2.4-	Thermodynamics and Statistical Mechanics
2.5-	Heat and Mass Transfer
2.8-	Tribology and Manufacturing
2.9-	Polymers and Fibers

Professional Areas. The eight fields listed below represent some possible professional areas of concentration in graduate study in mechanical engineering. They are described more fully in the introduction to this Department, as well as under Undergraduate Study. Listed under the latter are some of the graduate courses offered in each area by the Department of Mechanical Engineering. The others are described in the general course listing. Additional courses in each area are offered by other departments and also may be taken by graduate students.

Energy Conversion and Conservation — problems of energy conversion and conservation, including cryogenic applications.

Environmental Engineering — problems of air, water, and land pollution, and of conserving material and energetic resources.

Biomedical Engineering — the application of engineering techniques to the advancement of human health, including diagnosis, therapy, health care systems, and development and production of devices used in the medical field.

Manufacturing and Materials Processing — manufacturing processes, design and control of process machinery, process optimization, and computer-controlled automation. Textiles, polymer and metals processing.

Transportation — transportation technology and systems including structures, power and propulsion, automation and control.

Computers and Control — the application of computers to problem solving and design and the use of automatic controls for processes and devices.

Mechanics and Materials — acoustics and noise control, continuum mechanics, numerical computation, techniques of solving problems of solid mechanics. Physical and microstructural bases of mechanical behavior of engineering materials and its modeling.

Design — problem solving applied to the creation of, principally, hardware involving any of the engineering disciplines.

Graduate Core Subjects

The Department offers the following series of basic core courses which cover the major mechanical engineering disciplines, expose students to applications of the disciplines and to the modeling of real engineering situations, and bring the courses to the starting points of their more advanced and specialized branches. A selection of these courses represents excellent preparation for more advanced work and for the doctoral qualifying examination.

2.032	Dynamics (A)
2.083	Applied Elasticity (A)
2.151	Advanced System Dynamics and Control (A)
2.25	Advanced Fluid Mechanics (A)
2.301	Advanced Mechanical Behavior of Materials (A)
2.451J	General Thermodynamics I (A)
2.55	Advanced Heat Transfer (A)
2.731	Advanced Engineering Design (A)
2.810	Advanced Manufacturing Processes of Metals (A)

Master of Science in Mechanical Engineering and Master of Science

The general requirements for the degrees are given in Chapter IV of this catalogue with the provision that the 66 required units must be taken during the two regular terms or during the summer term (not including the January Independent Activities Period).

The Department of Mechanical Engineering also requires that all incoming graduate students demonstrate satisfactory English writing ability, or be required to successfully complete remedial training.

To qualify for the Master of Science in Mechanical Engineering a student must have had two terms of advanced mathematics and must take one course in each of two areas of engineering science. Students not satisfying this requirement are awarded the Master of Science without specification of field.

The student working for the Master of Science without specification (**not** the Master of Science in Mechanical Engineering) elects a program which is not necessarily restricted to those courses given by the Department of Mechanical Engineering. The selection of individual courses should place some emphasis on a foundation in engineering science and mathematics. The program must appear substantial and logical in the judgment of the faculty advisor. As a well-balanced program, it should emphasize one or more of the analytical, economic, design, or experimental aspects of the field.

A description of the requirements for these degrees may be obtained from the Graduate Registration Office.

Master of Science in Technology and Policy

Students interested in applying their mechanical engineering background to problems of policy and socioeconomic assessment of technology may apply for the interdepartmental Master of Science Program in Technology and Policy. This program combines courses in advanced technology in the particular field of the student's choosing with courses in economics, systems analysis, political science, and law. It engages the student in significant project work integrating technology and policy. Well-qualified students may complete this program in one calendar year. General requirements and application procedures are described in Chapter V of this catalogue.

Master of Science in Textile Technology

Candidates for the Master of Science in Textile Technology should have the training offered by the Institute (or equivalent training from another institution) in the fields of either chemical engineering, chemistry, mechanical engineering, business and engineering administration, or industrial physics. The program for the degree lasts from one to two years, depending upon preparation. Students who have graduated with high standing from technical or textile schools which offer less extensive preparation in science and engineering may be accepted for study but should expect to spend at least two years fulfilling degree requirements.

Mechanical Engineer

For those who desire preparation for engineering practice at a professional level beyond the Master of Science, the Mechanical Engineer is offered. The degree requires approximately one year of study beyond the Master of Science. The program is centered around the application of engineering principles to advanced development problems and includes an applications-oriented thesis. The general requirements for the degree are given in the Graduate Education chapter; however, a detailed description of the Mechanical Engineer program may be obtained from the Graduate Registration Office.

Materials Engineer

Candidates interested in studying materials engineering in the Department should in general have training equivalent to that offered by the Institute in its undergraduate programs in any of several departments of engineering or science. The graduate program encompasses study in the areas of mathematics, physics, chemistry, electrical materials, continuum and dislocation mechanics, metallurgy, ceramics, elastomers, and plastics, as well as research. In general, two years are required for completion of the Materials Engineer degree. General requirements for the Materials Engineer, including qualifying examination, are described in Chapter IV of this catalogue.

Environmental Engineer

Candidates interested in studying environmental problems should have training equivalent to the Master of Science in Mechanical Engineering. The degree of Environmental Engineer goes beyond the Master's program but without the research focus of the doctorate. The program prepares students for careers in government, industry, and private practice where technical decision making is integrated with environmental planning and management functions. Detailed requirements, suggested subjects, and sample programs may be obtained from the Graduate Registration Office.

Joint MIT-WHOI Program
Course II-W

A joint program with the Woods Hole Oceanographic Institution is intended for students whose primary career objective is oceanographic engineering. Students divide their academic and research efforts between the campuses of the two institutions. While in residence at MIT, students enrolled in this course follow a program similar to that of other students in this Department. The program is described in more detail under the section on MIT's Joint Program in Oceanographic Engineering with the Woods Hole Oceanographic Institution.

Doctor of Philosophy and Doctor of Science

Admission to the doctoral program is granted only after the candidate has passed a qualifying examination, which should be taken as soon as possible after completing the Master's program. The requirements for the doctoral degree include a program of advanced study, a minor program, and a thesis in the field of mechanical engineering or in the field of materials engineering. In addition, the Department requires that all incoming graduate students, whether they enter for the Ph.D. or S.M., must, by taking a test, demonstrate satisfactory English writing ability, or be required to successfully complete remedial training.

The program of advanced study and research may be selected in any field of science or engineering approved by the Department Committee on Graduate Studies. While no fixed number of units is prescribed, the usual program includes a substantial number of courses in the student's principal area of interest. These, with the minor program, usually require an additional two terms of work beyond the Master's degree. The major and minor programs must be approved by the student's doctoral committee and the components must have the *advance* approval of the Committee on Graduate Studies of the Department of Mechanical Engineering. The qualifying examination must be completed before the program of doctoral research is undertaken.

For the thesis, each candidate undertakes a program of research which contributes significantly to the major field of interest. This contribution may be analytical, experimental, or design knowledge. The program of advanced study and the thesis are under the supervision of a doctoral committee selected by the student and the thesis supervisor. The doctoral committee makes an annual evaluation of the candidate's progress and conducts a final examination based on the thesis. While no fixed number of units is prescribed, research usually requires at least one year of registration.

Candidates who enter this doctoral program following award of the Master of Science in Textiles Technology must meet the foregoing requirements but with a thesis based on research in the field of fibrous materials.

Doctor of Philosophy in Biomedical Engineering

The Department has an extensive program of research and teaching in biomedical engineering. In addition to pursuing programs for the regular Master's degree and doctorate awarded by the Department, with a focus in biomedical engineering, qualified students registered in the Department alternatively may elect an interdepartmental doctoral program in biomedical engineering (administered by the Committee on Biomedical Engineering) which is described in Chapter V of this catalogue.

Fellowships and Assistantships

A large number of fellowships and research assistantships and a few teaching assistantships are available to incoming students. These appointments and awards provide adequate financial support for both tuition and living expenses. In practically all cases the thesis research is done as an integral part of the work associated with the research assistantship or fellowship. Application for

these appointments and awards is made by checking the appropriate boxes on the application form for admission. Information about these appointments and other financial assistance may be obtained by writing the Head of the Department of Mechanical Engineering or the Graduate Registration Officer. Students are not considered for awards until they are assured of admission to the graduate school.

Inquiries

Additional information concerning academic and research programs, admissions, financial aid, etc. may be obtained by writing to: Professor David Gordon Wilson, Undergraduate Officer, Room 3-154, MIT, Cambridge, Massachusetts 02139, (617) 253-2305; and Professor Warren M. Rohsenow, Graduate Officer, Room 3-156, (617) 253-2208.

Department of Nuclear Engineering

Neil Emmanuel Todreas, Ph.D.
Professor of Nuclear Engineering
Head of the Department

Professors

Gordon Lee Brownell, Ph.D.
Professor of Nuclear Engineering

Sow-Hsin Chen, Ph.D.
Professor of Nuclear Engineering

Michael John Driscoll, Sc.D.
Professor of Nuclear Engineering

Thomas Henderson Dupree, Ph.D.
Professor of Nuclear Engineering and Physics

Jeffrey Philip Freidberg, Ph.D.
Professor of Nuclear Engineering

Elias Panayiotis Gyftopoulos, Sc.D.
Ford Professor of Engineering

Kent Forrest Hansen, Sc.D.
Professor of Nuclear Engineering
Associate Dean of the School of Engineering

Otto Karl Harling, Ph.D.
Professor of Nuclear Engineering
Director, MIT Nuclear Reactor Laboratory

Allan Francis Henry, Ph.D.
Professor of Nuclear Engineering

David Dayton Lanning, Ph.D.
Professor of Nuclear Engineering

Lawrence Mark Lidsky, Ph.D.
Professor of Nuclear Engineering

John Edward Meyer, Ph.D.
Professor of Nuclear Engineering

Norman Carl Rasmussen, Ph.D.
Professor of Nuclear Engineering

David John Rose, Ph.D.
Professor of Nuclear Engineering

Kenneth Calvin Russell, Ph.D.
Professor of Nuclear Engineering and Metallurgy

Sidney Yip, Ph.D.
Professor of Nuclear Engineering

Associate Professors

Michael Warren Golay, Ph.D.
Associate Professor of Nuclear Engineering

Mujid Suliman Kazimi, Ph.D.
Associate Professor of Nuclear Engineering

Kim Molvig, Ph.D.
Associate Professor of Nuclear Engineeing

Assistant Professors

I-Wei Chen, Ph.D.
Assistant Professor of Nuclear Engineering and Nuclear Materials

Carolyn D. Heising-Goodman, Ph.D.
Assistant Professor of Nuclear Engineering

Richard Keith Lester, Ph.D.
Esther and Harold E. Edgerton Assistant Professor of Nuclear Engineering

Alan Caril Nelson, Ph.D.
Assistant Professor of Nuclear Engineering and of Health Sciences and Technology in the Harvard-MIT Division of Health Sciences and Technology

Adjunct Professor

Dieter J. Sigmar, Ph.D.
Adjunct Professor of Nuclear Engineering

Administrative Officer

(To be appointed)

Administrative Assistant

Jennifer DeVries-Gwinn

Assistant to the Department Head

Donna Dutton, M.B.A.

Senior Research Associate

Charles Berney, Ph.D.

Senior Research Engineer

Bruce Montgomery, Sc.D.
Associate Director, Francis Bitter National Magnet Laboratory

Postdoctoral Associates

Frederick Best, Ph.D.
Michael Pagitsas, Ph.D.

Research Affiliates

Robert W. Atcher, Ph.D.
John H. Hopps, Jr., Ph.D.
Sonya Shortkroff, M.S.
William E. Vesely, Ph.D.
Lothar Wolf, Ph.D.

Lecturer

Marvin M. Miller, Ph.D.
Principal Research Engineer, Energy Laboratory

Visiting Scientist

Yong-Sheng Chao, M.S.

Professors Emeriti

Manson Benedict, Ph.D.
Institute Professor, Emeritus
Professor of Nuclear Engineering, Emeritus

Irving Kaplan, Ph.D.
Professor of Nuclear Engineering, Emeritus
Senior Lecturer

Department of Nuclear Engineering

The Department of Nuclear Engineering provides undergraduate and graduate education for students interested in developing the peaceful applications of nuclear reactions, plasma physics, and related aspects of radiation. In keeping with MIT's traditional role in other branches of knowledge, the Department aims to educate the individuals who make the key scientific and engineering advances in these fields. Although the technological problems of energy generation by neutron-induced fission of heavy elements in nuclear reactors and fusion of light particles in thermonuclear plasmas receive primary emphasis in the Department, the totality of its interests is best described as the engineering physics of low-energy charged particles, neutrons, and radiation. Included is a strong involvement in the broader problems of providing energy in socially acceptable ways and of energy policy alternatives in general.

Fission reactors are used to produce heat and electricity, to propel submarines and ships, and to transmute elements and to produce radioisotopes. The fraction of electricity now obtained from nuclear power is increasing and in some countries is already over 20 percent. In the United States it is 13 percent. Because of conservation and other reasons, the growth in electricity has declined in recent years. This, combined with public concerns, has led to a significant reduction in new nuclear power plant orders. Nevertheless, the energy program of most nations includes a significant nuclear component and because of the worldwide energy problem this is likely to continue.

World resources of fossil fuels are limited and in uncertain supply. The need for alternative methods of energy production is becoming more critical with each year. Energy from nuclear fission is an important source of new electrical generation. The safe and economic development, design, construction, and operation of nuclear power plants and their related nuclear fuel processing facilities has become a major field of engineering.

Nuclear power is now a more economical form of electric energy generation than oil. Further, nuclear power is cheaper than coal in many parts of the world. One challenging task facing today's nuclear engineers is reducing the capital cost of nuclear power stations and extending the life of nuclear fuels so that nuclear plants become the most economic way of generating electricity in ever-widening regions of the world. These cost reductions can be realized by improving the performance of today's reactors, by development of better methods for designing tomorrow's reactors, and by conceiving types of reactors better than any now in use.

Another challenge to nuclear engineers is the development of economic nuclear power systems that regenerate or yield a net increase in their essential fuel. Foremost are breeder reactors which use regenerated plutonium or uranium-233 to make available all the latent fission energy of abundant uranium-238 or thorium instead of the relatively scarce isotope uranium-235, which is the principal fissionable material in presently operating reactors. Breeder reactors can provide an energy resource capable of supplying the needs of the world for thousands of years.

Fission reactors find widespread use in research on the interaction of radiation and matter and in the production of radioisotopes and the transmutation of elements. Also, the large amount of energy obtainable per unit mass of fissile fuel and the fact that air is not needed to sustain the fission reaction make fission reactors especially valuable in submarine and space applications.

Another potential source of nuclear energy and neutrons is controlled fusion of light elements. Energy from such thermonuclear reactions would provide another practically inexhaustible supply of energy. These fusion reactions must be carried out in a fully ionized plasma heated to a temperature of many million degrees and confined under stable conditions by strong magnetic fields. Recent progress in confining plasmas increases the likelihood that controlled fusion will become a practical source of energy within the lifetime of today's engineering students. The use of fusion reactions for an economic supply of neutrons could be achieved even sooner. Attainment of a practical fusion energy source requires improved behavior of plasmas in electric and magnetic fields, development of materials capable of withstanding high stresses and exposure to intense radiation, and great engineering ingenuity in combining fusion power components into a practical and economic system. The Department is active in these three fields: the fundamentals of plasma behavior, materials for intense radiation fields, and the engineering of fusion systems.

Study of the fundamentals of plasma behavior leads to improved understanding of astrophysical and ionospheric phenomena, magnetohydrodynamic energy conversion, ion propulsion, direct-conversion thermionic diodes, and high-power gas lasers. The latter two topics are applications of particular present interest in the Department. Students in the Department concentrating on applied plasma physics are therefore not only trained to advance knowledge of controlled fusion and of the plasma field as a whole, but also to apply the fundamental science in other contexts of more immediate practical significance. In these plasma activities, the Department is an active participant in MIT's broad, interdepartmental program of research and instruction in plasma physics and its varied applications.

The Department's involvement with reactors and sources of radiation has led to an applied radiation physics program concerned with the radiations these sources emit and with uses to be made of radiation. This program deals in a unified manner with neutrons, charged particles, gamma rays, and light and other electromagnetic radiations. It is concerned with the production of neutrons and gamma rays by fission reactors, the production of alpha, beta, and gamma rays by radioisotopes, the production of electrons, positive ions, neutrons, and gamma rays in particle accelerators, and the production of coherent electromagnetic radiation by lasers. Topics treated include the detection and measurement of radiation, the interaction of radiation with matter, the use of radiation in processing materials, the design of irradiators, biological effects of radiation, and the use of scattering experiments with neutrons and coherent light to determine the structure and molecular dynamics of solids, liquids, and dense gases.

To achieve the full potential of nuclear energy from either fission or fusion reactors, it is necessary to develop materials capable of withstanding intense radiation for long periods of time. Nuclear reaction systems require novel materials processed in special ways. The Department's nuclear materials engineering program is concerned with effects of radiation on materials and development of improved radiation-resistant materials. Also of major importance are the chemical and metallurgical engineering aspects of the production and fabrication of enriched uranium, thorium, and plutonium to serve as fuel for fission reactors, and the processes for recovering these materials from the highly radioactive spent fuel discharged from reactors. Processing and enrichment of lithium and hydrogen-isotopes for fusion reactor fuels are also treated.

In these programs, attention is focused on the technology of the fission reaction and plasma phenomena and on aspects of applied mathematics, physical science, and engineering which contribute importantly to the efficient development of these fields — for example, low-energy nuclear physics, plasma physics, nuclear materials, numerical methods and high-flux heat transfer. The Department follows a broad interdisciplinary approach, making use of important segments of physics, chemistry, applied mathematics, and metallurgy, and drawing on the techniques of chemical, civil, electrical, and mechanical engineering where relevant to the solution of nuclear engineering problems. The programs aim to teach the basic principles of nuclear technology and applied plasma and radiation physics, and to show students how other fields of undergraduate specialization may be applied to problems in nuclear technology.

To fulfill society's growing expectations for increased electric and thermal energy production, not only must new generating technologies be developed, but generating plants must be designed and operated so as to produce energy safely, reliably, economically, and with acceptable environmental impact. Most thermal-electric generating technologies involve similar requirements and methods of design and analysis, for structural integrity under conditions of high temperatures and pressures, for reliability of components and systems, and for economic and environmental impact evaluation. Consequently the Department is involved in active programs with applications across the entire field of energy production in the areas of structural mechanics, reliability analysis, safety and licensing, environmental impact of power production, and engineering economics.

Undergraduates and graduate students in other departments at MIT who wish to learn how their major professional field may be utilized in nuclear developments can find certain subjects or groups of subjects offered by the Department of Nuclear Engineering to be of interest. Programs of study focused on nuclear power plant engineering are of special interest to students of chemical, electrical, or mechanical engineering. Programs focused on applied plasma or radiation physics are valuable for students in physics or electrical engineering. Students in chemical engineering, or metallurgy and materials science, find the program in nuclear materials engineering of particular interest. An interdepartmental program on structural mechanics in nuclear power technology has been established for students in civil, mechanical, materials science, ocean, and aeronautical, as well as nuclear, engineering.

Undergraduate Study

Bachelor of Science in Nuclear Engineering

The undergraduate programs in Nuclear Engineering are designed to prepare students for careers in the nuclear power industry, or for graduate study in nuclear engineering and related disciplines. The field is very broad and hence the program is arranged to provide the student with considerable flexibility, while meeting the intellectual demands of career preparation.

The Department offers two undergraduate programs leading to a Bachelor of Science in Nuclear Engineering. The first, Course XXII, is structured for completion in four years. The second, Course XXII-A, is part of a five-year Engineering Internship Program leading to both a Bachelor of Science and a Master of Science in Nuclear Engineering. Course XXII-A combines study with industrial engineering practice.

The curriculum for both programs contains four major components. The first is the Institute Science Requirement, which provides the student with the appropriate foundation in physics, mathematics, and chemistry. The second component is the Institute Humanities, Arts, and Social Sciences Requirement which is included in all bachelor's degree programs. The third component is Engineering Principles, in which a student is expected to become familiar with the foundations of engineering practice. The particular areas the student is required to study include strength of materials, fluid flow, thermodynamics, heat transfer, and computer modeling of physical systems. Most of the engineering departments at the Institute offer subjects covering these topics. Thus there is considerable latitude in fulfilling this segment of the curriculum. The fourth component of the undergraduate curriculum is a broadly based introduction to the specialties of nuclear engineering. Thus, students take subjects dealing with the physical phenomena of interest in nuclear power generation, nuclear and reactor physics, and nuclear engineering design. In addition, students may choose electives in applied radiation physics and technology, plasma physics, fusion reactor engineering, or engineering of nuclear systems.

The curriculum is designed to serve the interests of those who wish to specialize early in their program, as well as students preferring to obtain a broadly based background. Students are encouraged to select subjects from several departments at the Institute in order to perceive the many aspects of science and engineering in a meaningful perspective. Students are permitted to use graduate subjects for their elective if they wish advanced training in some aspect of the field.

The Departmental requirements under the Institute Science Distribution include 8.03, 18.03, and 22.02. The Engineering and Fundamentals constitute the major portion of the Departmental requirements. Engineering Principles I refers to subjects in the area of mechanics and materials, and can be satisfied by 1.04, 2.01, or 8.06. Engineering Principles II refers to the area of fluid mechanics. Suitable subjects for this area include 1.60, 2.20, 8.263, 10.301, or 10.302. Thermodynamics is the area of Engineering Principles III. Appropriate subjects include 2.40, 3.00, 6.018, or 8.08. Engineering Principles IV deals with heat transfer, for which acceptable subjects are 2.51 or 10.301, or 10.302. Computer Modeling constitutes the area of Engineering Principles V and can be satisfied by 1.00, or 22.006. Students with special interest in applied plasma physics should substitute a subject in electricity and magnetism, such as 6.601 or 8.07, for computer modeling. The choice of specific subjects and the order in which they are taken are arranged in consultation with the student's undergraduate advisor in the Department.

The programs require a total of 60 units of restricted electives from Course XXII undergraduate (or, where appropriate, graduate) offerings. Of these 60 units, at least 36 units should be for subjects covering engineering design and systems. The specific selections of subjects is to be approved by the student advisor and registration officer. The student is encouraged to select subjects focused around one of the principal areas within Nuclear Engineering such as fission reactor engineering, applied radiation physics, or fusion reactor engineering.

Students, particularly those who anticipate eventual graduate study in Nuclear Engineering at MIT are encouraged to take 8.04 and 18.075, 18.076 as undergraduates.

A design experience and a bachelor's degree thesis are required of all undergraduates in Nuclear Engineering. The usual methods of satisfying these requirements are different in Course XXII than in Course XXII-A and are discussed separately for each Program.

Bachelor of Science in Nuclear Engineering
Course XXII

Most requirements, flexibilities, and recommendations are common to both undergraduate programs and are given in the paragraphs headed "Bachelor of Science in Nuclear Engineering."

Engineering Design experience is considered an essential part of the curriculum and is required of all Course XXII students. This requirement of at least 36 units of engineering design and systems may be satisfied by a reasonable choice of subjects as approved by the registration officer. The requirement may be partially satisfied by a design-oriented thesis or special topic (22.091).

A bachelor's degree thesis is also required and 12 credits accompany successful completion of the thesis.

The degree program in Course XXII is accredited by the Accreditation Board for Engineering and Technology, Inc.

Bachelor of Science in Nuclear Engineering
Course XXII

	General Institute Requirements		Total Units
	Specific science and humanities and social science subjects		132
	The subjects 8.03, 18.03, and 22.02 which are required in the Departmental Program appear on the list of Science Distribution Subjects and can be used to satisfy the Science Distribution Requirement.		
	Laboratory Requirement		12
	Departmental Program		
	Required Subjects		114
8.03	Physics III	5 0 7	
18.03	Differential Equations	4 0 8	
22.001	Seminar in Nuclear Engineering	2 0 4	
	Engineering Principles I[1]	12	
	Engineering Principles II[2]	12	
	Engineering Principles III[3]	12	
	Engineering Principles IV[4]	12	
	Engineering Principles V[5]	12	
22.02	Introduction to Applied Nuclear Physics	3 0 9	
	Thesis	12	
	Restricted Electives		60
	Undergraduate subjects offered by the Department of Nuclear Engineering. Graduate subjects may be considered. The student's program should include: a) One of the following subjects: 22.021 Nuclear Reactor Physics or 22.07 Basic Plasma Physics, and b) A total of 36 units of nuclear engineering design and systems subjects to be selected with the approval of the advisor. All students are encouraged to take 22.031.		
	Unrestricted Electives[6]		48
	Total Units Required for the S.B. Degree		366

1
Suitable subjects are 1.04 or 2.01 or 8.06.
2
Suitable subjects are 1.60, 2.20, 8.263, 10.301, or 10.302.
3
Suitable subjects are 2.40, 3.00, 6.018, or 8.08.
4
Suitable subjects are 2.51, 10.301, or 10.302.
5
Suitable subjects are 1.00 or 22.006 (For students interested in applied plasma physics 6.601 or 8.07).
6
It is always possible for second year students to arrange their course of study so that they have 12 units of elective freedom each semester.

Bachelor of Science in Nuclear Engineering
Course XXII-A

Most requirements, flexibilities, and recommendations are common to both undergraduate programs and are given in the paragraphs headed "Bachelor of Science in Nuclear Engineering."

Nuclear Engineering Department students who participate in the Engineering Internship Program are enrolled in Course XXII-A. The Program is structured as a five-year program leading to both a Bachelor of Science and a Master of Science in Nuclear Engineering. Students normally enter the program in their sophomore year at MIT. The students must be selected by a participating company in a series of competitive interviews. The Program consists of four work assignments at the same industrial firm. The first two are undergraduate work assignments designated as the required subject 22.092.

The student who enters this Program is not assured of admission to graduate school for the S.M. He or she must apply for graduate school and be formally accepted. It is intended that in most cases the decision on such applications is provided early in the fall term of the student's fourth year.

Engineering design and systems experience is considered an essential part of the Course XXII-A curriculum. This requirement of 36 units of engineering design units may be satisfied by work assignments that are design-related. Otherwise, the requirement is to be satisfied by appropriate selection of subjects, as approved by the registration officer. The requirement may be also partially satisfied by a design-oriented thesis or special topic (22.091).

The Bachelor's thesis requirement is usually satisfied upon acceptance of the Master's thesis which is prepared during the third and fourth work assignment. If the student does not enter the Master's portion of the Program (either from his/her own decision or because he/she has not been admitted to graduate school), the student may substitute work done as part of the first two work assignments, provided that the student prepares a written proposal and a written report in thesis format which is acceptable to the faculty advisor. Otherwise, the student must follow the same steps for satisfying the thesis requirement as those students in XXII.

Graduate Study

Bachelor of Science in Nuclear Engineering
Course XXII-A

	General Institute Requirements			Total Units
	Specific science and humanities and social science subjects			132
	The subjects 8.03, 18.03, and 22.02 which are required in the Departmental Program appear on the list of Science Distribution Subjects and can be used to satisfy the Science Distribution Requirement.			
	Laboratory Requirement			12
	Departmental Program			
	Required Subjects			114
8.03	Physics III	5	0 7	
18.03	Differential Equations	4	0 8	
22.001	Seminar in Nuclear Engineering	2	0 4	
	Engineering Principles I[1]		12	
	Engineering Principles II[2]		12	
	Engineering Principles III[3]		12	
	Engineering Principles IV[4]		12	
	Engineering Principles V[5]		12	
22.02	Introduction to Applied Nuclear Physics	3	0 9	
22.092	Engineering Internship		12	
	Restricted Electives			60
	Undergraduate subjects offered by the Department of Nuclear Engineering. Graduate subjects may be considered. The student's program should include: a) One of the following subjects: 22.021 Nuclear Reactor Physics or 22.07 Basic Plasma Physics, and b) A total of 36 units of nuclear engineering design and systems subjects to be selected with the approval of the advisor. All students are encouraged to take 22.031.			
	Unrestricted Electives[6]			48
	Total Units Required for the S.B. Degree			366

1
Suitable subjects are 1.04, 2.01, or 8.06.
2
Suitable subjects are 1.60, 2.20, 8.263, 10.301, or 10.302.
3
Suitable subjects are 2.40, 3.00, 6.018, or 8.08.
4
Suitable subjects are 2.51, 10.301, or 10.302.
5
Suitaole subjects are 1.00 or 22.006 (For students interested in applied plasma physics 6.601 or 8.07).
6
It is always possible for second year students to arrange their course of study so that they have 12 units of elective freedom each semester.

Five-Year Degree Programs

The five-year programs leading to a joint Bachelor of Science in chemical engineering, civil engineering, electrical engineering, mechanical engineering, nuclear engineering, or physics, and a Master of Science in nuclear engineering, are helpful to students who, early in their undergraduate studies, decide to pursue a graduate degree in nuclear engineering. Students desiring to enter such a program must meet the graduate admission requirements of the Department of Nuclear Engineering. They must submit their applications for admission at the end of their junior year. If admitted, the student's program is arranged between the registration officers of the two participating departments. For further information, interested students should contact either their undergraduate department or the Department of Nuclear Engineering.

The Nuclear Engineering profession is exceptionally broad and many undergraduate disciplines provide suitable preparations for graduate study.

An undergraduate degree in physics, engineering physics, chemistry, mathematics, metallurgy, or chemical, civil, electrical, mechanical, or nuclear engineering furnishes suitable preparation for graduate study in nuclear engineering. Optimum undergraduate preparation would include the following material:

Physics. At least two years, including mechanics, heat, light, electricity, and magnetism, and an introduction to wave mechanics and modern physics, equivalent to MIT subjects 8.01, 8.02, 8.03, and 8.04 or 8.211. Students planning to follow the Department's program of graduate study in applied plasma physics or applied radiation physics should have more advanced preparation in theoretical physics, electricity, and magnetism, equivalent to MIT subjects 8.06 and 8.07.

Mathematics. At least two and one-half years, including ordinary and partial differential equations, vector analysis, matrix algebra, orthogonal functions, Bessel and Legendre functions, Fourier and Laplace transforms, and an introduction to functions of a complex variable, equivalent to MIT subjects 18.01, 18.02, 18.03, 18.075, and 18.076.

Chemistry. At least one term of general, inorganic, and physical chemistry, including the periodic table, valence, oxidation-reduction potentials, equilibrium constants, and heterogeneous equilibrium.

Engineering Fundamentals. Mechanical properties of materials, fluid flow, heat transfer, and engineering thermodynamics, equivalent to MIT subjects 2.01 or 10.302, 10.301 or 10.13. Students without such undergraduate engineering preparation may obtain background in engineering fundamentals by taking 22.311 Engineering Principles for Nuclear Engineers.

Prospective graduate students should make every effort to complete undergraduate preparation before starting graduate

study. Students whose preparation is incomplete may make up their deficiencies after admission to graduate study, but they need more time to complete the graduate program.

Students who expect to apply for admission to the graduate course in Nuclear Engineering should discuss their undergraduate programs with the Department's Registration Officer, preferably before the end of their junior year. Applicants for admission are not required to take the Graduate Record Examination.

Engineering Internship Program

An additional five-year program that leads to a joint S.B.-S.M. in nuclear engineering is the Engineering Internship Program. This route to the S.M. is restricted to students participating in undergraduate Course XXII-A.

All classroom requirements for the S.M. degree are the same as for "Master of Science in Nuclear Engineering Course XXII." The student must also complete the third and fourth work assignments of the Engineering Internship Program (subject 22.92). During these work assignments, a thesis is prepared. This thesis must conform to departmental thesis rules and can serve to satisfy both Bachelor's and Master's thesis requirements.

Master of Science in Nuclear Engineering
Course XXII

The object of the master's program is to give the student as good a general knowledge of aspects of nuclear engineering as can be gained in one year of full-time graduate study. This provides a good foundation either for productive work in the nuclear field or for more advanced graduate study. The general requirements for this degree are listed in the Graduate Education chapter. Subjects recommended for all master's degree candidates include:

22.111	Nuclear Physics for Engineers I
22.112	Nuclear Physics for Engineers II
22.211	Nuclear Reactor Physics I

Other subjects may be selected in accordance with the student's particular field of interest. Most master's candidates specialize in one of four alternative fields: fission reactor technology, applied plasma physics, applied radiation physics, or nuclear materials engineering. For students specializing in **fission reactor technology,** additional subjects recommended are:

22.212	Nuclear Reactor Physics II
22.29	Nuclear Measurements Laboratory
22.312	Engineering of Nuclear Reactors

Other subjects of interest to Master of Science candidates specializing in fission reactor technology include:

22.313	Advanced Engineering of Nuclear Reactors
22.314J	Structural Mechanics in Nuclear Power Technology
22.33	Nuclear Engineering Design
22.34	Economics of Nuclear Power
22.35	Nuclear Fuel Management
22.37	Environmental Impact of Electric Power Production
22.38	Reliability Analysis Methods
22.39	Nuclear Reactor Operations and Safety
22.42	Numerical Methods of Reactor Analysis
22.56J	Principles of Medical Imaging
22.611J	Introduction to Plasma Physics I
22.63	Engineering Principles for Fusion Reactors
22.72J	Nuclear Fuels
22.76J	Introduction to Nuclear Chemical Engineering
22.77	Nuclear Waste Management

For students specializing in **applied plasma physics,** subjects recommended in addition to 22.111, 22.112, and 22.211 are:

22.610	Controlled Fusion Power
22.611J	Introduction to Plasma Physics I
22.612J	Introduction to Plasma Physics I
22.615	MHD Theory of Magnetic Fusion System
22.621	Thermonuclear Reactor Design
22.66	Transport Phenomena in Toroidal Systems
22.69	Plasma Laboratory

Students specializing in **applied radiation physics** should select subjects in addition to 22.111, 22.112, and 22.211 from:

22.29	Nuclear Measurements Laboratory
22.312	Engineering of Nuclear Reactors
22.51	Radiation Interactions and Applications
22.56J	Principles of Medical Imaging
22.57J	Radiation Biophysics
22.73J	Radiation Effects in Crystalline Solids

Students specializing in **nuclear materials engineering** should select subjects in addition to 22.111, 22.112, and 22.211 from those listed immediately above and:

22.70J	Materials for Nuclear Applications
22.71J	Physical Metallurgy Principles for Engineers
22.72J	Nuclear Fuels
22.75J	Radiation Effects in Reactor Structural Materials
22.76J	Introduction to Nuclear Chemical Engineering

Students with adequate undergraduate preparation normally need one full year to complete the requirements for the

Master of Science. Additional information concerning the requirements for the Master of Science in Nuclear Engineering are given in an information circular which may be obtained from the Department of Nuclear Engineering.

Master of Science in Technology and Policy

Students interested in applying their nuclear engineering background to problems of policy and socioeconomic assessment of technology may apply for the interdepartmental Master of Science Program in Technology and Policy. This program combines subjects in advanced technology in the particular field of the student's choosing with subjects in economics, systems analysis, political science, and law. It engages the student in significant project work integrating technology and policy. Well-qualified students may complete this program in one calendar year. General requirements and application procedures are described in Chapter V of this catalogue.

Master of Science in the Management of Technology

Students who would like to apply their nuclear engineering background and at least five years of technical work experience to issues in technical management may want to look into applying to the Joint Program in the Management of Technology. Jointly offered by MIT's School of Engineering and the Sloan School of Management, this Program entails a rigorous twelve-month curriculum, developed and taught by faculty from both schools, focusing on management principles for technical people in a technical environment. The Program is designed for scientists and engineers on a career path requiring increasing managerial responsibilities for technical activities. These are individuals planning to remain on the technical side of the organization rather than moving into general management positions in the near future. More information on general requirements and application procedures is included in Chapter V of this catalogue.

Nuclear Engineer

The two-year program of study leading to the Nuclear Engineer provides deeper knowledge of nuclear engineering than is possible in the master's program and is intended to train students for creative professional careers in engineering application or design.

General requirements for this degree, described in the Graduate Education chapter, include 162 units of subject credit plus a thesis. The Department requires that each student plan an individually selected program of study, to be approved in advance by the faculty advisor, and that he or she complete, and orally defend, a substantial project of significant engineering value.

The principal areas of study are: nuclear reactor physics, nuclear reactor engineering, nuclear materials engineering, nuclear fuel management, applied radiation physics and applied plasma physics. The objectives of the study program are to provide the candidate with a broad knowledge of the profession and to develop competence in engineering applications or design. The emphasis in the program is more applied and less research oriented than the doctoral program.

The engineering project required of all candidates for the Nuclear Engineer is generally the subject of an Engineer's thesis. A student with full undergraduate preparation normally needs two years to obtain the Nuclear Engineer. A student who satisfies the requirements for the Engineer's degree is simultaneously approved for the S.M. by the Department of Nuclear Engineering. Additional information concerning the requirements for the Nuclear Engineer may be found in an information circular available at the Department of Nuclear Engineering.

Doctor of Philosophy and Doctor of Science

The program of study leading to these degrees aims to give a comprehensive knowledge of nuclear engineering, to develop competence in advanced engineering research, and to develop perspective in assessing the role of nuclear science and technology in our society.

General requirements for the doctorate are given in the Graduate Education chapter of this catalogue and in the *Graduate School Manual*. The specific requirements of the Department of Nuclear Engineering are presented here. The three principal parts of the doctoral program are the major program leading to the General Examination, the minor program and the doctoral thesis. Upon a satisfactory completion of this program, the student ordinarily receives the Doctor of Science unless he or she requests the Doctor of Philosophy. The requirements for both degrees are the same.

The object of the **major program** is to give students good general knowledge of nuclear engineering, together with detailed familiarity with the specific field in which they intend to undertake research. To this end, before students may start their doctoral research, they are required to pass a general examination demonstrating adequate undergraduate preparation in physics, chemistry, mathematics, and engineering fundamentals and comprehensive knowledge at the graduate level of their chosen field in nuclear engineering.

The alternative fields in which doctoral candidates may elect to study and in which they are examined are: fission reactor physics, fission reactor engineering, applied plasma physics, applied radiation physics, nuclear materials engineering, nuclear fuel management, applied fusion technology, nuclear energy systems and policy analysis, medical radiological physics, reactor safety analysis. Details of the doctoral examination in each of these fields are given in an information circular for doctoral candidates that may be obtained from the Department of Nuclear Engineering.

Research Facilities

The object of the **minor program** is to broaden the student's knowledge. The minor consists of completing satisfactorily two or more related subjects, totaling at least 24 credit units, in a field other than nuclear engineering and of a more advanced character than would have been required for the student's undergraduate degree. The minor program should be arranged with and approved by the student's registration officer. Graduate level subjects taken at other schools may be used to satisfy the minor requirement if the registration officer judges them to be substantially equivalent to MIT graduate subjects.

Doctoral research may be undertaken either in the Department of Nuclear Engineering or in a nuclear related field in another department. Appropriate areas of research include the following: in fission reactor physics — physics of thermal reactors, physics of fast reactors, reactor dynamics, neutron transport theory, numerical methods of reactor analysis; in fission reactor engineering — high-flux heat transfer, two-phase flow in boiling systems, liquid-metal heat transfer, systems reliability, nuclear reactor safety, structural design of reactor components; in nuclear fuel management — in-core and out-of-core fuel cycle analysis, economics of energy production, power system modeling and planning; in applied plasma physics — plasma production and confinement, plasma kinetic theory, plasma diagnostics, charged particle transport theory, fusion power systems, thermionic energy conversion, gas laser technology; in applied radiation physics — chemical or biological effects of radiation, radiation processing of materials, neutron diffraction studies, neutron cross section correlations, studies of molecular dynamics by scattering of light or neutrons, shielding of gamma rays or neutrons; in nuclear materials engineering — properties of nuclear fuels, effect of radiation on reactor materials, solvent extraction of metals, isotope separation, nuclear fuel reprocessing, treatment of radioactive wastes.

The Department's educational program is supported by a number of outstanding experimental facilities for advanced research in nuclear engineering.

The MIT Nuclear Reactor Laboratory

The MIT Research Reactor operates at a power of 5,000 kw. It is fueled with U-235 and cooled and moderated by heavy water. Completed late in the spring of 1958, it is one of the finest university research reactors in the world. It provides first-hand experience in the design, performance, and operation of nuclear reactors and serves as a source of radiations for use in laboratory instruction on radiation detection and measurement methods. The reactor has been modified to increase the useful neutron intensity and its versatility as a research tool even more. A variety of research projects make use of the intense sources of neutrons and gamma rays produced by the reactor. Areas of research in which the reactor is being used include: neutron physics, cross-section measurements, reactor physics, neutron scattering by gases and liquids, solid-state studies based on neutron diffraction, radiochemistry, physics of neutron-capture processes, activation analysis, research with short-lived radioisotopes, radiation catalyzed chemical reactions, radiation induced biological effects, radiation therapy, and studies of radiation effect on materials.

Experimental Plasma Facilities

The Department utilizes extensive experimental facilities for production and confinement of large volumes of highly ionized plasmas and for studies of plasma turbulence, particle motions, and other phenomena. High-power lasers and other equipment are available both for plasma diagnostics and for study of basic physical interactions. Experimental apparatus for thermionic conversion studies is also available. The Department has facilities to support a unique program of controlled fusion engineering studies and has its own well-equipped graduate laboratory for instruction on plasma laboratory techniques.

The Department has played a major role in the design and operation of the new high field Tokamak fusion device ALCATOR, a joint project of the Research Laboratory of Electronics and the National Magnet Laboratory. ALCATOR is expected to produce a dense, hot plasma approaching the regime of fusion interest. ALCATOR is a major plasma physics installation and is expected to function for many years as the plasma equivalent of the MIT Research Reactor as an educational and research facility.

Most of the research on plasmas and controlled fusion is done in MIT's Research Laboratory of Electronics. This Laboratory is an association of faculty and graduate students from many departments, and it includes groups active in all aspects of plasma research.

Other Research Facilities

The Department has a well-equipped nuclear instrumentation laboratory, a 14 MeV neutron source, and two subcritical natural-uranium reactors, one moderated by water and the other by graphite. Laboratory space and shop facilities are available for research in all areas of nuclear engineering. MIT's IBM Type 370/168 digital computer is used extensively in research and graduate instruction. In addition the Department has its own PDP-8 digital computer.

Inquiries

Additional information concerning academic and research programs, admissions, financial aids, assistantships, etc., may be obtained by writing to the Department of Nuclear Engineering, Room 24-102, MIT, Cambridge, Massachusetts 02139, (617) 253-3801.

Department of Ocean Engineering

Ira Dyer, Ph.D.
Professor of Ocean Engineering
Head of the Department

Professors

Martin Aaron Abkowitz, Ph.D.
Professor of Ocean Engineering

Arthur Bernard Baggeroer, Sc.D.
Professor of Ocean Engineering and Electrical Engineering

Alexander Douglas Carmichael, Ph.D.
Professor of Power Engineering

Ernst Gabriel Frankel, Mar. Mech.E.
Professor of Marine Systems

Justin Elliot Kerwin, Ph.D.
Professor of Naval Architecture

Patrick Leehey, Ph.D.
Professor of Naval Architecture and Applied Mechanics

Koichi Masubuchi, D.Eng.
Professor of Ocean Engineering and Materials Science
(Absent, spring)

Jerome H. Milgram, Ph.D.
Professor of Naval Architecture
(Absent)

John Nicholas Newman, Sc.D.
Professor of Naval Architecture
(Absent)

J. D. Nyhart, J.D.
Professor of Ocean Engineering and Management
(Absent)

Associate Professors

David Valentine Burke, Jr., Ph.D.
Associate Professor of Ocean Engineering

Chryssostomos Chryssostomidis, Ph.D.
Associate Professor of Naval Architecture

Judith Tegger Kildow, Ph.D.
Associate Professor of Ocean Policy

Henry Stuart Marcus, D.B.A.
Associate Professor of Marine Systems

John Kim Vandiver, Ph.D.
Associate Professor of Ocean Engineering

Robert James Van Houten, Ph.D.
Associate Professor of Ocean Engineering

Ronald Wai-Chun Yeung, Ph.D.
Associate Professor of Naval Architecture

Assistant Professors

Joao Manuel Gomes de Oliveira, Ph.D.
Esther and Harold E. Edgerton Assistant Professor of Ocean Engineering

Harilaos Nicholas Psaraftis, Ph.D.
Assistant Professor of Marine Systems

Michael Stefanos Triantafyllou, Sc.D.
Assistant Professor of Ocean Engineering

Paul Christos Xirouchakis, Ph.D.
Assistant Professor of Ocean Engineering

Adjunct Professor

Clark Graham, Ph.D.
Adjunct Professor of Naval Architecture

Senior Lecturers

Dean Alden Horn, Nav.E.

Harry A. Jackson, B.S. (Visiting)

William Wallace Murray, Ph.D.
(Visiting)

William S. Pellini, B.S. (Visiting)

Willard Franklin Searle, Jr., Nav.E. (Visiting)

Lecturers

Damon Ellis Cummings, Ph.D.
(Visiting)

Charles Noel Flagg, Ph.D.

Keatinge Keays, Nav.E.

Susan Blackmore Peterson, Ph.D.
(Visiting)

Wolfgang Reuter, S.M.
(Visiting)

Leah Johnson Smith, Ph.D.
(Visiting)

Administrative Officer

Keatinge Keays, Nav.E.

Professors Emeriti

Evers Burtner, S.B.
Associate Professor of Naval Architecture and Marine Engineering, Emeritus

John Harvey Evans, B.Eng.
Professor of Naval Architecture, Emeritus

Alfred Adolf Heinrich Keil, Dr.Rer.Nat.
Professor of Ocean Engineering, Emeritus
Ford Professor of Engineering, Emeritus

Philip Mandel, B.S.
Professor of Naval Architecture Emeritus

Norman Judson Padelford, Ph.D., LL.D.
Professor of Political Science, Emeritus

Shannon Curtis Powell, Dott.Ing.
Professor of Marine Engineering, Emeritus

Department of Ocean Engineering

Since the earliest of times, the oceans have served societal needs. They have provided avenues of transportation, resources of food and minerals, and natural barriers of defense. These uses of the ocean are perhaps more important today than ever before as the world faces problems of growing populations and shrinking resources. Out of the need for increased utilization of the ocean has come a heightened sense of purpose. Simply stated, the task in ocean engineering is to use the oceans and to use them wisely.

The Department of Ocean Engineering provides the essential skills that ultimately enable its students to conceive, initiate, and direct complex engineering projects. Such tasks demand flexible and adaptive engineering minds. For this reason, the degree requirements in the Department of Ocean Engineering begin with the same basic mathematics, science, and engineering subjects as other traditional engineering disciplines, such as civil and mechanical engineering. The education then reaches beyond these traditional boundaries to prepare a professional who is capable of responding to the broad demands of complex engineering tasks. It is not uncommon to learn that companies wishing to employ ocean engineering graduates do so because they seek individuals who, in addition to having sound training in engineering fundamentals, also have sufficient breadth that they can provide a unifying influence when working with a team frequently composed of a diverse collection of specialists. For example, the design and construction of a ship or of a facility to convert wave, tide, or even thermal gradient energy to useful forms requires a great deal of conventional engineering. However, ultimate success may also depend on an understanding of physical ocean processes, such as waves, tides, and currents, chemical effects such as salt water corrosion, biological fouling of equipment, and long-term ecological impacts on the environment. Beyond the physical and technical challenges, the ocean engineer must also be sensitive to issues related to public policy and use of the seas.

Such a broad preparation does not prevent the student from additional preparation in a particular field of study. Through selection of degree programs and elective subjects, students may concentrate in areas such as structures, fluid mechanics, or naval architecture.

In whatever the chosen field, there is no shortage of tasks and career avenues to challenge the full range of engineering knowledge, skills, and imagination.

Career Opportunities in Ocean Engineering

Students in the Department of Ocean Engineering may prepare for various jobs and career paths, including:

Naval Architect
Marine Power Engineer
Ocean Systems Engineer
Offshore Engineer
Ocean Resources Engineer
Oceanographic Engineer
Sonar Engineer
Coastal Zone Manager
Government Planner and Regulator
Environmental Engineer

In marine transportation, naval architecture is representative of applied ocean engineering skills. A naval architect may be involved in designing ships that range from sailing yachts to supertankers. For almost 90 years, MIT has been a leading center of ship research and design, and is widely recognized for its contributions in such areas as hydrodynamics, ship structural mechanics and dynamics, propeller design, and overall ship design. The Pratt School of Naval Architecture and Marine Engineering, which was established through a bequest to MIT in 1912, is an integral and vital part of the Department of Ocean Engineering. Building upon this historical base of expertise in ship design, the Department's curriculum today offers studies in all systems that must operate in an ocean environment.

Marine transportation also encompasses broad questions of international trade. To answer such questions, the ocean engineer must be able to assess in an integrated fashion a wide range of technical, economic, and political considerations. Other aspects of marine transportation include designing deep-water ports, integrating harbor facilities with land-based transportation systems, and planning new uses of waterways to help solve urban transportation problems.

Oil and gas beneath the ocean floor are increasingly important to an energy-hungry world. An ocean engineer is concerned with all phases of discovering, producing, and delivering offshore petroleum resources. The task is complex and demanding, especially as drilling moves farther off the continental shelf and into deeper parts of the ocean. Another task of central importance in recent years is the development of new methods to protect marine wildlife and coastal regions against the undesirable side effects of offshore oil production. Mining of seafloor minerals is certain to assume greater importance as land-based mineral resources are depleted or withheld from free international trade. To the ocean engineer falls the task of developing technology for locating and recovering copper, nickel, and other valuable minerals that lie beneath the oceans. Much new technology is required to explore the feasibility of ocean mining; more still is needed to make it economically attractive and compatible with the environment.

Undergraduate Study

Once regarded as an inexhaustible source of food, the oceans are now known to be approaching critical levels of depletion for some species. Engineering techniques of analysis and prediction are essential to maintain the delicate natural balances of the oceans. The ocean engineer, together with marine biologists, aquatic ecologists, and public policy planners, has a critical role to play in managing ocean resources to ensure survival of marine species and continuing supplies of food for the world. Just as technology transformed modern agriculture, so ocean engineering has significant contributions to make to aquaculture.

Oceans serve as natural barriers of defense for many nations of the world. For some students, careers in ocean-related defense offer a logical extension of their ocean engineering education. The Department offers subjects designed to enable people to cope with technologies relevant to modern naval systems, including ship design alternatives, seafloor habitats, sonar systems, and underwater navigation and communication.

Elements of Ocean Engineering

The education of an ocean engineer or a naval architect revolves around three central components. The first is a firm foundation in such basics as hydrodynamics, structural mechanics, vibratory phenomena, energy conversion, materials, and electronics. Second, the engineer needs broad exposure and practical experience in skills such as analysis and design. Third, the context of applications needs to be understood, and this can be approached by dealing with the societal functions typically served by ocean engineers. These functions include transportation, mineral extraction, defense, environmental protection, fishing and development of renewable sources of energy.

The Department's undergraduate and graduate programs combine these components in a balanced way to provide an educational base upon which to build a rewarding career.

Once a student has attained the engineering basics, individualized programs to meet particular interests are strongly encouraged. The Department's faculty has wide and continuing research and industrial experience. Departmental facilities, which include a variable pressure propeller tunnel, a ship model towing tank, a channel for oil-water interface studies, an acoustics and vibration laboratory, a marine data systems laboratory, a design laboratory, computer facilities, and a model shop, offer a variety of opportunities for laboratory experience.

The sections that follow describe the Department's undergraduate and graduate programs. Special requirements for the Graduate School and opportunities for financial aid are summarized in the section on graduate study.

Bachelor of Science in Ocean Engineering, in Naval Architecture and Marine Engineering, or without designation
Course XIII

Course XIII is the basic program offered by the Department. For undergraduates, the four-year program relates to students interested in engineering aspects of ocean sciences, ocean exploration, and the utilization of the oceans for transportation, defense, and resources. The program leads to the Bachelor of Science in Ocean Engineering, in Naval Architecture and Marine Engineering, or without designation of field. A curriculum without designation of field permits pursuit of broader marine-related interests. Graduates are prepared for work in industry or government, or for further study in graduate school.

All Course XIII undergraduates take the same required subjects in mathematics, science, and engineering fundamentals, along with subjects fulfilling the General Institute Requirements in humanities and laboratory work. Some departmentally prescribed subjects may be replaced by other subjects if such substitutions enhance student objectives. The elective program consists of two parts: planned electives, which are designed to meet the student's Course objective, and unrestricted electives, which permit further study in specialized areas or a broadening of the student's overall educational experience.

The Department offers counseling to students wishing to use some combination of planned and unrestricted electives for environmental studies. Such a course of study is similar to the other four-year MIT programs, supplemented with elective studies, that prepare students for environmentally related work.

Versions of the Course XIII program leading to the Bachelor of Science in Ocean Engineering, or to the Bachelor of Science in Naval Architecture and Marine Engineering, are accredited by the Engineers' Council for Professional Development, while those leading to the Bachelor of Science without designation of field are not.

Bachelor of Science in Ocean Engineering, in Naval Architecture and Marine Engineering, or without designation
Course XIII

	General Institute Requirements	Total Units
	Specific science and humanities and social science subjects.[1]	132
	The subjects 2.40, 13.001, and 18.03, which are required in the Departmental Program, appear on the list of Science Distribution Subjects and can be used to satisfy the Science Distribution Requirement.	
	Laboratory Requirement	12
	Departmental Program	
	Required Subjects[2,3]	**87**
2.40	Thermodynamics	4 0 8
13.001	Introduction to Marine Applied Mechanics	4 0 8
13.002	Marine Applied Mechanics	4 0 8
13.003J	Dynamics	4 0 8
13.004	Linear Systems in Ocean Engineering	3 0 9
13.73	A Survey of Ocean Engineering	1 1 1
13.40	Elements of Ocean Engineering Design	3 3 6
18.03	Differential Equations	4 0 8
	Planned Electives[4,5]	**at least 59**
	Subjects are selected by the student and Faculty Advisor and are chosen to attain the educational objective of preparation for a career in Ocean Engineering, in Naval Architecture and Marine Engineering, or an educational objective defined by the student.	
	Unrestricted Electives[3,6]	**70**
	Total Units Required for the S.B. Degree	**360**

1
14.01 Economic Principles I is required in the humanities, arts, and social science program if another subject in the field of economics is not included in the elective program.
2
The Department allows substitution of subjects of similar content after consultation with the Faculty Advisor.
3
For the degree without designation of field delete 13.40 Elements of Ocean Engineering Design (3-3-6) from the list of required subjects and increase the unrestricted elective units by 12.
4
For the degree in Ocean Engineering at least five from the following eight areas: Acoustics and Vibration, Design, Hydrodynamics, Instrumentation, Materials and Fabrication, Ocean Environment, Power and Propulsion, and Structures. No undergraduate thesis is required, but a suitable Special Problem (of at least 9 units), 13.700-13.709 Special Problems in Ocean Engineering must be included.
5
For the degree in Naval Architecture and Marine Engineering, at least one subject in each of the following areas: Design, Hydrodynamics, Materials and Fabrication, Power and Propulsion, and Structures. A suitable Special Problem (of at least 9 units), 13.700-13.709 Special Problems in Ocean Engineering must also be included.
6
Schedules of students in Course XIII may always be arranged to leave available 12 units of Unrestricted Elective in the second year.

Bachelor of Science in Ocean Engineering, in Naval Architecture and Marine Engineering, or without designation
Course XIII-C

Course XIII-C is an Engineering Internship program that enables students to combine professional experience with their academic work, while at the same time providing for part of their educational expenses. The four-year program leads to the Bachelor of Science in Naval Architecture and Marine Engineering, or Ocean Engineering, or without designation. Students in the internship program also may apply for admission to the Graduate School to obtain the Bachelor of Science concurrently with the Master of Science at the end of their fifth year.

All MIT sophomores in good standing can apply for entrance to the program. Alternating periods at the Institute and at cooperating establishments are arranged so that graduation is not delayed beyond the normal date.

The companies and laboratories participating in the internship program cover all important aspects of ocean engineering, including naval architecture and marine engineering. Assignments with these organizations provide opportunities to participate in activities such as construction, testing, design, development, research, and technical planning.

Versions of the Course XIII-C program leading to the Bachelor of Science in Ocean Engineering, or to the Bachelor of Science in Naval Architecture and Marine Engineering, are accredited by the Engineers' Council for Professional Development, while those leading to the Bachelor of Science without designation of field are not.

1
14.01 Economic Principles I is required in the humanities, arts, and social science program if another subject in the field of economics is not included in the program.
2
13.901 and 13.902 are suggested.
3
The Department allows substitution of subjects of similar content after consultation with and concurrence of the Faculty Advisor.
4
For the degree without designation of field delete 13.40 Elements of Ocean Engineering Design (3-3-6) from the list of required subjects and increase the Unrestricted Elective units by 12.

Bachelor of Science in Ocean Engineering, in Naval Architecture and Marine Engineering, or without designation
Course XIII-C

	General Institute Requirements	Total Units
	Specific science and humanities and social science subjects.[1]	132
	The subjects 2.40, 13.001, and 18.03 which are required in the Departmental Program, appear on the list of Science Distribution Subjects and can be used to satisfy the Science Distribution Requirement.	
	Laboratory Requirement[2]	12
	Departmental Program	
	Required Subjects[3,4]	**99**
2.40	Thermodynamics	4 0 8
13.001	Introduction to Marine Applied Mechanics	4 0 8
13.002	Marine Applied Mechanics	4 0 8
13.003J	Dynamics	4 0 8
13.004	Linear Systems in Ocean Engineering	3 0 9
13.73	A Survey of Ocean Engineering	1 1 1
13.40	Elements of Ocean Engineering Design	3 3 6
18.03	Differential Equations	4 0 8
13.771	Engineering Internship	12
13.772	Industrial Practice in Ocean Engineering[5]	
	Planned Electives[6,7]	**at least 57**
	Subjects are selected by the student and Faculty Advisor and are chosen to attain the educational objective of preparation for a career in Ocean Engineering, in Naval Architecture and Marine Engineering, or an educational objective defined by the student.	
	Unrestricted Electives[4,8]	**60**
	Total Units Required for the S.B. Degree	**360**

5
Credit toward the Bachelor of Science for Industrial Practice in Ocean Engineering is limited to a maximum of 36 units and a minimum of 12 units.
6
For the degree in Ocean Engineering at least five from the following eight areas: Acoustics and Vibration, Design, Hydrodynamics, Instrumentation, Materials and Fabrication, Ocean Environment, Power and Propulsion, and Structures.
7
For the degree in Naval Architecture and Marine Engineering, at least one suitable Planned selected in each of the following areas: Design, Hydrodynamics, Materials and Fabrication, Power and Propulsion, and Structures.
8
Schedules of students in Course XIII-C may always be arranged to leave available 12 units of Unrestricted Electives in the second year.

Graduate Study

Graduate study in the Department of Ocean Engineering can lead to the following degrees: Master of Science; Ocean Engineer; Doctor of Philosophy; or Doctor of Science.

An acceptable program of subjects plus an acceptable thesis leading to the Master of Science usually requires about one calendar year, if the undergraduate preparation is adequate. For some students up to two academic years is needed.

The Ocean Engineer degree requires at least two years, including a substantial thesis.

Obtaining the Doctor of Science or Doctor of Philosophy with a specification in an ocean-related field usually requires more than three years following a Bachelor of Science.

In most cases, students working together with their program advisors can tailor their programs of graduate study to suit individual interests and career objectives. Detailed Departmental requirements are available from the Departmental Student Administration Office.

Ocean Engineering/ Naval Architecture and Marine Engineering Course XIII

Course XIII is the central course of the Department, with major fields of study or specialization including:

Applied mechanics
Coastal zone development
Environmental engineering
Fluid mechanics
Hydrodynamics
Marine acoustics
Marine data systems engineering
Marine engineering
Marine materials and fabrication
Marine resource development
Marine systems
Naval engineering
Ocean engineering and law
Ocean transportation
Offshore engineering
Operations research
Public policy and ocean use
Seafloor engineering
Ship and offshore rig dynamics
Ship propulsion
Ship systems
Structural mechanics

While most of these fields may be studied and researched largely in the Department, interdepartmental programs described in the Interdepartmental Study and Research chapter also serve students with interests in some of the foregoing. We draw your attention especially to the formal degree programs in Environmental Engineering, Mineral Resources Engineering and Management, Operations Research, and Transportation.

The Department also offers a doctoral program jointly with the Transportation Division of the Department of Civil Engineering. Marine transportation students registered in the Department of Ocean Engineering and working toward the doctorate must fulfill all the requirements of the Transportation Division doctoral program plus a dissertation relating to marine transportation.

Naval Construction and Engineering Course XIII-A

This Course provides appropriate academic background for naval officers who later actively participate in concept formulation, design, and construction of naval vessels. In addition to general engineering and science and a core program of subjects in ocean engineering, each student follows one of several specialized curricula in aspects of, or applicable to, naval construction and engineering.

In addition to full-time study at the Institute for six academic terms and two summer terms, the Course provides, during the summer preceding the final year, either appropriate nonresident work experience or an additional term of full-time resident academic study.

The Course leads to the Ocean Engineer or Master of Science. For programs leading to the Ocean Engineer, a Master of Science may be awarded simultaneously upon recommendation of the Department or of some other department related to the student's specialty. For programs leading to the Master of Science, an additional Master of Science may be awarded simultaneously in a second field of specialization upon recommendation of the department represented by that field.

The Master of Science awarded by the Department to students who successfully complete the relevant portion of the Course XIII-A program is in Naval Architecture and Marine Engineering or in Ocean Engineering. A Master of Science awarded by another department in fulfillment of its requirements would be labeled in accordance with its program, for example Master of Science in Mechanical Engineering.

Admission to Course XIII-A requires that the Department's entrance requirements for graduate study be satisfied.

Ocean Systems Management Course XIII-B

The XIII-B Program in Ocean Systems Management (formerly Shipping and Shipbuilding Management) is intended for graduate students interested in the business and government management phases of marine activities, including design and construction of ships, underwater research vehicles, offshore platforms, ocean mining, ports, offshore oil and gas production, and fisheries.

Depending on the amount of background preparation, a student entering this program can take from one to two years to complete the degree. The program can be accomplished in one year by an MIT Ocean Engineering Department undergraduate who carefully schedules his or her elective time from the junior year on. Such a student is awarded concurrently an S.M. in Ocean Systems Management and an S.B. degree. The requirements are:

Technical Background. Technical background should consist of an S.B. degree in Engineering or Science. Background should include at least one undergraduate subject in each of the following topics: differential equations, probability, and microeconomics. Any deficiency should be eliminated during the first term at MIT. Students not possessing a background in the ocean engineering field are required to take 13.40 Elements of Ocean Design.

Core requirements. Satisfaction of the core requirements for the S.M. in Ocean Systems Management. These requirements are as follows:
Optimization Theory (1.143J, 6.272, 15.062, 15.081J or equivalent)
One of the following two (accounting or Private or Public Sector Finance):
Accounting (15.516, 15.515, 15.521 or equivalent)
Private or Public Sector Finance (15.412, 15.016 or equivalent)

One of the following four: Public Policy and Use of the Sea (13.92) Legal Aspects of Ocean Resources and Systems Management (13.962)
Management of Marine Systems (13.68)
Economics of Ocean Transportation (13.661J).

Area requirements. A graduate program must include a minimum of 72 units plus a thesis which must represent at least the equivalent of a half-term of full-term work. No more than nine units of these 72 units may be gained from Special Problem registration, subjects 13.710-13.719. At least 48 units must be "A" level subjects of which 34 units must be in the field of Ocean Systems Management. At least three subjects must be chosen from the following list. (Courses taken as core requirements cannot be double counted to meet this requirement.)

13.61	Network Scheduling, Routing, and Planning
13.62	Engineering Systems Analysis
13.621	Engineering Risk-Benefit Analysis
13.63	Reliability, Availability, and Maintainability of Systems
13.631	Port Planning and Development
13.65	Production Analysis
13.661J	Economics of Ocean Transportation
13.665J	Logistical and Transportation Planning Methods
13.67	Marine Decision Making Under Uncertainty
13.68	Management of Marine Systems
13.681J	Issues in Transportation Management
13.69	International Shipping
13.92	Public Policy and Use of the Sea
13.93	Fisheries Management
13.94J	Ocean Engineering and Law Seminar
13.961J	Resources Management
13.962	Legal Aspects of Ocean Resources and Systems Management
13.98J	Coastal Zone Management

In addition, optional topics not chosen for the core requirements can be used to fulfill these area requirements. Subjects taken while a graduate student to remove deficiencies in preparation may be included in making up the above total units, including those undergraduate subjects for which "G" credit is allowed. In addition, the student must demonstrate the ability to program on a high-level compiler.

Technology and Policy (S.M.)

The Department also offers a Master's degree in Technology and Public Policy. This program educates students with a strong technical foundation in a marine-related field as well as a strong competence in dealing with policy issues. This program is interdepartmental and permits students to select specialized courses from throughout the Institute, notwithstanding the program's requirements (see Technology and Policy in Chapter V of this catalogue). Students in this Program come from departments throughout the School of Engineering, forming an interesting community within the School. Graduates of this program may enter directly into public or private practice or elect to continue graduate or professional study further. Requirements for entry into this program are the same as those required for the XIII-B Program with adjustments made for the special requirements of the Technology and Policy Program.

Joint Program in the Management of Technology

Individuals interested in applying their ocean engineering background and at least five years of technical work experience to issues in technical management may apply for admission to the Joint Program in the Management of Technology. Jointly offered by MIT's School of Engineering and the Sloan School of Management, the program entails a rigorous twelve-month curriculum developed and taught by faculty from both schools, focusing on management principles for technical persons in a technical environment. The program is designed for scientists and engineers on a career path requiring increasing managerial responsibilities for technical activities, who plan to remain on the technical side of the organization rather than moving into general management positions in the near future. More information on general requirements and application procedure is included in Chapter V of this catalogue.

Joint MIT-WHOI Program Course XIII-W

A joint program with the Woods Hole Oceanographic Institution is intended for students whose primary career objective is oceanographic engineering. Students divide their academic and research efforts between the campuses of the two institutions. While in residence at MIT, students enrolled in this course follow a program similar to that of other students in the Department. The program is described in more detail under the section on MIT's Joint Program in Oceanographic Engineering with the Woods Hole Oceanographic Institution.

Entrance Requirements for Graduate Courses

Undergraduate preparation for admittance to graduate study in the Department of Ocean Engineering ideally should be equal in quality, quantity, and breadth of coverage to the Department's undergraduate curricula. An undergraduate degree in ocean engineering is not required.

If undergraduate preparation is lacking in one or more areas, the deficiencies may be made up concurrently with graduate work, usually by successfully completing one or a few upper level undergraduate subjects. Undergraduate subjects so required may not count toward advanced degree requirements. Somewhat less broad undergraduate work is required of candidates for the degree of Master of Science without specification, provided that the student has a correspondingly increased competence in areas pertinent to his or her proposed graduate program.

Requirements for Completion of Graduate Degrees

The program of studies for an advanced degree must meet the general requirements specified by the Institute in Chapter IV of this catalogue and must be acceptable to the Departmental Committee on Graduate Students.

The program for a Master of Science must include a minimum of 72 subject units plus a thesis acceptable to the Department. A minimum of 48 of the 72 units must be "A" subjects. The master's thesis should represent the equivalent of a half term of full-time work.

A program for an Engineer's degree ordinarily includes two subjects in the areas of economics, industrial management, public policy, or law, and at least 12 units of comprehensive design. Should the student be working toward the simultaneous award of the Engineer's and master's degrees, a single thesis generally is acceptable, provided it is appropriate to the specifications of both degrees and demonstrates the educational maturity expected of candidates for the higher degree.

Additional Departmental requirements applicable to the S.M. and Ocean Engineer's degrees, and a statement regarding Departmental policy with respect to combinations of degrees, are available from the Departmental Student Administration Office, Room 5-225, MIT, Cambridge, Massachusetts 02139, (617) 253-1994.

In addition to the Institute requirements for the doctoral program, the Department requires that a student successfully complete qualifying examinations before being admitted to a doctoral program. The programs of students must be acceptable to the Departmental Committee on Graduate Students, both with respect to depth in the major area and broadness in collateral areas. Details of the examination and other special Departmental requirements, including those for the doctoral thesis, may be obtained from the Departmental Student Administration Office.

The Department interprets its program rather broadly. Thus a program for a degree with specification can include selected subjects in other departments, such as mathematics, aeronautics and astronautics, or civil or mechanical engineering. The thesis may be in another department if it is directly applicable to the respective graduate degree program.

Assistantships and Graduate Scholarships

There are many teaching and research assistantships available to graduate students in the Department each year. These are awarded on the basis of both qualification and need. The duties associated with these assistantships contribute directly to the assistant's educational program. An assistant may not register for more than 36 units per term, depending on the appointment held. Additional registration may be allowed when directly connected with an assistant's assigned duties.

A limited number of MIT fellowships and scholarships are available to graduate students in the Department of Ocean Engineering. In addition, some industrial fellowship aid is available. Fellowships are also awarded each year by the Society of Naval Architects and Marine Engineers. These fellowships are valid for study at any institution of the recipient's choice and usually are awarded to applicants who, through their education or their professional work, have evidenced strong interest in some field of ocean engineering.

Prospective students are invited to communicate with the Department regarding any of these educational and financial opportunities. Applications for the Society of Naval Architects and Marine Engineers Graduate Fellowships are made directly to that Society. Inquiries for the fall term should be made late in the preceding fall term.

Inquiries

Additional information concerning academic programs, research opportunities, admissions, financial aid, etc. may be obtained by writing to the Department of Ocean Engineering, Room 5-225, MIT, Cambridge, Massachusetts 02139, (617) 253-1994.

Joint Program in Oceanographic Engineering with the Woods Hole Oceanographic Institution

MIT and the Woods Hole Oceanographic Institution (WHOI) on Cape Cod offer joint programs of graduate study and research for students with special interests in biological oceanography, chemical oceanography, marine geology, marine geophysics, oceanographic engineering, and physical oceanography. These graduate programs are administered by committees drawn from the faculty and staff of both institutions. Students accepted to the Joint Program have access to the extensive intellectual and physical resources available for advanced study at both Woods Hole and MIT.

The Woods Hole Oceanographic Institution operates three ocean-going research ships, and several inshore boats. A resident staff of more than 800 scientists, engineers, and support personnel conduct a wide range of ocean-related studies in biology, chemistry, physical oceanography, geology, geophysics, and oceanographic engineering from extensive laboratory facilities in Woods Hole. A marine facility is maintained by MIT in Boston Harbor consisting of dock space and a small research vessel capable of coastal work. Subjects in various aspects of oceanography as well as a large number of subjects directly applicable to ocean science and engineering are offered by many MIT departments and by the WHOI staff. These include:

1.19	Introduction to Technology and Law
1.59J	Materials of Construction
1.62	Free Surface Hydraulics
1.64	Dynamics of Stratified Fluids (A)
1.67	Sediment Transport and Coastal Processes (A)
1.68	Physics of Natural Water Bodies (A)
1.69	Introduction to Coastal Engineering (A)
1.691	Wave Dynamics in Coastal Engineering (A)
1.692	Wave Dynamics in Oceanographic Engineering (A)
1.697J	Oceanographic Systems I
1.698J	Oceanographic Systems II
1.699J	Special Projects in Oceanographic Engineering (A)
1.75	Limnology and Wetland Ecology (A)
1.76	Aquatic Chemistry (A)
1.79	Plankton Ecology (A)
1.80	Fundamentals of Ecology
2.065J	Flow Noise (A)
2.071J	Introduction to Structural Mechanics
2.131	Ecodynamic Systems I
2.132	Ecodynamic Systems II
2.63	Energy Production from Renewable Resources (A)
3.20	Thermodynamics of Materials (A)
3.21	Kinetic Processes in Materials (A)
3.35	Solidification Processing (A)
3.36J	Welding Engineering (A)
3.39	Mechanical Behavior of Materials (A)
3.54	Corrosion—The Environmental Degradation of Materials (A)
3.90J	Fracture of Structural Materials (A)
3.93J	Materials Science of Polymers (A)
6.455J	Marine Data Systems (A)
7.411-7.419	Seminars in Biological Oceanography (A)
7.421	Special Problems in Biological Oceanography (A)
7.43	Phytoplankton Ecology (A)
7.44	Ecology of Oceanic Zooplankton
7.45	Benthos and Fish (A)
7.46	Topics in Physiology and Biochemistry of Marine Animals (A)
7.491	Research in Biological Oceanography (A)
10.803	Introduction to Technology and Law
11.362	Land Use and Environmental Policy Implementation (A)
11.365J	Coastal Zone Management (A)
12.007	Dynamics of the Earth: Plate Tectonics and Continental Drift
12.011	Sedimentary Processes: Rivers
12.102	Plate Tectonics and Marine Geophysics (A)
12.20J	Environmental Chemistry of the Ocean-Atmosphere System
12.21	Physics of the Ocean
12.221-12.229	Project Studies in Oceanography
12.32	Mechanics of Sedimentary Processes (A)
12.56	Advanced Seminar in Plate Tectonics (A)
12.72	Oceanic Volcanology and Petrology (A)
12.73	Introduction to Marine Geology (A)
12.74	Marine Micropaleontology (A)
12.75	Marine Sediments (A)
12.76	Plants, Animals and Sediments (A)
12.77	Marine Geophysics (A)
12.781	Special Problems in Chemical Oceanography at Woods Hole (A)
12.79	Marine Sediments Laboratory (A)
12.791	Special Problems in Marine Geology and Geophysics at Woods Hole (A)
12.80	Marine Chemistry (A)
12.810J	Wave Motions in the Atmosphere and Oceans (A)
12.822	Paleoceanography (A)
12.83	Marine Geochemistry (A)
12.87	Equatorial Physical Oceanography (A)
13.014	The Oceans
13.021	Marine Hydrodynamics I (A)
13.07	Free Surface Hydrodynamics (A)
13.08	Stability and Motion Control of Ocean Vehicles (A)
13.09	Potential Flows (A)
13.10J	Introduction to Structural Mechanics
13.112J	Analysis and Design of Offshore Structures (A)
13.15	Materials for Ocean Engineering
13.441	Offshore Engineering Design (A)
13.442J	Interdisciplinary Design of Wave-Power Conversion Devices
13.74J	Marine Data Systems (A)
13.76	Introduction to Random Processes in Ocean Engineering (A)
13.84J	Flow Noise (A)
13.85	Fundamentals and Applications of Underwater Sound (A)
13.86	Ocean and Seabed Acoustics (A)
13.87	Wave Propagation in Random Media (A)
13.92	Public Policy and Use of the Sea (A)
13.94J	Ocean Engineering and Law Seminar (A)
13.961J	Resources Management (A)
13.962	Legal Aspects of Ocean Resources and Systems Management (A)
13.97	Introduction to Technology and Law
13.98J	Coastal Zone Management (A)
13.990J	Oceanographic Systems I
13.991J	Oceanographic Systems II
13.994	Buoy Engineering (A)

13.998	Principles of Oceanographic Instrument Systems—Sensors and Measurements (A)
13.999J	Special Projects in Oceanographic Engineering (A)
15.228J	Ocean Engineering and Law Seminar (A)
16.082J	Flow Noise (A)
16.792	Introduction to Technology and Law
17.326	International Organization, Legal and Political Response to Science and Technology (A)
19.05J	Environmental Chemistry of the Ocean-Atmosphere System
19.10	Climate of the Past
19.46	Numerical Modeling in Meteorology and Oceanography (A)
19.65J	Turbulence and Random Processes in Fluid Mechanics (A)
19.681	Synoptic Scale Dynamics in the Atmosphere and Oceans (A)
19.682	Instability and Turbulence in Geophysical Systems (A)
19.69	Fluid Dynamics of the Atmosphere and Ocean (A)
19.70	Oceanic and Atmospheric Models (A)
19.71J	Wave Motions in the Atmosphere and Oceans (A)
19.77	Introduction to Physical Oceanography (A)
19.78	Dynamics of Shelf Circulation (A)
19.79	Numerical Modeling in the Oceanographic Sciences (A)
19.83	Physical Oceanography
19.842	Dynamics of Eddies and Circulation (A)
19.851	Circulation in the Coastal Ocean (A)
19.86	The General Circulation of the Oceans (A)
19.87	Physical Properties of Seawater (A)
19.891	Special Problems in Oceanography (A)
19.97	Laboratory Course in Geophysical Fluid Dynamics (A)
19.98	Air Sea Interactions (A)
19.99	Experimental Physical Oceanography
20.111	Analytical Practices in Biochemistry (A)
20.611	General Toxicology (A)
20.612	Biochemistry of Xenobiotics (A)
20.811	Biochemical Engineering (A)
20.821	Industrial Microbiology (A)
22.085	Introduction to Technology and Law

Subjects, seminars, and opportunities for research participation are offered at both institutions. Students live in either Cambridge or Woods Hole and transportation is provided for them to commute the 80 miles between institutions so they can take advantage of all available resources. Students have the opportunity to participate in oceanographic cruises during graduate studies. Depending upon individual study and research programs, students are encouraged to reside for at least one year at each place. Upon admission, students register in the appropriate MIT department and are assigned academic advisors at each institution.

The Joint Program involves several departments at MIT — Biology, Earth and Planetary Sciences, and Meteorology and Physical Oceanography in the School of Science, and Chemical Engineering, Civil Engineering, Electrical Engineering and Computer Science, Materials Science and Engineering, Mechanical Engineering, and Ocean Engineering in the School of Engineering. Details concerning entrance requirements, examinations, financial aid, etc. may be found in the descriptions of each individual department and the description following the School of Science section.

Oceanographic Engineering

The Departments of Chemical Engineering, Civil Engineering, Electrical Engineering and Computer Science, Materials Science and Engineering, Mechanical Engineering, and Ocean Engineering offer joint programs in engineering with the Woods Hole Oceanographic Institution leading to the Engineer, the Doctor of Philosophy, or the Doctor of Science degree.

Students interested in oceanographic engineering, oceanography-related engineering problems, engineering in the ocean, or the control of the ocean and its resources can be served by the Joint Program in Oceanographic Engineering.

Inquiries

Application for admission to the Joint Program or for financial aid should be made on the MIT Graduate Application Form which may be obtained from the Director of Admissions at MIT or from the Education Office at WHOI. Requests for further information may be addressed to the Dean of Graduate Studies, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts 02543; or to the appropriate Department Headquarters, Joint Program in Oceanography, MIT, Cambridge, Massachusetts 02139.

Center for Advanced Engineering Study (CAES)

The MIT Center for Advanced Engineering Study was established in order to provide ways for experienced professionals to attain and maintain the competence needed for continued leadership in an age of technological change. The Center adds a new dimension to the activities of MIT by offering educational programs which are designed to enable experienced men and women from industry, government, and educational institutions to acquire the understanding and skills needed to open technical frontiers.

The programs of the Center include both on-campus and off-campus programs.

Advanced Study Program

The Advanced Study Program is planned to enable engineers and scientists to work in depth in technological areas pertinent to their professions. It is thus possible to accommodate technical managers who wish to understand those developments that bear directly on their problems, men and women who seek competence in depth at technological frontiers, and those who desire to strengthen their technological base.

Fellows of the Program are affiliated with the Center for one or more terms. Each Fellow may be associated with a faculty member who acts as an advisor for the Program and helps to arrange activities divided among formal classroom study, tutorial or research study, and other MIT opportunities best suited to the Fellow's needs and background.

Fellows may develop courses of study to meet their individual needs or may participate in specialized programs such as the Advanced Study Program in Air Transportation, or the Visiting Engineer Program.

The entire offering of MIT undergraduate and graduate subjects, seminars, and colloquia is available. Subjects may be selected from those offered by the Schools of Engineering, Science, Architecture and Planning, Management, and Humanities and Social Science. Participation in ongoing research work may be carried out and self-study programs with informal tutorial assistance can be arranged. The program of each Fellow can be largely tailored to individual specifications provided it represents a serious intellectual commitment commensurate with his or her background and professional aims.

Advanced Study Program in Air Transportation

The Advanced Study Program in Air Transportation at MIT is designed for individuals who have supplied and continue to supply the initiative, leadership, and accomplishment that has catalyzed progress in the development of the world's air transportation systems. The Program offered in conjunction with the Flight Transportation Laboratory provides the opportunity for such people to spend one or more academic terms on the MIT campus participating in on-going educational and research activities of the Flight Transportation Laboratory, the Center for Advanced Engineering Study, and other centers, laboratories, and academic departments at MIT.

The Program is designed for practicing professionals drawn from airport operators, airline managements, government agencies, and aviation manufacturers. It is a multidisciplinary program covering technology, management, economics, law, and operations research, designed to prepare the participant for a career in managing and planning the development of air transport systems. The Program is international in its outlook; it is intended to attract and provide training for participants from Europe, North and South America, Asia, Africa, and elsewhere around the world, as well as the USA.

Visting Engineer Program

The Visiting Engineer Program enables outstanding, experienced, research engineers to spend an academic year or longer at MIT pursuing research in close collaboration with one or more MIT faculty members. The Program is intended for research engineers in US industry, government, and universities who have an outstanding record of research accomplishment and who wish to pursue their research work at MIT.

Participants are affiliated with CAES and with an academic department or research center. They share collegial relationships with faculty and research groups at MIT and work on a research project of mutual interest. Most of the Visiting Engineers' time is spent in their MIT colleagues' laboratories. They also have study offices in the CAES building and share the facilities and services of the Center with the Fellows in the Advanced Study Program. Participants have access to regular Institute facilities and services and may, if they wish, attend one regular academic subject each academic term.

Tuition for the Visiting Engineer Program for the 1981-82 academic year is $11,000. Participants may arrive in late August or early September 1981 and stay until late May or early June 1982. The fee for the 1982 summer term (June through late August) is $4,000.

Interested engineers may write to the Director, Advanced Study Programs Center for Advanced Engineering Study, or to the head or the appropriate academic department or laboratory, or to the faculty member with whom they wish to work. A resume, a statement outlining the research topic or interest, and copies of several recent journal articles or reports should be included with the letter.

General Information about On-Campus Programs

The Programs coincide with the normal academic terms and academic year. Special weekly seminars are planned and conducted during the fall and spring terms especially for Fellows of the Advanced Study Programs and the Education for Public Management Program. Each year a few special subjects of broad interdisciplinary interest are also offered within the Center for participants in the Programs.

Before the fall term begins, participants in the Advanced Study Program may attend Calculus Revisited, an optional six-week review which provides an opportunity for strengthening mathematical skills before entering the mainstream of activities of the Center. This review is an intensive development of the first two years of a modern approach to calculus. The point of view adopted is that of the technical professional who intends to apply mathematics to his or her problems. The aim is to provide the real understanding that supplies the basis for more advanced work and for continued self-development as well as for proficiency.

A certificate is awarded following satisfactory completion of a Program. Fellows may apply for admission to the MIT Graduate School. Those who are accepted and who fulfill all the requirements of the Graduate School are eligible for advanced degrees. Grades are recorded for all MIT subjects which are taken for credit.

The tuition fee, payable to MIT for any of the Programs described above, is $5,500 for the fall or spring term, $11,000 for the two-term school year, $4,000 for the regular summer term, and $2,000 for Calculus Revisited. A limited number of scholarships from the grant provided by the Alfred P. Sloan Foundation to establish the Center may be awarded to faculty participants from other colleges and universities to pay part of the tuition fees.

The personal and family costs incident to living in greater Boston for participation in the Program vary among the participants according to their personal circumstances. A personal budget for the year should include: 1) living costs; 2) the extra costs involved in moving; and 3) the costs of books and other study materials. Information on living costs is sent to each applicant.

The primary requisites for admission are evidence of serious intent, intellectual maturity, and the technical background needed for participation, with appropriate guidance, in regular MIT subjects and other scholarly activities at the Institute.

Descriptive brochures and application forms may be obtained by writing the Director, Advanced Study Program at the Center for Advanced Engineering Study, Room 9-435, MIT, Cambridge, Massachusetts 02139 (617) 253-6162. Applications for the fall term should be received before April 1; for the spring term before December 1; and for the summer term before April 1.

Self-Study Subject Development Program

The Self-Study Subject Development Program provides off-campus continuing education opportunities for practicing engineers, industrial scientists, and technical managers through the medium of videotape. The principal elements of these subjects are a set of lectures on videotape, a textbook, and a study guide containing reading assignments, problem sets, quizzes, and solutions to the homework and quiz problems.

Subjects now available are:

Artificial Intelligence
Calculus
Colloid and Surface Chemistry
Computer-Aided Manufacturing
Robot Assembly
Computer Languages
Computer Cryptography
Corrosion Engineering
Decision Analysis
Digital Signal Processing
Economics
Electrochemistry
Electronic Feedback Systems
Engineering Economy
Finite Element Methods
Friction, Wear and Lubrication: Tribology I
Advanced Tribology
Fluid Dynamics
Integrated Optics
Introduction to Experimentation
Management of Technological Innovation
Technology, Innovation and Industrial Development
Mechanics of Polymer Processing
Microprocessor Fundamentals
Management of Microprocessor
Modern Control Theory
New Horizons in Materials Processing
Nonlinear Vibrations
Operational Amplifiers and Active Filters
Probability and Random Processes
Quality Planning and Control
Reliability Engineering
Systems Engineering and Management
Thermostatics and Thermodynamics
Uncertain Exchange Rates
Women's Work: Engineering and Management

Information regarding the rental or purchase of these self-study subjects may be obtained by writing to the MIT Center for Advanced Engineering Study, Dept. 99-A, Room 9-234, MIT, Cambridge, Massachusetts 02139, (617) 253-7444.

The Seminar Office

The Seminar Office was created to meet the short-term continuing education needs of the professional engineer. The Office coordinates programs presenting recent technological advances and/or the social consequences of these advances, and holds meetings providing perspectives on timely scientific issues. Also presented are programs which discuss trends in the marketplace and their relationship to technological development.

Individual programs vary in length, lasting from one day to one month, and concentrate on technical and management applications rather than theory. Depending on whether the meeting is a workshop, short courses, seminar, or conference, the size of the group may range from 12-1,000 attendees.

Programs are offered throughout the academic year and may be held at MIT or at other locations around the country as well as overseas. While most of the workshops and seminars are not announced outside of the United States, attendance is opened to professionals worldwide, and continuing education conferences are usually international in scope.

For more information, contact Christine Simonsen at the Center for Advanced Engineering Study, Room 9-335, MIT, Cambridge, Massachusetts 02139, (617) 253-7406.

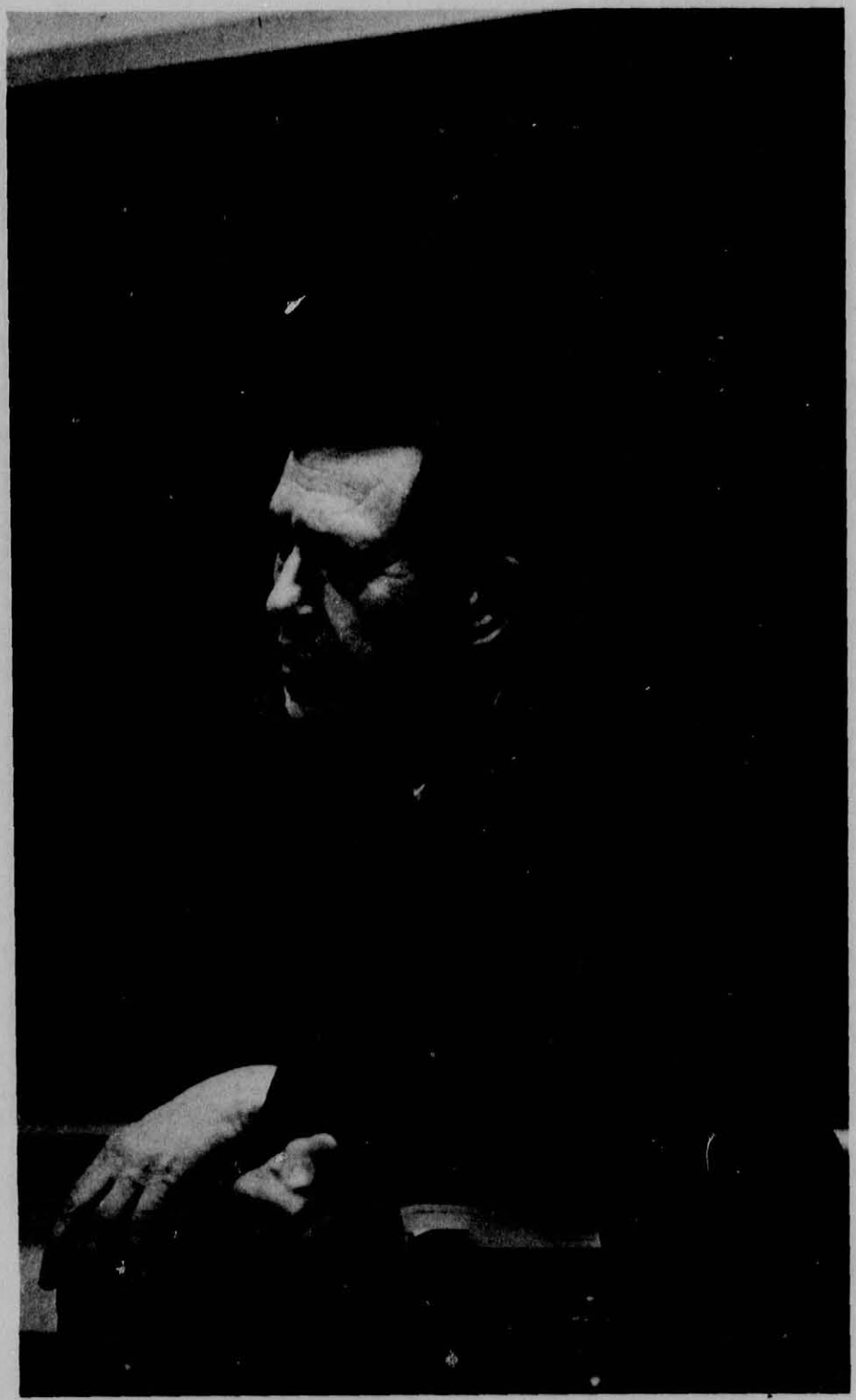
Research and Development in Continuing Education

The purpose of our research and development efforts in continuing education is to gain a better understanding of the technology transfer process as it relates to on-the-job problem solving. To date we have done studies of the impact of various technologies on this process, of various organizational environments, and of various critical topics. Our research has resulted in the development of several innovative sets of material and systems, e.g. PROCEED, electronically delivered courseware, and a prototype problem-oriented access system for users, which we call the Adaptive Reference System.

Our support is both industrial and governmental. Over thirty-five companies have contributed to our work as well as several departments, centers, and schools within MIT.

For more information, contact Karen Cohen at the Center for Advanced Engineering Study, Room 9-366, MIT Cambridge, Massachusetts 02139, (617) 253-6520.

School of Humanities and Social Science



The School of Humanities and Social Science reflects the great diversity of MIT today. In a university whose activities center around science and technology, the School represents the main fields of the liberal arts. Strong graduate programs exist in Economics, Linguistics, Philosophy, Political Science, and Psychology; students and faculty participate extensively in the research activities of numerous centers, laboratories, and departments outside the School. There is an ambitious and steadily broadening program of undergraduate education, which includes majors in economics, philosophy, language and mind, political science, and the humanities, plus an interdisciplinary major in science or engineering and the humanities. A flourishing program of extracurricular activities attracts many students, notably in drama and in music. Student participation in musical activities is, indeed, perhaps more extensive at MIT than at any other major university, with a vigorous symphony orchestra, several strong choral groups, a fine jazz band, a concert band, and a wide variety of similar groups.

The graduate programs are among the strongest at MIT. Because they admit relatively small numbers of students, teaching is conducted in a congenial atmosphere. The *esprit de corps* is strong and there is a marked emphasis on developing new and exciting fields of inquiry. Many students take advantage of the opportunity to develop close associations with such bodies as the Center for International Studies, the Center for Policy Alternatives, the Center for Advanced Engineering Study, the Energy Laboratory, the Research Laboratory of Electronics, and the Center for European Studies at Harvard. Some of the graduate programs stress the use of mathematical and computer-oriented skills, but many doctoral theses are concerned with non-quantitative social science or humanistic topics. Moreover, graduate students are not entirely confined to the established doctoral programs. There is always room for the occasional highly motivated student to develop a special program of his or her own.

The research achievements of the School are perhaps best known to the world at large through the widely publicized achievements of certain distinguished members of the faculty. The chief emphasis of research in the School, however, as in the rest of the Institute, has been less on the activities of brilliant individuals than on teamwork. In the field of communications, for example, there are many interdisciplinary projects, some involving collaboration among linguistics, philosophy, and psychology, which all have a special interest in psycholinguistics, and others involving political science and various branches of engineering. The Department of Economics and the Sloan School of Management cooperate closely in a number of branches of applied economics. Studies of the labor market are conducted by economists, sociologists, and political scientists. A long-established concern with science and public policy involves people all over the Institute, and is particularly strong in Political Science and the Program in Science, Technology, and Society. A growing interest among musicians in computers and acoustics leads them to work jointly with electrical engineers. As the engineering departments have become increasingly concerned with questions of applied social science, such as energy management, urban transportation problems, and the exploitation of the sea bed, new opportunities have emerged for collaboration.

Undergraduates benefit in a variety of ways from these advanced research and training programs. Students majoring in economics, philosophy, and political science, for example, take part in graduate seminars and may find part-time professional employment on faculty research projects. The Department of Humanities does not undertake graduate training, but does offer a number of undergraduate degree programs. Through Course XXI, students may major in one of the humanistic disciplines (history, literature, anthropology, music) or combine the study of any of these disciplines with a science or an engineering field in one of the unique dual degree programs (Course XXI-A and XXI-B, Program 1) offered by the Institute. In addition, Course XXI offers a major jointly administered by the Department of Humanities and the Program in Science, Technology, and Society. Undergraduates may indeed, once they have fulfilled the Institute Science Requirements, devote all of their time to the humanities and social sciences and acquire a solid foundation for advanced work in any of the disciplines represented in the School. The student of the humanities or social sciences who wishes to deepen his or her fluency in science or engineering, perhaps with an eye to a career in those fields, will also find a great deal of freedom (i.e., free elective time) to do so.

A chief concern of the School in undergraduate education has long been the provision of subjects to fulfill the purposes of the Institute Requirement in the Humanities, Arts, and Social Sciences. The School of Architecture and Planning offers some subjects that satisfy the requirement, but the great majority are provided by the School of Humanities and Social Science. The object of the requirement, broadly stated, is to ensure that every undergraduate at MIT is exposed to a wide range of cultural and intellectual influences. MIT seeks to offer much the same range of subjects as a first-rate liberal arts college, in addition to the special offerings made possible by well-developed graduate and research programs. There are numerous offerings in English and foreign literature, foreign languages, archaeology and anthropology, history, music and drama, and a wide variety of other subjects. The range of options is constantly changing, as new activities evolve at MIT and as student interests change. The arts have been expanding especially quickly, both in this School and in the School of Architecture and Planning. The requirement provides that every undergraduate must complete at least eight subjects in the humanities, arts, and social sciences. Three of these subjects are chosen from a list of over 100 subjects regarded as broadly humanistic in spirit; and in order to achieve some breadth of educational experience, students must select these subjects from three different fields of study. The requirement also provides that every undergraduate should have the opportunity to explore in some depth — three or four subjects — a single field of inquiry in which he or she takes a special interest.

The School is particularly anxious to encourage students equally concerned with the sciences and technology and with the humanities and social sciences to come to MIT. We are persuaded that modern society has been unduly constricted intellectually by the tradition that has tended to segregate scientific and humanistic education. Undergraduate education at MIT is moving increasingly in the direction already taken by research and placing growing emphasis on collaborative endeavors which connect the sciences and humanities.

The School's commitment to this view finds expression in a substantial Program in Science, Technology, and Society. This Program, which has both educational and research objectives, is concerned with the human consequences of scientific and technological advances. The Program is designed to be the interim, experimental phase in the development of a College of Science, Technology, and Society. The term "college" — first used at MIT in 1977 by the Whitaker College of Health Sciences, Technology, and Management — has been chosen to reflect the multidisciplinary and integrative character of this new venture.

To stress this new development is not to imply that MIT must emphasize science and technology in all its offerings in the humanities and social sciences. Ample room will remain for more or less conventional majors in economics, political science, philosophy, history, literature, foreign languages, anthropology, and music. Students will continue to demand the best in the humanities and social sciences as they demand the best in science and engineering. However, the emphasis will always be on making MIT undergraduate education something quite distinctive.

Harold John Hanham
Dean of the School of Humanities and Social Science

Office of the Dean

Harold John Hanham, Ph.D.
Professor of History and Political Science
Dean

Janet Romaine, B.A.
Assistant to the Dean

Peter Hopkinson Smith, Ph.D.
Associate Dean for the
Humanities Programs
Head, Department of Humanities
Professor of History
and Political Science

School Faculty and Staff Without Departmental Affiliation

Nicholas Herman, M.Div., M.B.A.
Research Associate

William Nash Locke, Ph.D.
Professor of Modern Languages, Emeritus
Director of Libraries, Emeritus

Program in Science, Technology, and Society

Carl Kaysen, Ph.D.
David W. Skinner Professor of Political Economy
Director

Peter Buck, Ph.D.
Assistant Director
Lecturer in the History of Science

Professors

Donald Laurence Morton Blackmer, Ph.D.
Professor of Political Science
Head, Department of Political Science
(Spring)
(Absent, fall)

Loren R. Graham, Ph.D.
Professor of the History of Science
(Absent)

Julian Gresser, J.D.
Professor of Law
(Visiting)

Gerald Holton, Ph.D.
James R. and Elizabeth P. Killian 1926 Visiting Professor

Kenneth Keniston, Ph.D.
Andrew W. Mellon Professor of Human Development

Thomas Samuel Kuhn, Ph.D.
Professor of Philosophy and History of Science

Leo Marx, Ph.D.
William R. Kenan Professor of American Cultural History

Robert Swain Morison, M.D., D.Sc.
Visiting Professor of Science and Society

Michael Joseph Piore, Ph.D.
Mitsui Professor in Problems of Contemporary Technology
Professor of Economics

Walter Alter Rosenblith, Ing. Rad.
Institute Professor

Merritt Roe Smith, Ph.D.
Professor of the History of Technology

Leon Trilling, Ph.D.
Professor of Aeronautics and Astronautics

Charles Weiner, Ph.D.
Professor of the History of Science and Technology

Jerome Bert Wiesner, Ph.D.
Institute Professor

Associate Professors

Louis Lawrence Bucciarelli, Ph.D.
Co-Director, Course XXI
Associate Professor of Engineering and Technology Studies

Kenneth Rogers Manning, Ph.D.
Class of 1922 Associate Professor of the History of Science

Emma Rothschild, M.A.
Associate Professor of Technology, Society and Rhetoric
(Absent, spring)

Sherry Roxanne Turkle, Ph.D.
Associate Professor of Sociology
(Absent, fall)

Joel Yellin, Ph.D.
Associate Professor of Environment, Technology, and Law

Assistant Professors

David Franklin Noble, Ph.D
Assistant Professor of the History of Technology

Charles Frederic Sabel, Ph.D.
Ford International Assistant Professor of Social Science

Research Associates

Marcel Evelyn Chotkowski LaFollette, Ph.D.

Harley Shaiken, B.A.

Fellows

Harley Balzer, Ph.D.
John H. Broomfield, Ph.D.
Martin Krieger, Ph.D.
John H. Weiss, Ph.D.
Rosalind Helen Williams, Ph.D.

Visiting Scholar

David E. Nye, Ph.D.

Administrator

Reta Marguerit Lee

Assistant to the Director

Rosalie Gerut

Professor Emeritus

Elting Elmore Morison, A.M.
Elizabeth and James Killian Class of 1926 Professor, Emeritus

Program in Science, Technology, and Society

Undergraduate Study

The rapid growth of science and technology in the 20th century has generated problems and conflicts which have a direct impact on people's lives and on the shape of society as a whole. Along with an awareness of these problems has come an increasing recognition that social, political, and ethical considerations in turn help determine the nature of scientific and technological development.

To provide a context in which these interactions can be systematically explored, MIT in 1977 committed itself to the creation of a College of Science, Technology, and Society. The Program in Science, Technology, and Society was established at that time as the interim, experimental phase of the College.

This new Program reflects MIT's longstanding concern to give its students an understanding of the human ramifications of science and engineering. Many individuals and programs at the Institute have devoted themselves to the study of particular aspects of these questions. But until now, there has been no substantial program, with both educational and research objectives, focused centrally and directly on the ways in which scientific, technological, and social factors interact to shape modern life.

STS is intended to be a center where faculty and students from all parts of the Institute can come together to discuss these interactions, the study of which clearly transcends the boundaries of any single discipline. Because the Program draws its faculty from the social and natural sciences, engineering, and the humanities, it is able to combine varied approaches to the field. STS employs the techniques and perspectives of the humanities and social sciences to examine the history, sociology, and philosophy of science and technology. At the same time, the Program looks at current social and political issues surrounding the growth and uses of scientific knowledge and technology. Through this combination of approaches, STS aims to understand the social, scientific, and technological forces which have given rise to the problems and possibilities facing contemporary industrial societies.

By exploring both the range of social and cultural forms which have evolved in response to scientific and technological changes and the variety of scientific and technological means which have been fashioned to serve human needs and purposes, STS aims to help students think more realistically, creatively, and humanely about important intellectual, moral, and social issues of our time.

There are several ways in which undergraduates can become involved in the Program. STS offers a wide range of undergraduate subjects intended to introduce students to the historical, social, and cultural contexts of science and engineering. The curriculum is organized around five general areas of inquiry: 1) the history of science; 2) the history of technology; 3) contemporary issues in science, technology, and society; 4) science, technology, and the organization of industrial society; and 5) cultural dimensions of science and technology. Within each of these categories, students can choose both broad-based introductory subjects and more specialized advanced subjects.

All STS undergraduate subjects can be counted toward the Institute Requirement in the Humanities, Arts, and Social Sciences. Besides electives, the Program offers a number of Humanities Distribution subjects. For students who want a deeper knowledge of the issues addressed by the Program, STS is available as a Field of Concentration.

Although at present there is no undergraduate major in Science, Technology, and Society, the Department of Humanities, in collaboration with STS faculty members, offers a special version of the interdisciplinary major in Humanities and Science or Engineering for students interested in the social and cultural dimensions of science and technology. (For a detailed description of this option, see Degree Program Requirements under the Department of Humanities.) Students majoring in other disciplines, such as political science or engineering, can also structure their programs to include a strong STS component. It is anticipated that STS will offer a degree program within the next few years. In addition, plans for the development of collaborative and dual degree programs between STS and other MIT Schools and departments are now under way.

Graduate Study

STS offers several graduate level subjects jointly with other MIT departments, but does not yet have a formal graduate program. Graduate students who wish to pursue questions relating to interactions among science, technology, and society are encouraged to consult with STS faculty members concerning the variety of arrangements which can be made to meet their needs and interests. Students can participate in reading and research seminars, become involved in faculty research projects, and, with departmental permission, structure a special concentration or minor in STS as part of their degree program. Individually tailored interdepartmental degree programs can also be arranged.

Research Assistantships

A few research assistantships are available each year to qualified graduate students for work under STS faculty supervision on projects supported by the Program.

Inquiries

Additional information on the Program may be obtained from the Director's office, Room E51-110, MIT, Cambridge, Massachusetts 02139, (617) 253-4062.

For subjects in Science, Technology, and Society, see STS 100-600 in Chapter VII of this catalogue.

Department of Economics

Edgar Cary Brown, Ph.D.
Professor of Economics
Head of the Department

Ann Fetter Friedlaender, Ph.D.
Professor of Economics and Civil Engineering
Associate Head of the Department

Professors

Morris Albert Adelman, Ph.D.
Professor of Economics

Sidney Stuart Alexander, Ph.D.
Professor of Economics and Management

Robert Lyle Bishop, Ph.D.
Professor of Economics

Michael Bruno, Ph.D.
Professor of Economics
(Visiting, fall)

Peter Arthur Diamond, Ph.D.
Professor of Economics

Evsey David Domar, Ph.D.
Ford International Professor of Economics

Rudiger Dornbusch, Ph.D.
Professor of Economics

Richard Samuel Eckaus, Ph.D.
Ford International Professor of Economics

Stanley Fischer, Ph.D.
Professor of Economics
(Absent)

Franklin Marvin Fisher, Ph.D.
Professor of Economics

Jerry Allen Hausman, D.Phil.
Professor of Economics

Paul Lewis Joskow, Ph.D.
Professor of Economics

Edwin Kuh, Ph.D.
Professor of Economics and Finance

Eric Stark Maskin, Ph.D.
Professor of Economics
(Absent)

Daniel Little McFadden, Ph.D.
Professor of Economics

Franco Modigliani, D.Jur., D.Soc.Sci., LL.D.
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Professor of Economics and Finance

Michael Joseph Piore, Ph.D.
Mitsui Professor in Problems of Contemporary Technology
Professor of Economics

Dale John Poirier, Ph.D.
Professor of Economics
(Visiting)

Kevin William Stuart Roberts, Ph.D.
Professor of Economics
(Visiting, fall)

Jerome Rothenberg, Ph.D.
Professor of Economics

Paul Anthony Samuelson, Ph.D., LL.D., D.Litt., Sc.D.
Institute Professor
Professor of Economics

Robert James Shiller, Ph.D.
Professor of Economics
(Visiting)

Abraham Siegel, Ph.D.
Professor of Industrial Relations
Dean, Alfred P. Sloan School of Management

Robert Merton Solow, Ph.D., LL.D., D.L.H.
Institute Professor
Professor of Economics

Gordon Robertson Sparks, Ph.D.
Professor of Economics
(Visiting)

Lance Jerome Taylor, Ph.D.
Professor of Nutritional Economics

Peter Temin, Ph.D.
Professor of Economics

Lester Carl Thurow, Ph.D.
Professor of Economics and Management

Martin Lawrence Weitzman, Ph.D.
Professor of Economics
(Absent, fall)

Associate Professors

Thomas Gilbert Cowing, Ph.D.
Associate Professor of Economics
(Visiting)

Henry Stuart Farber, Ph.D.
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Jeffrey Earl Harris, M.D., Ph.D.
Associate Professor of Economics

William Cody Wheaton, Ph.D.
Associate Professor of Economics

Assistant Professors

Joseph von Rosthorn Farrell, D.Phil.
Assistant Professor of Economics

Timothy Jerome Kehoe, Ph.D.
Assistant Professor of Economics

Robert Bruce Litterman, Ph.D.
Assistant Professor of Economics
(Absent)

Marilyn Jo Simon, Ph.D.
Assistant Professor of Economics

Lawrence Henry Summers, Ph.D.
Assistant Professor of Economics

Thomas John Teisberg, Ph.D.
Assistant Professor of Economics
(Absent)

Administrative Officer

Idella Lyman Tapley, A.B.

Professors Emeriti

Harold Adolph Freeman, S.B.
Professor of Statistics, Emeritus

Everett Einar Hagen, Ph.D.
Professor of Economics and Political Science, Emeritus

Charles Poor Kindleberger, Ph.D., D.H.C.
Ford International Professor of Economics, Emeritus

Charles Andrew Myers, Ph.D.
Professor of Industrial Relations
Sloan Fellows Professor of Management, Emeritus
Senior Lecturer

Paul Pigors, Ph.D.
Professor of Industrial Relations, Emeritus

Paul Narcyz Rosenstein-Rodan, Dr.Rer.Pol.
Professor of Economics, Emeritus

Department of Economics

Undergraduate Study

Economics, the study of economic institutions and systems, is useful in an intellectual sense because it trains students to think carefully and logically about complex social phenomena and to bring to mind relevant information on them. With such knowledge it is possible to understand the impact of broad socioeconomic developments and policies on economic systems and institutions as well as the response of these units to them. The growing awareness of these interactions on the part of scientists and engineers makes the study of economics especially relevant at MIT.

Bachelor of Science in Economics Course XIV

The Course leading to the Bachelor of Science in Economics combines training in technical economics with opportunities for a broad and balanced undergraduate education. Students may select programs that emphasize the relation of technology to economics by concentrating their free time in science and engineering; they may choose programs that concentrate more heavily on economics and other social sciences; or they may undertake to relate economics to history, philosophy, or literature. The successful completion of the degree prepares students for study in economics, industrial relations, business administration, law, and related fields, or for careers in teaching, government, research, unions, and business.

The aims of the degree program are threefold: to give students a firm grounding in modern economic theory; to provide a basic descriptive knowledge of the US and world economy; and to develop in students the capability for quantitative research and independent thought. These aims roughly correspond to the requirements of theory, electives, statistics, and research.

The requirements allow substantial freedom for students in designing individual programs within economics and in balancing the programs with subjects in other disciplines. The large amount of unrestricted elective time encourages students to shape programs close to their own needs and interests.

Students who have taken 14.01 Economic Principles I and 14.02 Economic Principles II by the end of their second year can follow a program which permits considerable depth in electives in the third and fourth years. The most satisfactory plan is to take 14.04 Intermediate Microeconomic Theory and 14.06 Intermediate Macroeconomic Theory in successive terms of the third year and to complete 14.31 Econometrics before the end of the third year. This satisfies prerequisites for all subjects, and prepares students for thesis research.

The Department specifies one science distribution subject, and one laboratory subject, and strongly recommends that all students take an additional subject in computer techniques and, if professionally interested in economics, further work in mathematics.

Bachelor of Science in Economics Course XIV

	General Institute Requirements		Total units
	Specific science and humanities and social science subjects[1]		132
	The Science Distribution Requirement can be satisfied by 14.30, which is required in the Departmental Program, plus appropriate subjects totaling		24
	The subject 14.31 which is required in the Departmental Program, appears on the list of Laboratory Subjects and can be used to satisfy the Laboratory Requirement		
	Departmental Program		
	Required Subjects		75
14.01	Economic Principles I	3 0 6	
14.02	Economic Principles II	3 0 6	
14.04	Intermediate Microeconomic Theory	4 0 8	
14.06	Intermediate Macroeconomic Theory	4 0 8	
14.30	Introduction to Statistical Method in Economics[2]	4 0 8	
14.31	Econometrics[3]	3 4 5	
	Thesis	9	
	Restricted Electives		63
	Elective subjects in economics	39	
	A coherent program in a field related to economics but outside the Department as agreed on between the student and the Faculty Advisor. Subjects which also satisfy the General Institute Requirement may be used with a corresponding increase in unrestricted electives.	24	
	Unrestricted Electives		66
	Total Units Required for the S.B. Degree		360

1
No more than 27 units in Economics, excluding the required subjects, and 14.11 Mathematical Economics and 14.31 Econometrics, may be used for the Humanities, Arts, and Social Sciences Requirement.
2
Or an approved alternative in statistics.
3
14 UR Undergraduate Research (12) approved as to content may be substituted for 14.31.

Graduate Study

Entrance Requirements for Graduate Study

The Department specifies the following prerequisites for graduate study in economics: one full year of college mathematics, including at least one term of calculus; one full year of college work in science; at least six term subjects in English, history, and other humanities or social science subjects (not in the candidate's own professional field) equivalent to those included in the undergraduate curriculum at MIT; and an appreciable number of professional subjects in economics for those qualified students who have majored in fields other than economics. A student whose deficiencies are of minor extent may be permitted graduate registration while taking appropriate subjects to remove them.

Master of Science in Economics

The majority of graduate students in the Department are doctoral candidates. Under special circumstances, however, admission may be granted to candidates seeking the Master of Science degree. The general requirements for the S.M. are given in Chapter III of this catalogue.

Doctor of Philosophy

A candidate for the doctorate must 1) demonstrate a mastery of five fields of study, one of which is economic theory, both micro- and macro-; 2) achieve a specified level of competence in economic history and econometrics; 3) submit and defend a dissertation that represents a contribution to knowledge; and 4) be in residence for a minimum of two years. Three of the five fields, including economic theory, are covered by the General Examination. Two minor fields may be satisfied by one year of course work. The four major and minor elective fields may be chosen from advanced economic theory, monetary economics, fiscal economics, industrial organization, transportation, international economics, economic development, Russian and Soviet economics, comparative economic systems, urban economics, labor economics, economic history, statistical theory, econometrics, human resources and the distribution of income and wealth, and (given outside the Department) finance. The econometrics requirement may be satisfied by offering it as a field or by taking 14.388 Applied Econometrics and, in either case, completing a major piece of empirical research. The minimal economic history requirement can be satisfied by taking one subject in the field.

No stated number of graduate subjects in the Department is required. However, the candidate ordinarily needs two full academic years of study to prepare adequately for the General Examination and to meet the other pre-thesis requirements. The doctoral thesis must be written in residence; as a rule, it represents at least one year's research.

The Department has no general foreign language requirements. When a foreign language is essential for full access to the literature in the field of major interest (for example, European economic history, Russian economics) or to thesis research, a language requirement is imposed by the Department upon the recommendation of the thesis supervisor or the Graduate Registration Officer. Such a requirement is administered by the Department of Humanities and can be met by satisfactory course work at other schools or at MIT or by examination.

Students interested in developing professional competence in economics and planning problems of the city may elect an interdepartmental program in the Departments of Economics and Urban Studies and Planning. Depending on background, candidates can expect two and one-half academic years of work to prepare for the General Examination.

Teaching and Research Assistantships

A limited number of students are supported by teaching and research assistantships. Typically, these appointments are available only to students who have passed their general examinations, but in special circumstances, research assistantships may be held by second-year students.

Inquiries

Additional information concerning academic programs in the Department, admissions, financial aid, etc. may be obtained by writing to Professor Robert L. Bishop, MIT, E52-344, 50 Memorial Drive, Cambridge, Massachusetts 02139, (617) 253-6181.

Department of Humanities

Peter Hopkinson Smith, Ph.D.
Professor of History and Political Science
Head of the Department
Associate Dean for Humanities Programs

Professors

Richard Mateer Douglas, Ph.D.
Professor of History

Martin Dyck, Ph.D.
Professor of German and Literature

David Mayer Epstein, Ph.D.
Professor of Music
Conductor of the MIT Symphony Orchestra
(Absent, spring)

Robert Michael Fogelson, Ph.D.
Professor of History and Urban Studies

Loren Graham, Ph.D.
Professor of the History of Science

Albert Ramsdell Gurney, Jr., M.F.A.
Professor of Literature
(Absent)

Harold John Hanham, Ph.D.
Professor of History and Political Science
Dean, School of Humanities and Social Science

John Harbison, M.F.A.
Professor of Music

James Wesley Harris, Ph.D.
Professor of Spanish and Linguistics

Robert Emmet Jones, Ph.D.
Professor of French and Humanities
(Absent)

Louis Kampf, B.A.
Professor of Literature

Alvin Charles Kibel, Ph.D.
Professor of Literature

Heather Nan Lechtman, M.A.
Professor of Archaeology and Ancient Technology
Director, Center for Materials Research in Archaeology and Ethnology

Robert Ellsworth MacMaster, Ph.D.
Professor of History and Literature

Thomas Henry Donald Mahoney, Ph.D.
Professor of History
(Absent)

Pauline Maier, Ph.D.
Professor of History
(Absent, fall)

Bruce Mazlish, Ph.D.
Professor of History

Krystyna Pomorska, Ph.D.
Professor of Russian and Literature

Harald Anton Thrap Olsen Reiche, Ph.D
Professor of Classics and Philosophy

Robert Irwin Rotberg, D.Phil.
Professor of History and Political Science

Merritt Roe Smith, Ph.D.
Professor of the History of Technology

Barry Bernard Spacks, M.A.
Professor of Literature

Jean Valentine, B.A.
Professor of Writing
(Visiting, fall)

Cynthia Griffin Wolff, Ph.D.
Professor of Literature

Associate Professors

Jeanne Shapiro Bamberger, M.A.
Associate Professor of Education and Music

John La Boiteaux Buttrick, M.S.
Associate Professor of Music

Elzbieta Ettinger Chodakowska, Ph.D.
Associate Professor of Writing

Catherine Vakar Chvany, Ph.D.
Associate Professor of Russian

Jane Coppock, Ph.D.
Associate Professor of Music

Isabelle de Courtivron, Ph.D.
Associate Professor of French
(Absent, fall)

Martin Diskin, Ph.D.
Associate Professor of Anthropology

Peter Samuel Donaldson, Ph.D.
Associate Professor of Literature
(Absent, spring)

Stephen Erdely, Ph.D.
Associate Professor of Music
Director of Music
(Absent, spring)

Rae Goodell, Ph.D.
Associate Professor of Science Writing

James Howe, Ph.D.
Associate Professor of Anthropology

Jean Elizabeth Jackson, Ph.D.
Associate Professor of Anthropology

Arthur Daniel Kaledin, Ph.D.
Associate Professor of History and American Studies

Lowell Edwin Lindgren, Ph.D.
Associate Professor of Music
(Absent, spring)

Travis Rhodes Merritt, Ph.D.
Associate Professor of Literature

James Paradis, Ph.D.
Associate Professor of Technical Communication

Ruth Perry, Ph.D.
Associate Professor of Literature

Elizabeth Pleck, Ph.D.
Associate Professor of History
(Visiting)

David Bird Ralston, Ph.D.
Associate Professor of History

Margery Resnick, Ph.D.
Associate Professor of Spanish
Director of Modern Languages

Emma Rothschild, M.A.
Associate Professor of Technology, Society, and Rhetoric

Arthur Steinberg, Ph.D.
Associate Professor of Archaeology

Stephen James Tapscott, Ph.D.
Associate Professor of Literature

Irene Tayler, Ph.D.
Thomas Meloy Associate Professor of Rhetoric and Literature

Marcus Aurelius Thompson, D.M.A.
Associate Professor of Music

David Thorburn, Ph.D.
Associate Professor of Literature

Edward Baron Turk, Ph.D.
Associate Professor of French

Barry Lloyd Vercoe, D.M.A.
Associate Professor of Music and Technology

Ellen Voigt, M.F.A.
Associate Professor of Poetry
(Absent, fall)

William Braasch Watson, Ph.D.
Associate Professor of History

Assistant Professors

Timothy Charles Aarset, D.M.A.
Assistant Professor of Music

Julia Alissandratos, Ph.D.
Assistant Professor of Russian

Bernard Avishai, Ph.D.
Assistant Professor of Writing

Alan David Brinkley, Ph.D.
Assistant Professor of History

Kathryn Crecelius, Ph.D.
Assistant Professor of French
(Absent, fall)

Suzanne DeAtley, Ph.D.
Assistant Professor of Archaeology

Susan Dickman, Ph.D.
Assistant Professor of Literature

David Dobrin, Ph.D.
Assistant Professor of Technical Writing

David Dollenmayer, Ph.D.
Assistant Professor of German
(Absent)

Ellen Fitzpatrick, Ph.D.
Assistant Professor of History

Elizabeth Garrels, Ph.D.
Assistant Professor of Spanish
(Absent)

Barbara Gastel, M.D.
Assistant Professor of Science Writing

Michael Geisler, Ph.D.
Assistant Professor of German

David Martin Halperin, Ph.D.
Assistant Professor of Literature

Frederick Hodgson, Ph.D.
Assistant Professor of French
(Absent, spring)

Philip Khoury, Ph.D.
Assistant Professor of History

Amy Lang, Ph.D.
Assistant Professor of Literature
(Absent, spring)

William Paul, Ph.D.
Assistant Professor of Literature

Louise Popkin, Ph.D.
Assistant Professor of Spanish
(Visiting)

Thomas Postlewait, Ph.D.
Assistant Professor of Writing

Harriet Ritvo, Ph.D.
Assistant Professor of Writing

Jay Rosellini, Ph.D.
Assistant Professor of German

Robert N. Scanlan, Ph.D.
Assistant Professor of Drama and Theatre Arts

Wilma Elaine Wetterstrom, Ph.D.,
Assistant Professor of Anthropology and Archaeology

Joanne Yates, Ph.D.
Assistant Professor of Business Communication

Senior Lecturers

Claire Jeanne Kramsch, M.A.
Senior Lecturer in German
(Absent, spring)

John Oliver, M.M.
Senior Lecturer in Music
Director, MIT Choral Society

Lecturer in Dance

Beth Soll, B.S.

Lecturers in English as a Foreign Language

Kathy Irving, M.A.
Abelle Mason, M.A.

Lecturers in French

Gilberte Furstenberg, M.A.
Jacqueline Hill, M.Ed.
Annie Poignant-Geoghegan, M.A.

Lecturers in German

Katherine Paszkolovits, M.A.
Christine Stets, M.A.

Lecturer in Humanities

Robert Allen Fein, Ph.D.

Lecturers in Music

Edward Cohen, M.A.

John Cook, Mus.B.

Adrianus Johanes Maria Houtsma, Ph.D.

Melissa Howe, M.M.

Lecturers in Spanish

Evelyn Lilienfeld, B.A.

Douglas Morgenstern, M.A.

Lecturers in Writing

Robin Becker, M.A.

Frank Conroy, B.A.
(Visiting)

Barbara Hartmann, Ph.D.

Fanny Howe

Ilona Karmel, A.B.

Marilyn Richardson, B.A.

Charles Sides, Ph.D.

Instructors

Suzanne Flynn, M.S.
Steven Mullaney, B.A.
Peter Cushing Perdue, M.A.
Sharon Traweek, M.A.
Janie Vanpee, M.A.
Gladys Varona-Lacey, M.A.

Administrative Officer

Marjorie Stern Lucker, A.B.

Director of Language Laboratory

Ruth Trometer, B.A.

Professors Emeriti

Howard Russell Bartlett, B.S., A.M.
Professor of History, Emeritus

Lynwood Silvester Bryant, A.M.
Professor of History and American Studies, Emeritus

Margaret Zaroodny Freeman, S.M.
Associate Professor of Russian, Emerita

William Chace Greene, M.A.
Professor of Literature, Emeritus

Edward Neal Hartley, A.M.
Professor of History, Emeritus
Institute Archivist, Emeritus

Richard Felix Koch, A.M.
Assistant Professor of Modern Languages, Emeritus

Roy Lamson, Ph.D.
Class of 1922 Professor of Literature, Emeritus

Klaus Liepmann
Professor of Music, Emeritus
Director of Music, Emeritus

Robert Reynolds Rathbone, A.M.
Professor of Technical Communication, Emeritus

Cyril Stanley Smith, Sc.D.
Institute Professor, Emeritus
Professor of the History of Science and Technology, Emeritus
Professor of Metallurgy, Emeritus

Theodore Wood, Jr., A.M.
Professor of Literature and American Studies, Emeritus

Robert Smith Woodbury, S.B., A.M.
Professor of the History of Technology, Emeritus

Department of Humanities

The Department of Humanities provides substantial curricula in anthropology/archaeology, foreign languages and literatures, history, literature, music, and writing, as well as special programs in American studies, Russian studies, the western tradition, ancient and medieval studies, and drama. In view of MIT's particular educational character, the Humanities faculty is committed to complementary objectives: to affirm and sustain the distinctiveness of humanistic study in itself as an indispensable element in a whole education; and to explore opportunities for productive interaction with scientific and technical disciplines. These aims are reflected in the variety and depth of the subject offerings.

As indicated in the descriptive summaries below, all the programs in or associated with the Department provide subjects which help to satisfy the Institute Requirement in Humanities, Arts, and Social Sciences; most include Distribution Subjects and Fields of Concentration which meet the principal terms of that Requirement; several are available as undergraduate degree programs in Course XXI, either in combination with Engineering or Science curricula (XXI-A, XXI-B, 1) or as full majors (XXI-B, 2).

Anthropology/Archaeology

Distribution Subjects
Field of Concentration
Major Programs: XXI-A; XXI-B, 1; XXI-B, 2

Anthropology studies human beings and their great diversity in adapting to physical and social environments. While the discipline is interested in humankind as a biological species, its tools and technology, its languages, modes of organization, ideas, religion, politics, and many other aspects, it is rooted in the notion that human creativity responds to these circumstances through the use of culture. Anthropology, then, is the study of culture. The archaeological emphasis examines human cultures over long time periods, mainly through the study of material remains. The cultural anthropological perspective draws its materials from the direct study of contemporary peoples living in a wide range of circumstances, from peasant villagers, tropical forest hunters and gatherers, to urban populations in the US.

The Anthropology/Archaeology Program at MIT offers students a broad exposure to the field. At the same time, the specialized research interests of its faculty permit students greater depth in certain areas. Members of the staff teach and conduct research on social and political organization, ecology, symbol systems, technology, material science, and paleobotany. Area interests concentrate on the New World, highland cultures of both Mexico and Peru as well as cultures of the tropical forest region of South and Central America. This focus includes contemporary groups and the ancient civilizations of the Andes and Mesoamerica. In addition, civilizations of the Mediterranean and ancient Near East are studied, particularly through their technological achievernents.

Two fields of interest currently are being developed in collaboration with colleagues and students of other departments. One involves the study of the technological aspect of ancient cultures and is carried out together with colleagues in the Department of Materials Science and Engineering. The other deals with cross-cultural studies of nutrition in conjunction with the Department of Nutrition and Food Science. In both of these areas there are ongoing research projects in which students may participate by arrangement with the appropriate faculty members.

The subjects offered within the Anthropology/Archaeology Program are organized in two groups: the Introductory Level (without prerequisites), and the Advanced Level. Included in the Anthropology/Archaeology offerings are subjects that may count as electives as well as Distribution subjects to satisfy the Institute requirements for the Humanities, Arts, and Social Sciences. A concentration in Anthropology/Archaeology may be arranged and students are advised to select from the Introductory level with a mix of Cultural Anthropology and Archaeology subjects.

The interdisciplinary concentration "Technology, Culture, and Development" is also offered through the Anthropology/Archaeology Program. Further information on the list of approved subjects is available in the Program office 14N-408, x3-3065, or through N. Herman 20B-232, x3-4089.

A major is also offered in XXI-A; XXI-B,1; XXI-B,2 (see programs concluding this section). Students interested in the major should consult an advisor as early as possible.

Foreign Languages and Literatures

Distribution Subjects
Field of Concentration
Major Programs: XXI-A; XXI-B, 1; XXI-B, 2

The Foreign Languages and Literatures Section offers a variety of programs. There are subject sequences in French, German, Greek, Russian, Spanish language and literature taught in the original; a subject sequence on literature taught in English translation; and a comprehensive program in English as a second language.

The study of a foreign language broadens one's cultural perspective, sharpens awareness of use and meaning of words in our own language, and increases one's range of expression. At MIT, students have the opportunity to bring their knowledge of a foreign language to the level at which they can not only speak fluently, but also read with pleasure. This skill, if preserved through use, is an intellectual and personal asset throughout a lifetime, no matter what career a student pursues.

In the programs at MIT, introductory subjects aim to familiarize students with the basic principles of the language in both its spoken and written forms. Instruction

includes reading of appropriate texts, practice in writing, and an introduction to the culture of the countries where the language is spoken. The intermediate level provides for review and refinement of grammar, study of more difficult reading matter with cultural and literary content, and compositions and discussions in the foreign language based on the reading material. Advanced subjects conducted in the foreign language stress analysis of the form and content of the literature and study of the culture and civilization of each country. A well-equipped language laboratory facilitates language learning.

Subjects in literature in translation make available in English great works from foreign literatures. These subjects enable students who do not know the original language to experience new avenues of thought, vision, and feeling. Although these subjects are given in English, students with a reading knowledge of a specific language will be encouraged to read works in the original. Courses in this sequence range from broad introductory subjects to more specific aspects of literary study.

Students may concentrate in any field of language and literatures. Programs should be arranged on an individual basis in consultation with a designated advisor.

Major programs are offered (XXI-A, XXI-B, 1, XXI-B, 2) in French, German, Russian, and Spanish.

All subjects may be counted as electives to fulfill the Institute Requirement in the Humanities, Arts, and Social Sciences. All level III and IV language subjects are counted for Distribution as are a number of subjects in foreign literature in the original language and world literature in English translation.

In choosing language subjects, students should bear in mind that credit toward graduation is not given for repeating work offered for admission.

Proficiency in a foreign language is a prerequisite for election to Phi Beta Kappa.

For subjects in Foreign Languages and Literatures in the original and in translation see subjects 21.201-21.349 in Chapter VII of this catalogue.

History

Distribution Subjects
Field of Concentration
Major Programs: XXI-A; XXI-B, 1; XXI-B, 2

History is the study of the recorded past. Interest in the past is, however, closely linked with a desire to understand the present. The history curriculum at MIT is therefore tailored in part to put the modern world in historical perspective. Subjects explore the social, economic, and political transformations that shape the present; and efforts are made to suggest where traditional assumptions remain in present-day politics, society, and culture.

The curriculum is centered in but not confined to European and American history, and seeks to encourage both an understanding of the human past and the development of skills necessary to articulate that knowledge effectively. Subject listings are divided into "Basic Fields" which provide surveys of scholarship organized by place and by topic or period, many of which fulfill the requirement for Humanities Distribution, and "Special Subjects and Seminars," which are more limited in scope and specialized in focus, and which are not necessarily offered on as regular a basis as are those designated "Basic Fields."

For subjects in History, see 21.350-21.491 in Chapter VII.

Literature

Distribution Subjects
Field of Concentration
Major Programs: XXI-A; XXI-B, 1; XXI-B, 2

The curriculum in literary studies at MIT has a double intent. First, it aims to meet the interests of the general student, who may be drawn to literary study only once or twice in his or her career at the Institute. Second, it provides a rich program of study for students concentrating or majoring in literature. To an extent unusual in an undergraduate program, the curriculum lays emphasis on interdisciplinary approaches to literary texts and on theoretical, generic, and thematic subjects that range across geographical and historical boundaries.

Every literature subject offers significant opportunities for individual participation in class discussion and **every subject is centrally committed to improving students' writing skills.**

A *Supplement* to this catalogue, available from the Humanities Department offices, offers more detailed descriptions of all literature subjects and includes specific information about required texts, writing assignments, and examinations.

Humanities Distribution Subjects. The new literature curriculum is notable for the range of its HUM-D offerings. In 1981-82 the Literature Section offers at least 14 subjects carrying Humanities Distribution credit. The most broad-gauged of these, recommended especially for students seeking general introductions to literary study, are 21.001 **Literature I,** which samples masterpieces of epic, drama, lyric, novel and film; 21.006 **Introduction to American Literature,** a survey of major American texts; and 21.010 **Literature and Film,** an introduction to narrative forms. Introductory subjects in Fiction, Poetry, and Drama are also available.

Nine other subjects carrying HUM-D credit are listed in the intermediate tier of the curriculum, and are open to all students. They include: Comedy; Tragedy; The Film Experience; Shakespeare; Modern Russian Literature; The American Novel; American Poetry; Literature, Ideology, and National Experience in the US; and Race and Identity in American Literature.

Concentrations in Literature. The Literature Section believes that all MIT students, and particularly those majoring in engineering and science, should seriously consider a concentration program in Literature. The requirements for a Literature Concentration are three subjects that form a coherent group. HUM-D subjects **not** being used to satisfy Institute requirements can count toward the Literature Concentration. Many subjects in Writing, Foreign Languages, History, and Western Traditions can also qualify as part of a Literature Concentration. In addition to concentration sequences in particular genres (e.g., poetry, drama, fiction) or in historical periods (e.g., ancient studies, 19th-century literature, modern and contemporary literature), students can arrange concentrations in popular culture, media and film studies, in minority and ethnic studies, in literary theory and in a range of national literatures. Students must discuss their plans for concentrating in Literature with a field advisor. A list of advisors is available from the Departmental Offices, 14N-409.

The Literature Curriculum is arranged in three graduated categories or tiers: 1) **Introductory subjects** (21.001-21.010), focused on major literary texts grouped in broad historical and generic sequences, all carrying Humanities Distribution credit. 2) **Intermediate subjects** (21.021-21.120), some carrying Humanities Distribution credit and some limited to students who have already taken one literature course. Intermediate subjects explore literary forms in greater depth and center on historical periods, literary themes, or genres. Students are encouraged to consult individual instructors about prerequisite requirements. 3) **Seminars** (21.170-21.178), restricted to students who have taken at least two previous subjects in literature, and demanding considerable independent work, such as oral reports and other special projects. Enrollment in seminars is strictly limited to a maximum of 12 students.

Subjects in creative and performing arts (21.180-21.185) are offered outside the tiering system.

The Literature Major. The Literature Section offers a variety of major programs, including joint majors in combination with curricula in Engineering or Science (XXI-A and XXI-B, 1) as well as a more intensive major program (XXI-B, 2), comprising ten subjects in literature and a four-subject minor in a related field.

For subjects in Literature, see subjects 21.001-21.199 in Chapter VII.

Music

Distribution Subjects
Field of Concentration
Major Programs: XXI-A; XXI-B, 1; XXI-B, 2

The Music Section offers a broad range of opportunities to experience and explore the field of music. A variety of subjects ranging from period and composer surveys to electronic music composition make up the subject offerings, with music theory and history forming the nucleus of study.

A symphony orchestra, choral groups, concert and jazz bands, and chamber music groups are an important part of MIT's cultural life and equally important to the music student's development, no matter what his or her technical proficiency. Academic credit is available for some performance-related subjects.

The music faculty comprises professional composers, performers, historians, and theorists, whose individual interest in the confluence of history, theory, and performance is central to an integrated music program.

A full major in music is available under Course XXI-B, 2. For students interested in combining the study of engineering or science with humanities, degree programs in Course XXI-A and XXI-B, 1 provide the opportunity to pursue special interests. Students wishing to enroll in

any of these degree programs should present a proposal for a course of study to the Music Section no later than the beginning of their junior year.

For subjects in Music, see subjects 21.60-21.692 in Chapter VII.

The Writing Program

Distribution Subjects
Field of Concentration
Major Programs: XXI-A; XXI-B, 1; XXI-B, 2

The MIT Writing Program provides students the opportunity to experiment with writing as a craft and as a means of self-expression. The Program helps prepare students to communicate the results of their work forcefully and clearly to members of their professions and to larger audiences. All subjects in the Program's three categories — creative writing, essay writing, and science and technical writing — emphasize the development of writing skills and strategies. Some subjects, including those at advanced levels and those offered for distribution, require substantial reading.

Some Writing Program subjects are tightly organized for students who want the discipline of directed study, while other subjects allow a student to follow his or her own initiative in selecting writing topics and forms of expression. In both kinds of classes, however, the student's writing receives considerable attention, advice, and encouragement. Most classes follow a workshop or seminar method.

Students may concentrate in Writing by selecting a program of four subjects. Normally, these would include both introductory and advanced subjects. Concentrations may be developed in science and technical writing, essay writing, and creative writing. Because options vary, students should contact the field advisor in the Writing Program for information and guidance.

Writing Majors are designed so that students with a strong interest in writing may pursue a course of study that is of use to them as writers or as scientists and engineers whose writing is an important element in their careers. The Course XXI-A and B, 1, Option One, Writing major programs require a combination of subjects in science or engineering, writing, and a related field of humanities, arts, or social science. Subjects in the Writing Program also may be used as one of the components of Course XXI-A and XXI-B, 1, Option Two.

The Course XXI-B, 2 major in Writing offers students the opportunity to focus in a single area of the writing curriculum — creative writing, essay writing, or science and technical writing — in conjunction with study of a related humanities, arts, or social science field. Students should contact the Course XXI Office (14N-305, x4446) and the Writing Program Office (14E-310, x7894) for information. Since all requirements are guidelines, students work out individual programs with their advisors.

For subjects in Writing, see subjects 21.725-21.799 in Chapter VII.

Special and Interdisciplinary Programs in Humanities

American Studies

Distribution Subjects
Concentration by Special Arrangement
Major Programs: XXI-A; XXI-B, 1

American Studies at MIT offers students the opportunity to organize subjects from various fields (primarily History, Anthropology/Archaeology, Literature, Art and Architecture, Political Science, Urban Studies, and Music) into personally constructed interdisciplinary programs as a way of gaining an integrated understanding of American society and culture. Students can concentrate in American Studies; or they can major in it as part of the degree program (XXI-A and XXI-B,1) in the Department of Humanities. Both concentrators and majors are referred to an American Studies advisor to work out a coherent and integrated program of study. Concentrators are asked to take four subjects, normally at least one in American History and one in American Literature; majors are normally asked to take at least two in each of these fields. In both cases, variations are possible. American Studies is essentially a humanistic program; the American Studies subjects listed below are drawn primarily from the curricula of the Department of Humanities, though many subjects offered by other Departments and programs (e.g., Science, Technology, and Society) at MIT are also listed, and students are urged to take them.

For more information on American Studies subjects, see the appropriate listings in Chapter VII.

	Humanities Subjects in American Studies
21.006	Introduction to American Literature I (HUM-D)
21.007	Introduction to American Literature II (HUM-D)
21.030	Popular Narrative: Science Fiction
21.031	The Film Experience (HUM-D)
21.032J	American Television: A Cultural History
21.042	Modern Black Poetry
21.087	Modernist Poetry

21.101	The American Novel (HUM-D)
21.103J	Literature, Ideology and National Experience in the United States (HUM-D)
21.104	Race and Identity in American Literature (HUM-D)
21.105	American Voices
21.111	Melville and His Age
21.112	Twain and His Age
21.120	Twentieth-Century American Literature
21.175	Major Authors: Emily Dickinson
21.175	Major Authors: Emerson, Thoreau, Whitman
21.390	American History to 1865 (HUM-D)
21.391	American History Since 1865 (HUM-D)
21.400	Colonial America
21.401	The American Revolution
21.402	The Establishment of the American Republic 1790-1850
21.403	The Civil War and Reconstruction
21.404	America in the Progressive Era, 1877-1917
21.405	America in the Twenties and Thirties, 1917-1941
21.406	America Since World War II, 1941 to the Present
21.410	American Intellectual and Cultural History: From the Puritans to the Civil War (HUM-D)
21.411	American Intellectual and Cultural History: Civil War to the 1960s (HUM-D)
21.412J	American Urban History (HUM-D)
21.413J	History of the Physical Environment of Urban America
21.414	Afro-American History I
21.415	Afro-American History II
21.432	Religion and Culture in America
21.433J	Industrialization and Cultural Change in 19th-Century America
21.439	Fortress America: the Rise of the American Military, 1945-1975
21.449	Seminar in American Studies
21.581	The Family in Contemporary Society (HUM-D)
21.585	American Communes and Utopias
21.586	Sex Roles: A Comparative Perspective
21.589	The Anthropology of Industrial Society
21.607	American Music
21.608	Jazz
21.624	Musical Traditions in America (HUM-D)
21.781	Naturalist Writing
21.910	Youth and Industrial Society
21.913	Marx and Marxism
21.914	Sports and Physical Training
21.916	Contemporary Issues in Politics and Ideology

Other Subjects in American Studies

4.648	American Landscapes, Towns and Buildings
4.651	Modern Art from Cubism to the Present (HUM-D)
11.005	Urban Social Structure and Process (HUM-D)
11.007J	Politics and Public Policy (HUM-D)
11.164J	Urban Politics, Planning and Policy (HUM-D)
11.165	Law and Public Policy (HUM-D)
14.71	Economic History (HUM-D)
17.205	Bureaucracy and Public Policy
17.217	Media and Public Policy
17.241	Introduction to the American Political Process (HUM-D)
17.243	American Politics and Social Change (HUM-D)
17.245	The Supreme Court and Constitutional Processes
17.247	The Evolution of American Politics
17.249	Political Parties
17.251	Congress and the American Political System
17.253	Executive Leadership: Presidents, Governors, and Mayors
17.255	Politics, Television, and the News
STS 210	American Science Since the 1930s (HUM-D)
STS 300	History of Technology in America I: 1787-1876 (HUM-D)
STS 301	History of Technology in America II: 1876- the Present (HUM-D)
STS 310J	Industrialization and Cultural Change in 19th-Century America
STS 511	Capitalism and Its Critics (HUM-D)
STS 600	Technological Society and its Critics

Russian Studies

Distribution Subjects
Concentration by Special Arrangement
Major Programs: XXI-A; XXI-B, 1

Russian Studies is an undergraduate humanities program of analytical, historical, and evaluative subjects about people with a tradition and form of life different from the American in ways that are now complementary, now competitive. With a focus on both the society and the culture of a significant area of the world, this interdisciplinary and interdepartmental program is designed to make possible concrete exploration of important concerns of modern humanity including tradition and radicalism; rural versus urban life; the place of imagination in historical change; industrialization, technology, and the expressivistic modern sensibility; and humanism and terror. The program may be used selectively (all students should make some study of history or politics together with some of literature) to fulfill the Concentration component of the Institute

Requirement in Humanities, Arts, and Social Sciences. Students desiring this four-subject Concentration should consult first with the directors of Course XXI, Room 14N-305. Russian Studies is also available as a major in Programs XXI-A and XXI-B, 1. Readings and classes in all subjects are in English. Study of the Russian language is encouraged, however. Students may arrange language credits within the program and use their Russian within the subjects. For more information on Russian Studies subjects, see the appropriate listings in Chapter VII.

	Russian Studies Subjects
17.604	Soviet and Chinese Foreign Policy and the Communist World (A)
17.608	Radical and Revolutionary Ideologies (A)
21.079	Modern Russian Literature and its Historical Structure (HUM-D)
21.080	Dostoevsky, Tolstoy, Chekhov: Russia and the Modern Age
21.268	Russian Culture and Civilization (HUM-D)
21.310	Slavic Civilization: Magic, Vampires, and Sorcerers (HUM-D)
21.311	Soviet Literature and Moral Issues
21.312	Religious Trends in Soviet Thought and Literature
21.313	Russian Avant-Garde: Visual Arts, Literature
21.314	Russian Novel of the 19th Century (HUM-D)
21.315	Seminar on Tolstoy's War and Peace
21.316	Seminar on the Prose of A. Solzhenitsyn
21.375	The Making of Russia in the Worlds of Byzantium, Mongolia, and Europe (ca. 850-1800)
21.376	Imperial and Revolutionary Russia: Culture and Politics (HUM-D)
21.377	The Soviet Union: A Communist Society in Historical Perspective
21.991	Special Topics in Interdisciplinary Studies
21.992	Special Topics in Interdisciplinary Studies
STS 211	Russian Science and Society

Drama Program

Distribution Subjects
Field of Concentration

The Drama Program offers an opportunity for the serious study of dramatic literature based on practical experience acquired through the production of plays in the theatre. Students concentrating in drama are asked to divide their studies between subjects which explore the various forms and the traditional masterpieces of the drama throughout the ages, from the Greeks to the present, and theatre or dance practicum subjects that involve direct participation in various aspects of actual productions mounted in the Kresge Little Theatre. The program is thus coordinated with the activities of the MIT Dramashop and the Dance Workshop where students work and study with a professional staff who teach directing, acting, choreography, dance aesthetics, scene design, costume design, stage lighting, makeup arts, and general scenecraft. Projects in the Dramashop are integrated with course work in the Literature Section of the Department of Humanities, where the thematic and literary content of the drama is discussed in the light of specific problems met and overcome in the process of mounting the plays in a theatre.

The object of the program is to deepen the student's knowledge of drama and performance and of its function within the society by exposing him or her to the full range of theatre experience. Workshops in acting techniques, elements of dance, playwrighting, and experimental techniques are encouraged to supplement both the formal full-scale Dramashop productions and the more strictly literary reading subjects. Ultimately, the student should learn to recognize the theatre for what it has always been at its best: our culture's traditional laboratory of human motivation and character, a dynamic focal point within the community where our self-knowledge is tested and displayed.

Three subjects are required for a concentration in drama. Two must be chosen from the various literature offerings which concentrate on surveys of dramatic literature, theatre history, or specific major playwrights or dramatic movements. The other must be chosen from the available range of practical theatre arts courses in the curriculum. Each individual program is to be arranged in consultation with a field advisor. For information, contact Professor Robert N. Scanlan, Room W16-018, (617) 253-2908. Core subjects for the Drama Program are listed below.

	Subjects in Drama
21.005	World Drama (HUM-D)
21.009	Shakespeare (HUM-D)
21.021	Comedy (HUM-D)
21.022	Tragedy (HUM-D)
21.086	Twentieth-Century Drama
21.180	Plays and Playwriting
21.181	Acting I
21.182	Acting II
21.183	Theatre Arts: Elementary Stagecraft and Production Studies
21.184	Performance Workshop in Drama
21.185	Performance Workshop in Dance
21.298	The Avant-Garde Theatre in the 20th Century

The Western Tradition: Issues and Texts

Distribution Subjects
Field of Concentration

The Western Tradition Program offers a sequence of interdisciplinary humanities subjects, arranged chronologically and designed to introduce MIT students to major works in Western literature, philosophy, religion, history, art, and music. Texts are drawn from various fields so that major themes in the intellectual, cultural, and artistic traditions of the Western past may be studied in cross-disciplinary interconnection. In all subjects first-hand encounter with the texts is encouraged through frequent written exercises and guided classroom discussion. Special emphasis is placed on the question of cultural continuity, on the internal variety of the Western inheritance, and on comparisons, where possible, with other traditions. Faculty for 1981-82 is drawn from history, literature, foreign languages and literatures, and music.

Any one of these subjects may be used for Distribution. The Western Tradition is also a Field of Concentration. The Field Advisor is Professor William B. Watson, 14N-324, (617) 253-4146.

	Subjects in The Western Tradition
21.710	The Bible (HUM-D)
21.711	The Greeks (HUM-D)
21.712	The Romans (HUM-D)
21.713	Major Medieval Texts (HUM-D)
21.714	Renaissance and Reformation (HUM-D)
21.715	The Enlightenment (HUM-D)
21.716	Romanticism (HUM-D)
21.717	The Modern Period: 1900-1970 (HUM-D)

Ancient and Medieval Studies

Distribution Subjects
Field of Concentration

Through a wide variety of subjects drawn from a number of disciplines, this program provides a curricular framework for exploring topics in ancient and medieval studies which range from the history of ideas and institutions to that of material artifacts, literature, and certain branches of the original languages. The chronological span of the program includes the 6,500 years between 5000 BC and 1500 AD.

The goal of this program is to develop knowledge and understanding of the more distant past both for itself, in its uniqueness, and as an object of specifically modern questions and methods of inquiry. We are interested in the structure of institutions and social systems, and in relationships among the social order and learned traditions, values, ideologies, and ideas. Ancient and medieval studies derive a special claim to our interest from the fact that the record is so full and multiform and that much of it is of exceptionally high quality in substance and in form.

The concentration requirement consists of four subjects, at least one of which is taken in the medieval period by students whose focus is the Ancient World, or one in the ancient period by those whose focus is the Middle Ages. In either case, however, individual programs are determined by individual interest in consultation with one of the field advisers.

Students doing part of their concentration and/or distribution requirements in Greek are expected to take a minimum of two additional subjects in other parts of the program for concentration.

	Subjects in Ancient and Medieval Studies
21.060	Medieval Literature
21.061	Chaucer/Dante
21.178	Advanced Studies in Ancient Literature
21.256	Classical Greek II
21.310	Slavic Civilization: Magic, Vampires, and Sorcerers (HUM-D)
21.350	The Ancient World I: Ancient Near East and Greece (HUM-D)
21.351	The Ancient World II: Rome (HUM-D)
21.352	The Middle Ages I (HUM-D)
21.353	The Middle Ages II (HUM-D)
21.513	Religious Movements and Social Change (HUM-D)
21.540	Technologies in Ancient Societies
21.553	Origins of Civilization — Middle East
21.554	Origins of Civilization — Egypt
21.559	The Decline of Empires
21.584	Agrarian Society (HUM-D)
21.710	The Bible (HUM-D)
21.711	The Greeks (HUM-D)
21.713	Major Medieval Texts (HUM-D)

Associated Program

The Cambridge Humanities Seminar

The Cambridge Humanities Seminar is a collaborative effort by universities in the Boston-Cambridge area to enrich and diversify their interdisciplinary offerings in the humanities at an advanced level. The program is centered at MIT and offers subjects to students in the humanities at participating universities during the last two years of undergraduate and the first two years of graduate work in an area of scholarship periodically determined by its faculty membership. The program currently involves faculty in literature, history, philosophy, and fine arts. Its current subject is the nature of interpretation in the various humanistic disciplines. All subjects have limited enrollments. For further information, please contact Professor Alvin C. Kibel at MIT.

For information on Cambridge Humanities Seminar subjects offered in 1981-82, see descriptions of the following subjects:

21.171	Literary Interpretation
21.366	The Nature and Meanings of History
21.979	The Theory and Practice of Metaphor
21.981	On Quality in Art
21.983	Literature and History
21.984	Theory of the Novel
STS 206	Social and Political Implications of Science

Degree Program Requirements

Bachelor of Science in Humanities and Engineering
Course XXI-A; and
Bachelor of Science in Humanities and Science
Course XXI-B, Program 1

The major programs available under Courses XXI-A and XXI-B, 1 enable the student to combine humanistic studies with work in science or engineering, providing an educational experience of unusual scope and balance. There are two distinct paths by which the requirements for these degrees may be met.

Option One: In this version, groups of subjects from the humanistic and technical areas are conjoined in such a way as to centrally emphasize the basic command of each discipline, with or without an understood complementarity between them. One part is a selection from the undergraduate degree curriculum of a science or engineering department, or the Department of Psychology, usually omitting subjects of a more advanced or specialized nature. The other part consists of subjects in some field of the humanities, chosen by the student in consultation with a faculty advisor from one of the various disciplines of the Department of Humanities. Fields available include: Literature; Foreign Languages and Literatures (in French, German, Russian, or Spanish); History; Anthropology/Archaeology; Music; American Studies; Russian Studies; and Writing. A senior thesis (or, in some fields, a general examination) is required of all students in Option One.

In effect, Option One gives the opportunity to form a humanities major on a modest scale while allowing for continued serious commitment to a scientific or engineering interest. Some students may discover an interactive relationship between the two components, though this is not generally the program's central purpose. In some cases, competence on the science or engineering side may be considerably expanded by a careful selection of Science Distribution, Laboratory, and unspecified elective subjects. Thus, for the student who has extensive intellectual ambitions in each of the two areas, Option One may be a sound alternative to the simultaneous pursuit of two degrees.

Graduates of this option have gone on to advanced study in the humanities, engineering, and science, and into such professions as teaching, law, business, and medicine.

Bachelor of Science in Humanities and Engineering Course XXI-A; and Bachelor of Science in Humanities and Science Course XXI-B, Program 1 Option One

General Institute Requirements	Total Units
Specific science and humanities and social science subjects[1]	132
Science Distribution Requirement	36
Laboratory Requirement	12
Departmental Program	
Required Subjects[2]	14
Thesis or General Examination	
Restricted Electives[3]	111
Seven Elective Subjects restricted to one of the following Humanities disciplines, fields, or programs: a Foreign Literature (French, German, Russian or Spanish); History, Literature, Music, Anthropology/Archaeology, Russian Studies, American Studies, Writing	at least 63
Four Elective Subjects restricted to one of the engineering curricula (for XXI-A) or Four Elective Subjects restricted to one of the science curricula or to psychology (for XXI-B, 1)	at least 48
Unrestricted Electives	55
Total Units required for the S.B. Degree	360

Option Two: This program is intended to integrate rigorous study in science or engineering with a systematic understanding of areas of humanistic knowledge. It offers a broad undergraduate education for students who are concerned with the social and cultural dimensions of science and technology and who plan to pursue careers in such fields as science, engineering, medicine, law, and management. Students in the program are prepared for advanced work in technical and humanistic fields and in fields requiring a grasp of the relationship between the two kinds of knowledge.

Option Two is administered by the Department of Humanities in conjunction with faculty from the Program in Science, Technology, and Society. Students enrolled in the major are expected to acquire a solid foundation in the practice of science or engineering, to pursue a coherent sequence of humanistic subjects, and to integrate their humanistic and technical interests through a program of core subjects.

Two Reading Seminars, normally taken in either the sophomore or the junior year, provide a focus for the program's interdisciplinary orientation and a shared intellectual experience for all of its members. Small groups of students join with faculty members from Humanities and STS in the careful reading and critical discussion of major primary and secondary works which illustrate or examine interactions of science, technology and society.

In addition to the Reading Seminars, students are asked to take at least two subjects specifically chosen to increase their disciplined understanding of the relations between technical and humanistic fields of study. One of these must be a broad-based subject in the history of science or technology; the other must treat the cultural dimensions of science and technology. A list of approved subjects in each of these categories is available from the Course XXI Office.

The remaining element in this program consists of a planned group of 10 electives centered around the student's individual interests. Although students must take at least four of their elective subjects in science/engineering and at least four in the humanities, a wide range of combinations is possible. Examples of elective combinations suited to various intellectual concerns and career paths are available at the Course XXI Office.

1
Of this total, the Requirement in Humanities, Arts, and Social Sciences accounts for eight subjects totaling at least 72 units, of which all but the Distribution Subjects are normally contained within the major program of Course XXI students. This has the practical effect of increasing the number of units in Unrestricted Electives by 45, to a total of 100.

2
Literature majors need the permission of the Literature faculty to write a thesis. Literature students not writing a thesis must elect an additional seminar from the third tier of the curriculum. Especially qualified students in Music may be permitted to write a thesis, others elect to take either a General Examination or two additional elective subjects in Music. For students in Anthropology/Archaeology, 21.50 is strongly recommended. For students in Russian Studies the "thesis" may consist of a special project such as fieldwork or a translation, a general examination, or a regular research thesis.

3
Students in Literature are required to take a major seminar, 21.171, in place of one of the elective subjects in Literature, and are encouraged to take other advanced Literature seminars as well. Literature majors not writing a thesis **must** take one seminar in addition to 21.171. Three of the elective subjects in Literature must represent substantial involvement in any three of the following periods: 1) Ancient and Classical; 2) Medieval; 3) Renaissance; 4) 17th Century and Enlightenment; 5) 19th Century. Students in the American Studies program are asked to take at least two subjects in American History, at least two in American Literature, and the rest from a list of American Studies subjects elected from various fields. Students in Writing take four subjects in Writing, of which three must be selected from one of the following areas: creative writing, essay writing, science and technical writing. At least one of these must be drawm from the advanced tier of the curriculum. In addition they take three subjects in a field of humanities, arts, or social science pertinent to their educational goals in writing. Students in Music are required to take two subjects in composition, 21.641 and 21.642; two subjects in the history and literature of music, 21.621 and 21.622; and three music electives (excluding 21.60, and performance subjects). Two semesters of ensemble performance are also required; these may be taken for credit as performance subjects in addition to the regular requirements. Students in Russian Studies are required to take at least two subjects on Russian society (e.g. history, political science) and at least two on Russian culture (e.g. literature). Students combining humanistic study with Psychology in the XXI-B, 1 program must meet certain area requirements specified by the Department of Psychology (consult the Course XXI Office for details).

Bachelor of Science in Humanities and Engineering Course XXI-A; and Bachelor of Science in Humanities and Science Course XXI-B, Program 1 Option Two

	General Institute Requirements		Total Units
	Specific science and humanities and social science subjects[1]		132
	Science Distribution Requirement		36
	Laboratory Requirement		12
	Departmental Program		
	Required Subjects		50
21.901J	Reading Seminar in Humanities, Science and Technology I	9	
21.902J	Reading Seminar in Humanities, Science and Technology II	9	
	One subject from **each** of the following two groups:	**at least**	18
	Group I: History of Science and Technology		
STS 200	Scientific Revolution	3 0 9	
STS 201	History of 19th- and 20th-Century Science	3 0 9	
STS 300	History of Technology in America I: 1787-1876	3 0 6	
STS 301	History of Technology in America II: 1876 the Present	3 0 6	
	Group II: Cultural Dimensions of Science and Technology		
21.505	Anthropology and Technology	3 0 6	
21.715	The Enlightenment	3 0 9	
24.05J	Nature of Scientific Knowledge	3 0 6	
STS 611J	Writing: Technology and Society	3 0 6	
21.ThU	Thesis	14	
	Restricted Electives		**at least 99**
	A coherent grouping of 10 elective subjects which, in conjunction with the subjects specified above, provides a rigorous understanding of a body of humanistic knowledge, a body of scientific/engineering knowledge, and the relations between them. The exact combination of subjects is chosen in consultation with a faculty advisor and approved by a supervisory committee. Ordinarily at least four subjects must be drawn from the humanities and at least four from science/engineering or psychology. Each sub-grouping of four or more subjects may be chosen from among the offerings of a particular discipline; or it may represent a coherent combination of subjects drawn from different disciplines.		
	Unrestricted Electives[1]		31
	Total Required Units for the S.B. Degree		360

1
Since the major program normally contains at least 5 of the 8 subjects which satisfy the Institute Requirement in Humanities, Arts, and Social Sciences, the number of units of Unrestricted Electives is effectively increased by 45, to a total of 76.

Bachelor of Science in Humanities and Science Course XXI-B, Program 2

This program provides a full major in Foreign Languages and Literatures, History, Literature, Anthropology/Archaeology, Music, or Writing and Literature. Like XXI-A and XXI-B, 1, the program is based on the regular Institute requirements, but provides an opportunity to pursue a particular humanistic discipline in greater range and depth than do the other two programs. The required curriculum consists ordinarily of eight to ten subjects in a chosen field plus four subjects from a related field of humanities, social sciences, foreign literatures, linguistics, or visual arts. A generous number of electives makes it possible to continue work in science, engineering, humanities, or other fields, allowing students to increase their concentration in the chosen major discipline or to broaden intellectual interests by studies in fields outside the major program. Depending on the field of specialization, requirements may include seminars devoted to advanced study in the junior and senior years, and a thesis or general examination in the fourth year. Faculty counselors in each of the disciplines help students to arrange programs suitable to both their main lines of interest and future professional objectives.

Inquiries

Additional information concerning academic programs in the Department may be obtained from Professors Travis R. Merritt and Louis L. Bucciarelli, the Directors of Course XXI, Room 14N-305, MIT, Cambridge, Massachusetts 02139, (617) 253-4446.

1
Of this total, the Requirement in Humanities, Arts, and Social Sciences accounts for eight subjects totaling at least 72 units, of which all but the three Distribution Subjects are normally contained within the major programs of Course XXI students. This has the practical effect of increasing the number of units in Unrestricted Electives by 45, to a total in the range 99 to 76.

2
One subject not conducted in the foreign language may, with the consent of the major advisor, be counted toward the fulfillment of these eight electives. Students may also, with permission, arrange an area-studies major that would allow for additional subjects not conducted in the foreign language to count toward this requirement.

Bachelor of Science in Humanities and Science Course XXI-B, Program 2

	General Institute Requirements		Total Units
	Specific science and humanities and social science subjects[1]		132
	Science Distribution Requirement		36
	Laboratory Requirement		12
	Departmental Programs		
	Restricted Electives		126 to 149
	One of the following		
	Foreign Languages and Literatures		
	Thesis		18
	Eight elective subjects in one of the following languages: French, German, Russian, or Spanish at language level III and above[2]	**at least**	72
	Four elective subjects in one second discipline of the humanities, social sciences, visual arts, or four subjects from various disciplines that form a coherent grouping	**at least**	36
	History		
	Thesis		14
	Nine elective subjects in History,	**at least**	81
	Four elective subjects in a second discipline of humanities, social science or visual arts	**at least**	36
	Literature[3]		
	Literary Interpretation (21.171)		12
	Two other advanced-level Literature seminars		24
	Four elective subjects significantly involved in four of the following literary periods: 1) Ancient and Classical; 2) Medieval; 3) Renaissance; 4) 17th Century and Enlightenment; 5) 19th Century	**at least**	36
	Three additional electives in Literature	**at least**	27
	Four elective subjects in a second discipline of humanities, social science or visual arts	**at least**	36

(continued on next page)

3
A Literature major with a strong record and a plausible plan of study may, with the permission of the Literature faculty, substitute a 14-unit thesis for one of the required elective subjects.

Restricted Electives (continued)			
Music[4]			
General Examination or Thesis			14
Four subjects in composition 21.641, 21.642, 21.643, and one more		**at least**	36
Four subjects in history and literature of Music: 21.621, 21.622, and two more		**at least**	36
Three additional Music electives (excluding 21.60 and performance subjects)		**at least**	27
Four elective subjects in a second discipline of humanities, social science or visual arts		**at least**	36
Anthropology/Archaeology[5]			
Thesis			18
Eight elective subjects in Anthropology/Archaeology (to include 21.501, 21.502, and 21.503)		**at least**	72
Four elective subjects in a second discipline of humanities, social sciences or visual arts		**at least**	36
Writing			
Thesis			14
Five subjects in Writing of which three must be in one of the following areas: creative writing, essay writing, science and technical writing. One of these three must be drawn from the advanced tier of the curriculum.		**at least**	45
Four subjects in a humanities, arts or social science field pertinent to the students's educational goals in writing.		**at least**	36
Four elective subjects in another discipline of humanities, arts, or social science.		**at least**	36
Unrestricted Electives			**54 to 31**
Total Units Required for the S.B. Degree			**360**

4
Students who declare music as their major must pass a test showing proficiency in instrumental or vocal performance. This test is given by three senior members of the music faculty at the beginning of each semester. In their senior year, majors must pass a basic musicianship test that includes sight-singing, dictation, and scales and harmonic progressions on the keyboard. Seniors participate in a tutorial program in preparation for the General Examination. Especially qualified students may be permitted to substitute a thesis or an analytical or historical topic or an original composition. Full music majors must participate in four semesters of ensemble performance, which may be taken for credit as performance subjects in addition to the regular requirements.

5
Students in Anthropology/Archaeology are strongly urged to take 21.50 An Introduction to Anthropology, in addition to the required program. The thesis might consist of a field project, a special senior seminar, or a regular research thesis.

Department of Linguistics and Philosophy

Samuel Jay Keyser, Ph.D.
Professor of Linguistics
Director, Center for Cognitive Science
Head of the Department

Professors

George Stephen Boolos, Ph.D.
Professor of Philosophy

Joan Wanda Bresnan, Ph.D.
Professor of Linguistics

Sylvain Bromberger, Ph.D.
Professor of Philosophy

C. Tyler Burge, Ph.D.
Professor of Philosophy
(Visiting, fall)

Richard Lee Cartwright, Ph.D.
Professor of Philosophy
(Absent, spring)

Noam Avram Chomsky, Ph.D.
Institute Professor
Professor of Linguistics

Jerry Alan Fodor, Ph.D.
Professor of Philosophy
and Psycholinguistics

Kenneth Locke Hale, Ph.D.
Ferrari P. Ward Professor of
Modern Languages and Linguistics

Morris Halle, Ph.D.
Institute Professor
Professor of Linguistics

James Wesley Harris, Ph.D.
Professor of Spanish and
Linguistics

René Paul Viktor Kiparsky, Ph.D.
Professor of Linguistics

Thomas Samuel Kuhn, Ph.D.
Professor of Philosophy
and History of Science

Wayne O'Neil, Ph.D.
Professor of Linguistics

John Robert Ross, Ph.D.
Professor of Linguistics

Irving Singer, Ph.D.
Professor of Philosophy

James Frederick Thomson, M.A.
Professor of Philosophy

Judith Jarvis Thomson, Ph.D.
Professor of Philosophy

Associate Professors

Ned Block, Ph.D.
Associate Professor of Philosophy

James Higginbotham, Ph.D.
Associate Professor of Philosophy
(Visiting)

Paul Horwich, Ph.D.
Associate Professor of Philosophy

Assistant Professors

Joshua Cohen, Ph.D.
Assistant Professor of Philosophy
and Political Science

Judith Wagner DeCew, Ph.D.
Assistant Professor of Philosophy

Edwin William McCann, Ph.D.
Assistant Professor of Philosophy
(Absent, fall)

Administrative Officer

Marilyn Matthes Silva, A.B.

Professor Emeritus

Roman Jakobson, Ph.D.
Institute Professor, Emeritus

Undergraduate Study

Bachelor of Science in Philosophy Course XXIV

Philosophy aims at analysis and criticism of the concepts and principles fundamental to the sciences, to our commonsense view of the world, and to our modes of valuation. The study of philosophy is thus appropriate for those who enjoy thinking carefully and logically about basic issues, for those who seek perspective on a scientific education, and for those who wish breadth of educational experience prior to entering professional programs such as law or medicine.

Two programs are offered leading to the degree of Bachelor of Science in Philosophy. Program 1 is designed to provide: 1) familiarity with the history and current status of the main problems in epistemology, metaphysics, and ethics; 2) mastery of some of the technical skills requisite for advanced work in philosophy; 3) facility at independent philosophical study; and 4) work at an advanced level in an allied field. A relatively large amount of unrestricted elective time is available so that students can devise programs suited to individual needs and interests.

Program 2, called the program in Language and Mind, addresses itself to topics and problems related to philosophy, psychology, linguistics, and artificial intelligence that do not fall neatly into any one of those fields. Central among these topics are the nature of language, of mental representation of knowledge, and of the innate basis for the acquisition of such knowledge. A core set of seven subjects is required for the purpose of teaching students the central facts and issues in the study of language and the representation of knowledge. A further requirement of specialization within the program of four additional subjects in one of the fields is designed to ensure preparation for graduate study in either philosophy or psychology or linguistics.

Bachelor of Science in Philosophy
Course XXIV
Program 1

	General Institute Requirements		Total Units
	Specific science and humanities and social science subjects		132
	Science Distribution Requirement		36
	Laboratory Requirement		12
	Departmental Program		
	Required Subjects		60
24.200	Ancient Philosophy	3 0 9	
24.202	Modern Philosophy: Descartes to Kant	3 0 9	
24.211	Theory of Knowledge	3 0 9	
	or		
24.221	Metaphysics	3 0 9	
24.231	Ethics	3 0 9	
24.241	Symbolic Logic	3 0 9	
	Restricted Electives		54
	A coherent program of 54 units of which 18 must be in philosophy and 36 in advanced subjects in some other discipline		
	Unrestricted Electives		66
	Total Units Required for the S.B. Degree		360

1
Of this total, the Requirement in Humanities, Arts, and Social Sciences accounts for eight subjects totaling at least 72 units. Six of the seven required subjects in the Language and Mind Program can be used to satisfy this requirement, including 24.900J, which counts toward the Humanities Distribution Requirement. This has the practical effect of increasing the number of units of Unrestricted Electives by 45, to a total of 108.

2
Any student taking the required subjects for the Language and Mind Program automatically satisfies the requirements for Concentration in Philosophy.

Bachelor of Science in Philosophy
Course XXIV
Program 2: Language and Mind

	General Institute Requirements		Total Units
	Specific science and humanities and social science subjects[1]		132
	Science Distribution Requirement		36
	Laboratory Requirement		12
	Departmental Program		
	Required Subjects[2]		69
	Either of the following two subjects		
24.117	Philosophy of Mind and Psychology	3 0 9	
	or		
24.119	Minds and Machines	3 0 9	
24.151	Introduction to Philosophy of Language	3 0 6	
24.241	Symbolic Logic	3 0 9	
24.900J	The Study of Language	3 0 6	
24.901J	Language and its Structure	3 0 6	
	Two of the following four subjects *except* not both 9.55 and 24.116J		
9.55	Introduction to Language and Cognition	3 0 6	
9.59	Psychology of Language and Communication	3 0 6	
9.65J	Cognitive Processes	3 0 6	
24.116J	Introduction to Cognitive Science	3 0 9	
	Restricted Electives		48
	A coherent program of 48 additional units which normally should be chosen from one or two of the four groups below		
	Unrestricted Electives		63
	Total Units Required for the S.B. Degree		360

Group I:	**Philosophy**	
24.115	Concepts of Genetic Determination	
24.200	Ancient Philosophy	
24.202	Modern Philosophy: Descartes to Kant	
24.211	Theory of Knowledge	
24.221	Metaphysics	
24.251	Philosophy of Science	
24.253	Induction and Probability	
24.421	Background of Contemporary Philosophy	
24.517J	Cognitive Theories	
24.521	Topics in Philosophy of Mind	
24.525	Topics in the Theory of Action	
24.701	Topics in Logic	
24.711	Philosophy of Logic	
24.721	Reference	
24.725	Meaning	
24.801	Philosophy of Mathematics	
24.831	Topics in Philosophy of Psychology	
24.851	Problems of Explanation and Theory Formation	

Group II:	**Linguistics**	
24.951	Introduction to Linguistics I: Syntax	
24.952	Introduction to Linguistics III: Theory of Grammar	
24.953	Advanced Grammar I: An Introduction to the Extended Standard Theory of Grammar	
24.954	Advanced Grammar II	
24.956	Introduction to Linguistics IV: Universal Grammar	
24.957	Introduction to Linguistic Theory at an Advanced Level	
24.958	Linguistic Structure	
24.961	Introduction to Linguistics II: Phonology	
24.962	Advanced Phonology	
24.964	Theory of Phonology	
24.966J	Laboratory on the Physiology, Acoustics and Perception of Speech	
24.968J	Speech Communication	
24.972	Formal Foundations of Linguistic Theory	
24.982	Linguistic Change	
24.992	Survey of General Linguistics I	

Group III:	**Psychology**	
9.01	Neuroscience and Behavior	
9.02	Nature, Nurture, and the Individual Brain	
9.30	Animal Behavior	
9.35	Perception: Mechanisms and Models	
9.50	Research in Psychology	
9.59	Psychology of Language and Communication	
9.591	Seminar in Psychology of Language and Communication I	
9.592	Seminar in Psychology of Language and Communication II	
9.65J	Cognitive Processes	
9.651	Cognitive Processes	
9.652J	Seminar in Cognitive Development	
9.653J	Cognitive Theories	
9.88	Development of Behavior	
9.881	Seminar in the Development of Behavior	
9.92	Topics in Psychology	

Group IV:	**Artificial Intelligence**	
6.034	Artificial Intelligence	
6.036	Problem-Solving Paradigms	
6.088	Machine Vision and Manipulation	
6.501	Sound, Speech, Hearing	
6.541J	Speech Communication	
6.542J	Laboratory on the Physiology, Acoustics and Perception of Speech	
6.543	Natural Language Processing	
6.863	Natural Language and the Computer Representation of Knowledge	
6.865	Introduction to Machine Vision and Manipulation	

Graduate Study

The Department offers two programs leading to the degree of Doctor of Philosophy, one in linguistics and one in philosophy.

Doctor of Philosophy in Linguistics

The program of study leading to the Doctor of Philosophy in Linguistics seeks to provide a comprehensive knowledge of modern linguistics, with particular emphasis on its theoretical aspects.

To enter the doctoral program, each student must satisfy the Institute requirements for admission to the Graduate School listed in Chapter IV and, in general, must have done well in previous academic work. The student must also be formally accepted by the Department of Linguistics and Philosophy as a degree candidate. The Department does not require that applicants have taken any particular set of subjects or that they be trained in any particular discipline. Instead, applicants must present evidence that they are able to engage in serious study of complex subject matter. As examples of such evidence we might cite: 1) mastery in depth of a language or group of languages, e.g., classical Greek, Semitic, Japanese; 2) original research (publications, projects etc.); 3) academic work of high quality in mathematics, the natural sciences, philosophy, psychology, history, linguistics, theory of literature, etc.; and 4) work experience in a relevant area, especially if it required considerable application, imagination, or ingenuity.

The following subjects are normally required of all doctoral candidates in linguistics, unless they have obtained adequate preparation elsewhere:

24.951	Introduction to Linguistics I: Syntax
24.961	Introduction to Linguistics II: Phonology
24.952	Introduction to Linguistics III: Theory of Grammar
24.962	Advanced Phonology
24.982	Linguistic Change
24.992	Survey of General Linguistics I
24.941 *or* 24.942	Topics in the Grammar of a Non-Indo-European Language
24.958	Linguistic Structure
24.972	Formal Foundations of Linguistic Theory
24.957	Introduction to Linguistic Theory at an Advanced Level
24.956	Introduction to Linguistics IV: Universal Grammar
24.959	Workshop in Syntax
24.969	Workshop in Phonology
24.973	Topics in Logic and Semantics

Before students may begin their doctoral research they are required to pass a comprehensive General Examination which is composed of two parts. The first part is a written examination consisting of two substantial papers on topics chosen in consultation with members of the faculty. Usually one paper is on phonology and the other is on syntax, but it is possible for one or both papers to treat the interaction of two topics, for example the interaction between syntax and semantics. In conformity with Institute regulations, the second part of the examination is oral. It deals with topics treated in the candidate's written examination but is not limited to these and probes into the candidate's competence in linguistics in general.

Every candidate for the doctorate must complete a program of studies in a minor field, the purpose of which is to broaden the interests and capacities of the student in areas other than those of his or her major intellectual objective.

Doctor of Philosophy in Philosophy

The program of studies leading to the doctorate in philosophy provides courses and seminars in such traditional areas as logic, ethics, metaphysics, epistemology, philosophy of science, philosophy of language, philosophy of mind, aesthetics, social and political philosophy, and history of philosophy. Interest in philosophical problems arising from other disciplines, such as linguistics, psychology, mathematics, and physics, is also encouraged.

To enter the doctoral program, students must have done well in their previous academic work and must be formally accepted as candidates for the degree by the Department of Linguistics and Philosophy. Although there are no formal course requirements for admission, applicants must satisfy the committee on admissions that their preparation in philosophy and allied disciplines is sufficient for undertaking study of philosophy at the graduate level.

Before beginning dissertation research, students are required to take two years of course work to pass general examinations and to demonstrate competence in three of the following four areas: metaphysics and epistemology; value theory; philosophy of logic, language, science, and mathematics; and the history of philosophy.

Candidates for the doctorate may take a minor in a field other than philosophy. Possibilities include linguistics, mathematics, physics, psychology, computer science, and other humanities or other social sciences. There is no general language requirement for the doctorate, except in those cases in which competence in one or another foreign language is needed to carry on research for the dissertation.

Inquiries

Information regarding undergraduate or graduate academic programs, research activities, admissions, financial aid, and assistantships may be obtained from the Department of Linguistics and Philosophy, Room 20D-105, MIT, Cambridge, Massachusetts 02139, (617) 253-4141.

Department of Political Science

Alan Anthony Altshuler, Ph.D.
Professor of Political Science and Urban Studies and Planning
Head of the Department (Fall)

Donald Laurence Morton Blackmer, Ph.D.
Professor of Political Science
Head of the Department (Spring)

Professors

Hayward Rose Alker, Jr., Ph.D.
Professor of Political Science

Suzanne Berger, Ph.D.
Professor of Political Science

Lincoln Palmer Bloomfield, Ph.D.
Professor of Political Science

Walter Dean Burnham, Ph.D.
Professor of Political Science

Nazli Choucri Field, Ph.D.
Professor of Political Science

William Edgar Griffith, Ph.D.
Ford International Professor of Political Science

Harold John Hanham, Ph.D.
Professor of History and Political Science
Dean, School of Humanities and Social Science

Willard Raymond Johnson, Ph.D.
Professor of Political Science

William Weed Kaufmann, Ph.D.
Professor of Political Science

Michael Lipsky, Ph.D.
Professor of Political Science

Ithiel de Sola Pool, Ph.D.
Arthur and Ruth Sloan Professor of Political Science

Lucian Wilmot Pye, Ph.D.
Ford International Professor of Political Science

George William Rathjens, Ph.D.
Professor of Political Science

Robert Irwin Rotberg, D.Phil.
Professor of History and Political Science

Harvey Morton Sapolsky, Ph.D.
Professor of Public Policy and Organization
Associate Chairman of the Faculty

Eugene Bertram Skolnikoff, Ph.D.
Professor of Political Science
Director, Center for International Studies

Peter Hopkinson Smith, Ph.D.
Professor of History and Political Science
Head, Department of Humanities
Associate Dean for Humanities Programs

Myron Weiner, Ph.D.
Ford Professor of Political Science

Associate Professors

Lloyd Stanley Etheredge, Ph.D.
Associate Professor of Political Science

Ted Ronald Ivan Greenwood, Ph.D.
Associate Professor of Political Science

Deborah Anne Stone, Ph.D.
Associate Professor of Political Science

Martha Wagner Weinberg, Ph.D.
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Assistant Professors

Joshua Cohen, Ph.D.
Assistant Professor of Philosophy and Political Science

Albert Thomas Ferguson, Jr., Ph.D.
Assistant Professor of Political Science

John Roy Freeman, Ph.D.
Assistant Professor of Political Science

Emma Jackson, Ph.D.
Assistant Professor of Political Science

Stephen Michael Meyer, Ph.D.
Assistant Professor of Political Science

William Russell Neuman, Ph.D.
Assistant Professor of Political Science

Richard Joel Samuels, Ph.D.
Assistant Professor of Political Science

Brian Henry Smith, Ph.D.
Assistant Professor of Political Science

Senior Lecturers

Edwin Diamond, M.A.
Louis Menand III, Ph.D.

Visiting Lecturer

Richard Greene, Ph.D.

Administrative Officer

Elizabeth Terlingen Merkle, Pharm.

Professors Emeriti

Everett Hagen, Ph.D.
Professor of Economics and Political Science, Emeritus

Harold Robert Isaacs, A.B.
Professor of Political Science, Emeritus

Norman Judson Padelford, Ph.D. LL.D.
Professor of Political Science, Emeritus

Department of Political Science

Undergraduate Study

Political science is concerned with the systematic study of government and the political process. Within the discipline, scholars analyze the development, distribution, and uses of political power; the determinants and consequences of various forms of political behavior and sources of political conflict; the ways in which conflicts are both intensified and resolved; and the relationship between the individual and the state. It is a discipline of special interest to scientists and engineers who must understand the political system within which they live in order to evaluate their influence upon that system, as well as to those students who are considering careers in public service or university teaching and research.

The Department has a research-oriented faculty which welcomes the association of both undergraduate and graduate students in ongoing research. Among the major features of the Department are: 1) an emphasis on empirical methods and research training, 2) a concern with issues of public policy, particularly in the areas of arms control and defense, science policy, transportation, urban affairs, health, communications, population and migration, nutrition, and foreign policy; 3) comparative studies involving the United States and other advanced industrial societies, the developing countries of the third world, and communist countries; and 4) a strong interdisciplinary perspective which incorporates political sociology, political psychology, political demography, and economic and political development.

There are two programs: a general program in political science, and a program for students who are interested in studies in public policy.

Internships

The Department sponsors a number of activities for students who want to gain first-hand experience in politics or public policy agencies and processes. Students can receive academic credit for working in government or policy-related agencies in the Boston area during the academic year in conjunction with 17.351J or 17.353. Through the Washington and Boston Internship Program, students may work in Congress, executive branch, or advocacy organizations during the summer. Arrangements can be made for students to build upon previous experience as paid interns by designing a supplemental academic program with a faculty member.

Bachelor of Science in Political Science
Course XVII

The political science curriculum for undergraduates combines professional social science training with opportunities for a broad liberal arts education. Students are able to choose subjects from a wide range of both undergraduate and graduate offerings, and they are also encouraged to engage in independent research projects. In addition, the Department sponsors a variety of fieldwork programs in governmental agencies at all levels.

The undergraduate program prepares students for study in political science, law, public policy, and related fields, and for careers in government, business, law, research, teaching, or journalism. This program is also designed to give students, whatever their career objectives, an understanding of political institutions and processes. Some students want to focus on political systems themselves; others choose to concentrate on the political aspects of public policy, focusing on such issues as transportation, health, or arms control. Both of these perspectives are found in the program.

Subjects are offered by the Department in the following fields: political theory, American politics and public policy, urban politics and policy, science and public policy, defense and arms control policy, political psychology, political development, political communications and behavior, comparative politics, and international relations and foreign policy. Certain offerings are particularly designed for undergraduates and a large number of graduate subjects are open to undergraduates as well. Students' individualized programs are worked out with the assistance of a faculty advisor.

The Department believes that every political science major should have the experience of conducting and writing at least one substantial research project, a requirement which is fulfilled by the senior thesis. Each undergraduate chooses a thesis advisor in his or her area of interest. The student then registers for Prethesis Reading Seminar in the fall term and for Thesis in the spring term of the senior year.

In addition to the thesis, there are numerous other opportunities for students to pursue research interests. For example, a student may wish to take an independent reading subject in an area for which no formal subject is being offered. Also, students are eligible to receive academic credit or limited funding for expenses or wages through the Institute-wide Undergraduate Research Opportunities Program. Students should consult the Department's UROP coordinator to discuss specific projects.

Bachelor of Science in Political Science
Course XVII

	General Institute Requirements		Total Units
	Specific science, and humanities and social science subjects[1]		132
	Science Distribution Requirement[2]		36
	Laboratory Requirement		12
	Departmental Program		
	Required Subjects		18
17.913	Pre-thesis Reading Seminar	9	
17.ThU	Thesis	9	
	Restricted Electives	**at least**	81
	Normally 9 courses divided as follows:		
	a. At least one course that provides exposure in depth to each of the following four aspects of political science: *Political Philosophy* *American Polity* *A Non-American or International Perspective* *Public Policy*		
	b. In addition to the above 4 courses, majors take at least 5 additional political science subjects.		
	Specific courses satisfying both these criteria should be chosen in consultation with a faculty advisor.		
	Unrestricted Electives[2]		81
	Total Units Required for the S.B. Degree		360

1
Of this total, the Requirement in Humanities, Arts, and Social Sciences accounts for eight subjects totaling at least 72 units.
2
1.00 Principles of Computer-Based Engineering Problem Solving (3-1-8), and 14.30 Introduction to Statistical Method in Economics (4-0-8) are suggested.

Bachelor of Science in Political Science: Public Policy
Course XVII-A

For students who wish to combine the study of politics with the study of substantive social and technical problems, policy options, and change strategies, the Department has developed a new major field of study. It focuses on the ways in which political and non-political factors combine to shape policy choices, implementation strategies, and ultimate policy outcomes.

Students who major in public policy studies are required to take two introductory subjects (17.201J and 17.203), and select five restricted elective subjects in consultation with a faculty advisor. It is normally expected that at least one subject focuses on other disciplinary approaches to the study of public policy (such as economics, law, sociology, history, or philosophy), one explores process approaches to policy formulation, implementation or evaluation, and one examines a substantive policy area.

Majors are also required to complete an internship in a public sector agency. This may be accomplished in conjunction with coursework (17.351J or 17.353), the summer intern program, or other appropriate work experience. Expertise in a substantive policy area or an aspect of policy studies must be developed through course work and exhibited through the pre-thesis and thesis courses.

Bachelor of Science in Political Science: Public Policy
Course XVII-A

	General Institute Requirements		Total Units
	Specific science and humanities and social science subjects[1]		132
	Science Distribution Requirement[2]		36
	Laboratory Requirement		12
	The subject 17.203, appears on the list of Laboratory Subjects and can be used to satisfy the Laboratory Requirement.		
	Departmental Program		
	Required Subjects		42
17.201J	Politics and Public Policy	3 0 9	
17.203	Evaluation Research Laboratory	3 5 4	
17.913	Pre-thesis Reading Seminar	3 0 6	
17.ThU	Thesis	9	
	Restricted Electives	**at least**	45
	A coherent program of five subjects in which the student samples a range of approaches to the study of public policy. The exact combination of elective subjects is to be chosen in consultation with a faculty advisor. The sequence should include other disciplinary approaches, policy process approaches, and a subject which focuses on substantive policy areas. Four of the five subjects must be taken within the political science department.		
	Internship		24
	The student must complete an internship program designed in cooperation with a faculty advisor. Three examples are the internship through 17.351J, 17.353, or a summer internship. Other alternatives may be substituted through curricula or non-credit experiences with the consent of a faculty advisor.		
	The Policy Specialty		
	The student is required to demonstrate substantial knowledge of a particular policy area or process. This requirement normally is fulfilled through the integration of classes, internship experience, pre-thesis and thesis subjects.		
	Unrestricted Electives[2]	**at least**	69
	Total Units Required for the S.B. Degree		360

1
Of this total, the Requirement in Humanities, Arts, and Social Sciences accounts for eight subjects totaling at least 72 units.
2
1.00 Principles of Computer-Based Engineering Problem Solving (3-1-8), and 14.30 Introduction to Statistical Method in Economics (4-0-8) are suggested.

Graduate Study

The Department of Political Science offers work leading to the Master of Science in Political Science and the Doctor of Philosophy.

Entrance Requirements for Graduate Study

The Department specifies the following prerequisites for graduate study in political science: at least six term subjects in English, history, and other humanities or social science subjects equivalent in scope to those included in the undergraduate curriculum of the Institute. Except for a recommended upper-level year subject on the history of political thought, these subjects normally should be in other than the candidate's own professional field.

Master of Science in Political Science

The Master of Science is particularly intended for students concerned with developing skills in applied research and those seeking careers in public service. The master's program emphasizes intensive preparation in a single field of study. The Department offers special concentrations at the master's level in the fields of arms control and defense analysis, and science and public policy, although other fields may be offered by special arrangement. Students seeking admission as master's candidates should state the field in which they intend to concentrate and outline their proposed course of study. Subjects included in the student's program need not be restricted to those offered within the Department, but the entire program must meet with the approval of the student's advisory board. The general requirements for the S.M. are described in Chapter IV of this catalogue.

Accelerated Master of Science in Political Science

The Department offers a five-year program leading to the Bachelor of Science and Master of Science, awarded simultaneously. This program is open to MIT undergraduates only. It allows the student to plan for a combined S.B.-S.M. thesis written during the last three terms at the Institute. A separate S.B. thesis is not required. Undergraduate Institute requirements may be completed during the fifth year of the program.

Doctor of Philosophy

Candidates for the doctorate must prepare themselves in four approved fields of study. Two of these fields (the required field of political analysis and one other) are normally satisfied by completing stipulated subjects or demonstrating achieved competences. The remaining two fields are the focus of the student's General Examination, written and oral. The student is also required to present and defend an advanced research paper (Second Year Paper) prior to the General Examination. Established fields include political analysis, political communication and behavior, American government, comparative politics, communist studies, defense policy, science technology and public policy, international politics and foreign policy, political and economic development, concepts and methods, urban politics, West European politics, Latin American politics, political demography, and others.

Approved combinations of some of these fields together with economics, industrial management, sociology, social psychology, or science and engineering fields may be acceptable. A program in urban politics and planning is offered jointly with the Department of Urban Studies and Planning, and a program in international planning is offered with the International Nutrition Planning Program. There also are a variety of joint MIT-Harvard University teaching programs in subjects such as Analysis of Complex Systems, West European Studies, and political demography.

Programs of study logically combining advanced work in some scientific, engineering, management, or other social science field with political science are welcomed. For example, some political science students have developed programs around the interdisciplinary field of communications policy. Graduate work in this field at MIT is described in more detail in Chapter V of this catalogue. A candidate's qualifications must indicate promise of ability to develop fruitful new lines of inquiry on problems touching the relationship of government, human behavior, science, technology, and the political process. Guided field research and close working ties with faculty members engaged in major research activities are stressed.

Teaching and Research Assistantships

Financial assistance is available to qualified applicants in the form of research assistantships, graduate traineeships, and a limited number of fellowships, subject to the availability of funds. Research assistants work under faculty supervision on projects administered by the Department and through MIT affiliated research facilities such as the Center for International Studies, the Joint Center for Urban Studies, and the Center for Policy Alternatives. In addition, advanced graduate students may qualify to become teaching assistants.

Inquiries

Additional information regarding academic and research programs in the Department, admissions, assistantships, financial aid, etc. may be obtained from the Department Head, E53-470, MIT, Cambridge, Massachusetts 02139, (617) 253-5262.

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Jerry Alan Fodor, Ph.D.
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Merrill Frederick Garrett, Ph.D.
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Lecturer

Jeremy Michael Wolfe, Ph.D.

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Diane Major
John Bruce Swan, A.E.

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Barbara Sakitt, Ph.D.

Research Associates/Scientists

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Benjamin Morgan Dawson, Ph.D.
Rhea Diamond Gendzier, Ph.D.
John Hollerbach, Ph.D.
David Owen Pettijohn, M.S.
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Jane Gwiazda, Ph.D.
Harris Ritchie Lieberman, Ph.D.
Mary Jo McKiveen Nissen, Ph.D.

Administrative Officer

Diane McLaughlin, M.B.A.

Administrator for Academic Programs

Carla Welch Kirmani

Psychology, the study of behavior, has grown in recent years with unforeseen rapidity. New avenues of approach have been opened by convergent developments of methods in the natural and social sciences and in mathematics, raising the hope that human beings, who have achieved considerable mastery over the world around them, might also come closer to an understanding of themselves.

Psychology at MIT stresses the connections with basic science and concentrates its efforts on the search for new knowledge in three distinct but interrelated areas: the study of relationships between brain and behavior (physiological psychology); the study of perception and information processing (general experimental psychology); and the study of origins of individual behavior (developmental and cognitive psychology; psycholinguistics). Accordingly, instruction in psychology on all levels, undergraduate, graduate, and postdoctoral, is organized to fall into these three areas which border on such diverse fields as computer science, biophysics, neurology, neurochemistry, sociology, and philosophy, as well as linguistics and other communication sciences.

Programs of research on these three principal themes — those of brain and behavior, perception and information processing, and early development and psycholinguistics — are carried on in the Institute's psychology laboratories in close contact with the teaching program. The MIT psychology building contains machine shops and electronic shops, a specialized research library, and facilities for brain research (electrophysiology, experimental surgery, and neurohistology) for comparative studies of animal behavior, for observations on perception and memory in humans in normal and abnormal states, and for the study of early stages in the acquisition by children of language, logic, and knowledge of the world.

Undergraduate Study

Psychology subjects at the undergraduate level normally begin with 9.00 Introduction to Psychology, 9.55 Introduction to Language and Cognition, or 9.90J Human Development: Individual and Social Perspectives. The remaining, more advanced subjects fall into the three areas covered by the Department: brain and behavior, experimental, and cognitive psychology. There is at present no undergraduate major in psychology at MIT; however, psychology subjects can form an important part of the student's major in Course XXV (Interdisciplinary Science Program). For all undergraduates, many psychology subjects may be taken to fulfill the Institute Requirement in the Humanities, and Social Sciences. Students interested in developing strong backgrounds in psychology should examine the suggested options of the Master of Science program that follows.

Graduate Study

The Department offers work leading to the Master of Science in Psychology and Brain Science and the Doctor of Philosophy. The program of studies leading to these graduate degrees is designed to prepare students for careers in teaching and research, or may also serve as a pre-medical orientation. The departmental program permits concentration in any one of the three areas already described: brain and behavior, experimental psychology, and developmental-cognitive psychology, including psycholinguistics. Throughout graduate study, students are involved in research projects occupying at least one-half of their time; aptitude is assessed as much in the light of demonstrated research abilities as in performance in seminars or tutorials.

Entrance Requirements for Graduate Degrees

Approximately one-half of the incoming graduate students have majored in psychology or related fields; the balance are promising candidates with other backgrounds. For admission, students are expected to have the equivalent of one year of college-level work in three of the following four areas: physics, chemistry, biology, and mathematics. Minor deficiencies in the undergraduate preparation can be removed, with the permission of the Department, by taking the appropriate subjects at the Institute.

Master of Science in Psychology and Brain Science

In order to provide better preparation for students desiring graduate study in medicine, biology, psychology, and neurophysiology, the Department of Psychology offers a special program in psychology and the brain sciences. This program allows a limited number of undergraduate students to conduct research in the departmental laboratories, with the fruits of the research providing the basis for our Master of Science degree. In order to enter this program, the applicant must already be enrolled as an undergraduate at MIT and then must be accepted in the Graduate School by the Department of Psychology.

Students enrolled in the special master's program are provided a firm foundation in the physical and biological sciences during the first two undergraduate years. In the latter half of their junior year they should begin laboratory work in one of the following three areas: neurosciences, natural computation and perception, or cognitive systems. Since only a very limited number of Master of Science candidates can be accommodated in the Department, it is imperative that students wishing to enter this program begin their research experience in psychology as early as possible and no later than the second half of the junior year. In this way, the major portion of the senior year and the subsequent summer may be devoted to research and thesis.

In order to aid students in planning a flexible undergraduate curriculum which could lead into the master's degree program, a list of recommended basic subjects is given below. Many of these subjects can be incorporated into any undergraduate curriculum. Following this list are guidelines that suggest three possible distributions of graduate electives, each group forming a cohesive unit in one of three areas: neuro-sciences, natural computation and perception, or cognitive systems. Substitutions appropriate to individual objectives are proposed when applying at the end of the junior year to the Graduate School for admission to the Master of Science program.

Master of Science in Psychology and Brain Science Course IX

	General Institute Requirements	Total Units
	Basic Subjects	
5.41	Introduction to Structure, Bonding and Mechanism	5 0 7
7.01	General Biology	4 0 8
9.00	Introduction to Psychology	3 0 6
9.01	Neuroscience and Behavior	3 0 6
9.35	Perception: Mechanisms and Models	3 0 6
9.921	Research in Psychology	0 24 0
18.03	Differential Equations	4 0 8
	This course of study requires a thorough undergraduate preparation. The MIT equivalents are tabulated below. It is expected the candidate will have successfully completed these or equivalent subjects.	
	The Laboratory Requirement will normally be satisfied by 9.50	
	Area specialization (see following)	**66**
	Thesis	**36**

	Suggestions For Specialization (elect one of the following three areas):	Units
	Area I: Neurosciences	**69**
6.071	Introduction to Electronics	4 2 6
7.05	General Biochemistry	5 0 7
9.016J	The Human Nervous System	6 3 6
9.02	Nature, Nurture and the Individual Brain	3 0 6
9.021	Topics in Brain and Behavior	3 0 6
9.361	Neurophysiology of the Visual System	3 0 6
20.512J	The Neurosciences II	6 0 9
	Area II: Natural Computation and Perception	**66**
6.034	Artificial Intelligence	4 0 8
2.10	Elementary Programming and Machine Computation	2 1 6
9.340	Control of Movement in Biological and Robotic Systems	3 0 6
9.36	Natural Computation and Control	3 0 6
9.361	Neurophysiology of the Visual System	3 0 6
9.365	Dissection by Psychophysics (at least 6)	
24.968J	Speech Communication	3 0 9
	Area III: Cognitive Systems	**66**
1.00	Principles of Computer-Based Engineering Problem Solving	3 1 8
6.034	Artificial Intelligence	4 0 8
9.591	Seminar in Psychology of Language and Communication I	3 0 6
9.651	Cognitive Processes	3 0 6
9.88	Development of Behavior	3 0 6
9.90J	or Human Development: Individual and Social Perspectives	3 0 6
24.117	Philosophy of Mind and Psychology	3 0 9
24.968J	Speech Communication	3 0 9

Doctor of Philosophy

The doctoral program begins with 9.901 Proseminar in Psychology, which is taken during the first graduate year and serves to equalize the diverse backgrounds of the incoming graduate class. Following the Proseminar, candidates choose appropriate graduate subjects to prepare themselves for the general examinations and to meet other pre-thesis requirements. Because the number of required graduate subjects other than the Proseminar is minimal, candidates have great flexibility in choosing subjects that best supplement their research activities.

The doctoral thesis represents an outgrowth of two preceding research reports, each written in the first two years of graduate study. As a rule, the thesis itself represents one year's research and must be written in residence.

Candidates are required to fulfill the departmental minor and language requirements. The language or languages are ordinarily chosen from German, French, or Russian; however, substitutions may be made if they have professional significance. Sufficient proficiency in computer languages may also qualify for one modern language.

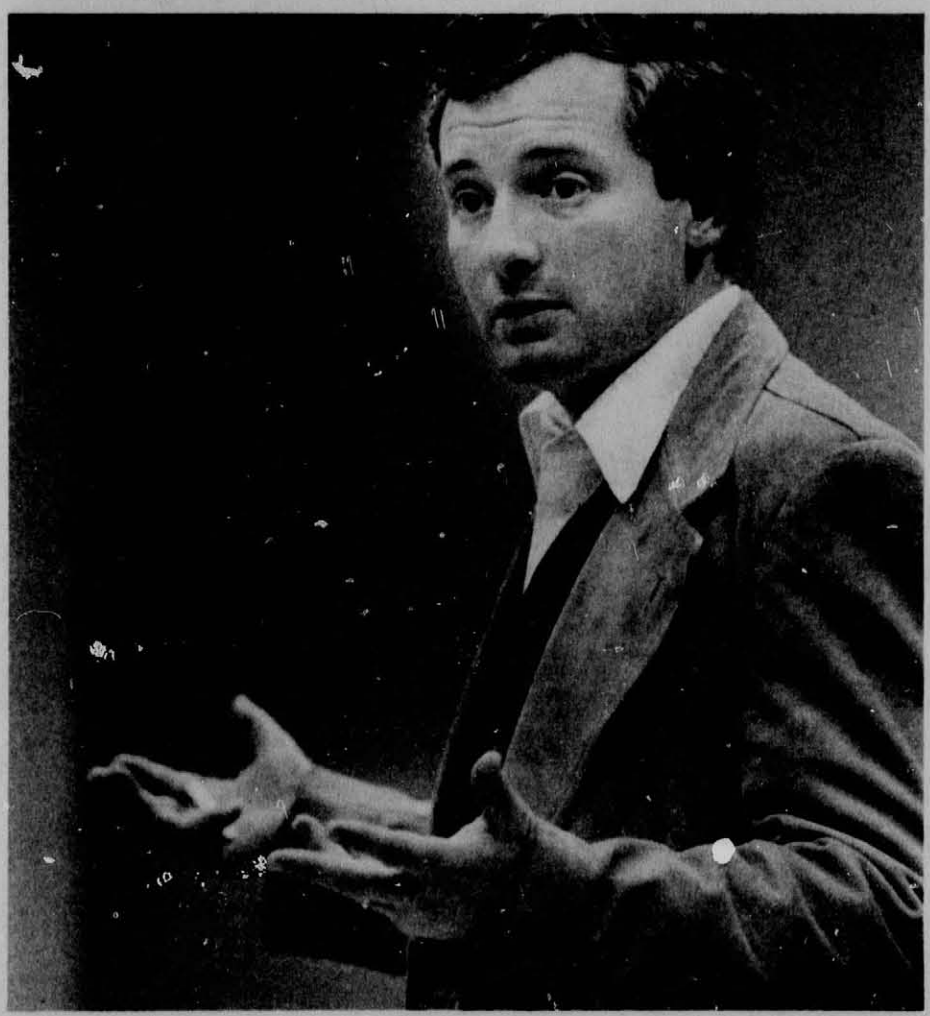
Inquiries

Additional information regarding teaching and research programs in the Department, admissions, assistantships, and financial aid, may be obtained from the Department of Psychology, Room E10-008, MIT, Cambridge, Massachusetts 02139, (617) 253-5741.

Sloan School of Management







The Alfred P. Sloan School of Management, founded in 1952 as the School of Industrial Management, is the outgrowth of a pioneering curriculum, first organized at MIT in 1914, which combined management and engineering education. From that time, Course XV, Management, became the regular vehicle for providing this unique pattern of education to MIT's undergraduates. During this period many of the Institute's most distinguished graduates made their reputations as managers and business leaders. The gift of Alfred P. Sloan, Jr. in 1952, however, was the landmark in establishing a new level and a broader scope in management education at MIT, and much of the story of management education at the Institute has been written since then.

The Sloan School now offers an undergraduate program leading to the Bachelor of Science in Management; graduate programs leading to the Master of Science in Management and the Doctor of Philosophy; a one-year Alfred P. Sloan Program in executive development leading to the Master of Science in Management; and a nine-week Program for Senior Executives in executive development. In addition, the Sloan School participates with the School of Engineering in the new interdepartmental Joint Program in the Management of Technology, leading to a Master of Science in the Management of Technology. Over the past several years the School has developed a large number of summer subjects designed primarily to meet the needs of practicing professionals in the various areas of the School's program.

In its efforts, the Sloan School is committed to educating enterprise managers — men and women who have the will to manage and to risk, who can deal with complex systems, who have insight into themselves as well as others, who understand the total environment in which they live, and who continue to learn. In fulfilling this commitment, the School provides students with a solid grounding in the academic disciplines relevant to management — economics, mathematics, and the behavioral sciences — and develops their awareness of the multiple

Sloan School of Management

facets which characterize important management problems, from technical data to human factors. The School also endeavors to teach students to make decisions and to move decisively and responsibly in an increasingly complex world. The opportunities for such graduates in a society full of challenge, both social and technical, are substantial and growing, in fields which include industrial management, the management of technology, the management of health services, the management of education, and the management of public and urban affairs.

In addition to educating men and women for management, the Sloan School is equally committed to research directed at new understanding of and better solutions to management problems. Together, research and education are mutually reinforcing goals, and the School is confident of their continued impact on the fields of management and management education.

Dean of the Sloan School of Management

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Gay Van Ausdall, B.A.
Managing Editor, *Sloan Management Review*

Alan Frederick White, S.M.
Director of Executive Education Programs and Lecturer

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Senior Lecturer

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Professor of Industrial Management, Emeritus

Edward Pennell Brooks, D.Sc.
Professor of Industrial Management, Emeritus
Dean, Emeritus

Douglass Vincent Brown, Ph.D.
Alfred P. Sloan Professor of Management, Emeritus

David Durand, Ph.D.
Professor of Management, Emeritus

Billy Earl Goetz, Ph.D.
Professor of Management, Emeritus

Mason Haire, Ph.D.
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Senior Lecturer

Carroll Louis Wilson, Sc.D.
Mitsui Professor in Problems of Contemporary Technology, Emeritus

Guest of the Institute

Alan Francis Kay, Ph.D.

The Alfred P. Sloan School of Management offers four undergraduate programs which provide bases for widely varying management-related careers. The programs include the Special Program in Management (Program 1), Behavioral Science in Management (Program 2), Management Science (Program 3), and Dynamics of Management Systems (Program 4).

Programs 2, 3, and 4 have been planned to meet the anticipated needs of most undergraduates interested in management. Program 1 is intended to cope with unanticipated student interests, as well as with the special requirements of highly motivated students, such as a highly concentrated interest in management in the public sector. Common to all of the curricula is the principle that students should gain a sound general education, with emphasis on an area of relevance to the design, planning, and control of complex organizations and social systems. A sequence of six core subjects provides a unified approach to informational and economic concepts common to decision making in such systems. Beyond this common core students have a number of alternative paths by which they are encouraged to study in depth an interrelated set of management disciplines.

In addition to the flexibility inherent in the four curricula, especially in the option for student initiative in Program 1, each program provides the further freedom of a number of unrestricted elective subjects. By different approaches to elective choice, a variety of educational objectives can be achieved. Students can schedule electives treating the functional areas of management to permit completion of the Bachelor of Science in Management at the end of four years of study and the Master of Science in Management at the conclusion of the fifth year. In-depth exposure to an area of physical science or engineering, in addition to an education in management, can be achieved by a technically oriented elective program. Appropriate selection of electives should permit a student to meet admission requirements of medical, law, or other graduate schools.

Program 1
Special Program in Management

The Special Program in Management has been designed to encourage student initiative in management education. Specific requirements are limited to General Institute Requirements and the six management core subjects. Beyond these, any student, or group of students, may propose a coordinated program which relates meaningfully to individual career objectives in management. Each student-initiated professional program must be approved by three faculty members, including at least two from the Sloan School of Management.

A proposed program should contain a specified series of subjects, planned and designated in advance of proposal submission, totaling between 54 and 63 Institute credit units. No more than one-third of these credits may be in Special Studies subjects. Not all of the individual subjects need be offered by the Sloan School of Management; however, the program as a whole is judged for its relevance and importance to management.

Program 1
Special Program in Management

	General Institute Requirements	Total Units
	Specific science and humanities and social science subjects.	132
	The Science Distribution Requirement can be satisfied by 6.030 and 14.30, which are required in the Departmental Program, plus appropriate subjects totaling[1]	12
	The subject 15.301, which is required in the Departmental Program, appears on the list of Laboratory Subjects and can be used to satisfy the Laboratory Requirement	
	Departmental Program	
	Required Subjects	**96**
6.030	Introduction to Computation 4 3 5	
14.30	Introduction to Statistical Methods in Economics 4 0 8	
15.001	Managerial Economics[2] 4 0 8	
15.301	Managerial Psychology Laboratory 2 6 4	
15.412	Financial Management 4 0 8	
15.501	Financial and Cost Accounting 3 0 6	
15.761	Operations Management 3 0 6	
15.812	Marketing Management 3 0 6	
15.813	or Marketing Issues in Public Systems 3 0 6	
	Managerial Environment[3]	**at least 9**
	Restricted Electives[4]	**54 to 63**
	A coordinated program of professional electives relevant to management should be developed by the student, subject to faculty approval.	
	Unrestricted Electives	**66 to 57**
	Total Units Required for the S.B. Degree	**360**

1
An additional science distribution subject may be included as part of an approved professional program.
2
14.01 and 14.02 may be substituted for 15.001.
3
Students may choose from a list of suitable subjects maintained at the Sloan School Undergraduate Office. The list includes such subjects as 11.165 Law and Public Policy, 14.20 Industrial Organization and Public Policy, 14.63 Labor in Industrial Society, 15.223 International Business Environments, 15.616 The American Legal System, 17.301 Science, Technology and Politics.
4
The student has the option of designing his or her own professional program of electives (subject to faculty approval) or of selecting one of the previously designated professional programs in Course XV. For examples of the latter option see the curricula of the Behavioral Science Program, the Management Science Program, and the Dynamics of Management Systems Program.

Program 2
Behavioral Science in Management

This program is designed to provide students with the proper tools for the utilization of behavioral science theory and research knowledge in the managerial context.

The curriculum pursues a spiral course exposing students to the same basic behavioral science principles at several levels of complexity, each time from a somewhat different vantage. In following such a course, students develop the structure necessary for the accomplishment of a major learning experience, the research practicum, in the senior year. In other words, following an introductory survey in 15.301 Managerial Psychology Laboratory (a "core" subject), students go through a second cycle of the spiral process as they study behavioral science concepts and their interrelations in depth in two subjects, Social Psychology and Complex Organizations. In the senior year students encounter the third cycle, that of actual experiences in searching for new knowledge and interpreting their findings.

This combination of theory, research, and practical experience in behavioral science enables students to pursue graduate study in many applied fields, with a firm groundwork in the fundamentals of behavioral science.

Program 2
Behavioral Science in Management

	General Institute Requirements	Total Units
	Specific science and humanities and social science subjects.	132
	The Science Distribution Requirement can be satisfied by 6.030 and 18.05, which are required in the Departmental Program, plus appropriate subjects totaling	12
	The subject 15.301, which is required in the Departmental Program, appears on the list of Laboratory Subjects and can be used to satisfy the Laboratory Requirement.	
	Departmental Program	
	Required Subjects	**153**
6.030	Introduction to Computation 4 3 5	
9.70	Social Psychology 3 0 6	
15.001	Managerial Economics[1] 4 0 8	
15.301	Managerial Psychology Laboratory 2 6 4	
15.304	Complex Organizations 3 0 6	
15.306	Behavioral Science Research Methods 3 0 9	
15.307	Behavioral Science Research Practicum 2 8 8	
15.351	Research and Development Management 2 0 7	
15.412	Financial Management 4 0 8	
15.501	Financial and Cost Accounting 3 0 6	
15.761	Operations Management 3 0 6	
15.812	Marketing Management 3 0 6	
15.813	or Marketing Issues in Public Systems 3 0 6	
18.05	Introduction to Probability and Statistics 3 0 9	
	Managerial Environment[2]	**at least 9**
	Restricted Electives	**12**
	A minimum of 12 units of additional engineering or science electives.	
	Unrestricted Electives[3]	**51**
	Total Units Required for the S.B. Degree	**360**

1
14.01 and 14.02 may be substituted for 15.001.
2
Students may choose from a list of suitable subjects maintained at the Sloan School Undergraduate Office. The list includes such subjects as 11.165 Law and Public Policy, 14.20 Industrial Organization and Public Policy, 14.63 Labor in Industrial Society, 15.223 International Business Environments, 15.616 The American Legal System, 17.301 Science, Technology and Politics.
3
Schedules of students in Course XV, Program 2, always may be arranged to leave available 24 units of Unrestricted Elective in the second year.

Program 3
Management Science

The Management Science program caters to mathematically and scientifically oriented men and women who would like to participate in solving some of the technical problems central to the successful management of public and private organizations.

In recent years the rise of the computer, along with the development of mathematical models of systems and the collection of large quantities of data, has stimulated the growth of a technology of management. This is the domain of operations research and management science, two names commonly used to describe the field. The knowledge and methods being developed are applicable to problem solving in business, government, and other public and private organizations. The elements of the technology are the interrelated techniques of systems analysis, mathematical models, statistics, and computer science. In systems analysis, problem solving is approached by identifying the system, establishing its objectives, and setting down measures of its performance. Then the variables or actions under managerial control are determined and a model is constructed to relate the controllable variables to the measures of system performance. Thereafter, the variables can be set to optimize performance.

The Management Science program develops an underlying competence in mathematical models, optimization techniques, statistics, and computers. This provides wide flexibility in career choice. It prepares students for immediate participation in systems analysis or operations research activities in industry or government. Alternatively, it provides a basic groundwork for pursuing graduate work in several directions, either more broadly toward management and social science or more technically toward a research career in operations research, computer science, or applied mathematics.

Program 3
Management Science

	General Institute Requirements	Total Units
	Specific science and humanities and social science subjects.	132
	The subjects 6.041, 15.053, and 18.700, which are required in the Departmental Program, appear on the list of Science Distribution Subjects and can be used to satisfy the Science Distribution Requirement.	
	The subject 15.301, which is required in the Departmental Program, appears on the list of Laboratory Subjects and can be used to satisfy the Laboratory Requirement.	
	Departmental Program	
	Required Subjects	**126**
6.041	Probabilistic Systems Analysis	4 0 8
15.001	Managerial Economics[1]	4 0 8
15.053	Introduction to Management Science	4 0 8
15.075	Statistics for Applications	3 0 6
15.301	Managerial Psychology Laboratory	2 6 4
15.412	Financial Management	4 0 8
15.501	Financial and Cost Accounting	3 0 6
15.564	Management Information Technology I	3 0 6
15.761	Operations Management	3 0 6
15.812	Marketing Management	3 0 6
	or	
15.813	Marketing Issues in Public Systems	3 0 6
18.700	Linear Algebra	3 0 9
	Managerial Environment[2]	at least 9
	Restricted Electives	**18**
	A minimum of 9 units is to be selected from the following list of electives:	
6.034	Artificial Intelligence	4 0 8
6.262	Markov Models and Their Applications	3 0 9
15.065	Decision Analysis	3 0 6
15.073J	Introduction to Stochastic Processes	4 0 8
15.076J	Statistics for Model Building	3 0 9
15.081J	Introduction to Mathematical Programming	3 0 9
15.521	Management Accounting and Control	3 0 6
15.522	Planning and Control in Non-Profit Organizations	3 0 6
15.565	Management Information Technology II	3 0 6
15.571	Advanced Computer Systems	3 0 6
15.874	Industrial Dynamics	3 0 9
	A minimum of 9 units of additional electives in management or economics	
	Unrestricted Electives[3]	**84**
	Total Units Required for the S.B. Degree	**360**

1
14.01 and 14.02 may be substituted for 15.001.

2
Students may choose from a list of suitable subjects maintained at the Sloan School Undergraduate Office. The list includes such subjects as 11.165 Law and Public Policy, 14.20 Industrial Organization and Public Policy, 14.63 Labor in Industrial Society, 15.223 International Business Environments, 15.616 American Legal System, 17.301 Science, Technology and Politics.

3
Schedules of students in Course XV, Program 3, always may be arranged to leave available 24 units of Unrestricted Elective in the second year.

Graduate Study

Program 4
Dynamics of Management Systems

The Dynamics of Management Systems program focuses on the feedback structure of organizations. The unifying concepts of feedback processes are stressed to show how the same principles are encountered in management, economics, engineering, life processes, and the humanities.

The systems of interest to the manager are multi-loop, contain both positive and negative feedback, and are of high order and nonlinear. To understand such systems, one must see them from as many perspectives as possible — as organized according to principles of structure; as descriptive subjects dealing with the structure and dynamics of social systems; as a mathematical interpretation relating structure and policy to growth and stability; as computer simulation of system models; and as field projects relating theory to practice.

This program uses feedback structure and dynamics to unify and interrelate the functional areas of management. The program is suitable for either the line manager or the systems analyst. It should serve as a foundation for graduate study or practice in a wide variety of fields.

Inquiries

For additional information on undergraduate curricula and referral to appropriate faculty counselors, students may consult the Undergraduate Program Office, Room E52-472, MIT, Cambridge, Massachusetts 02139, (617) 253-2931.

Program 4
Dynamics of Management Systems

	General Institute Requirements	Total Units
	Specific science and humanities and social science subjects.	132
	The Science Distribution Requirement can be satisfied by 15.852 and 18.03, which are required in the Departmental Program, and 2.02 or 6.002, which appear on the list of Restricted Electives.	
	The subject 15.301, which is required in the Departmental Program, appears on the list of Laboratory Subjects and can be used to satisfy the Laboratory Requirement.	
	Departmental Program	
	Required Subjects	**108**
15.001	Managerial Economics[1]	4 0 8
15.301	Managerial Psychology Laboratory	2 6 4
15.412	Financial Management	4 0 8
15.501	Financial and Cost Accounting	3 0 6
15.761	Operations Management	3 0 6
15.812	Marketing Management	3 0 6
	or	
15.813	Marketing Issues in Public Systems	3 0 6
15.852	Principles of Dynamic Systems I	3 0 9
15.873	Principles of Dynamic Systems II	3 0 9
18.03	Differential Equations	4 0 8
	Managerial Environment[2]	at least 9
	Restricted Electives	**42 to 48**
2.02	Introduction to System Dynamics	4 0 8
	or	
6.002	Circuits and Electronics	4 2 9
	and	
2.14	Control System Principles	3 2 7
	or	
6.003	Signals and Systems	4 2 9
	A minimum of 18 units to be selected from the following list of electives:	
15.874	Industrial Dynamics	3 0 9
15.875	Applications and Implementation of Industrial Dynamics	3 0 6
15.876	Dynamics of Health Service Systems	3 0 6
15.878	Economic Dynamics	3 0 6
15.879	Seminar in System Dynamics Policy Analysis	3 0 6
	Unrestricted Electives[3]	**78 to 72**
	Total Units Required for the S.B. Degree	**360**

1
14.01 and 14.02 may be substituted for 15.001.
2
Students may choose from a list of suitable subjects maintained at the Sloan School Undergraduate Office. The list includes such subjects as 11.165 Law and Public Policy, 14.20 Industrial Organization and Public Policy, 14.63 Labor in Industrial Society, 15.223 International Business Environments, 15.616 The American Legal System, 17.301 Science, Technology and Politics.
3
Schedules of students in Course XV, Program 4 always may be arranged to leave available 24 units of Unrestricted Elective in the second year.

The Sloan School of Management provides opportunity for graduate work leading to the degrees of Master of Science in Management and Doctor of Philosophy.

Entrance Requirements for Graduate Study

Undergraduate preparation for the graduate programs should include: mathematics through differential and integral calculus and principles of macro and microeconomics. However, any applicant strongly motivated to study in the Sloan School who has demonstrated high intellectual capacity, and who is prepared to eliminate any deficiencies in preparation before entering, will be seriously considered. Applicants for admission to degree candidacy, except in the Alfred P. Sloan Fellows Program, are required to take the Graduate Management Admission Test administered by the Educational Testing Service, Box 966, Princeton, New Jersey 08541. Information about dates and locations may be obtained from that agency. The January test is the latest one appropriate for admission in the following June or September.

Master of Science in Management

Degree candidates normally are admitted in September to a program of study extending over two academic years. Those who have had two or more years of full-time work experience and who are otherwise well qualified may be considered for June admission to an accelerated course permitting satisfaction of all requirements in a period of 12 months.

The Accelerated Master's Program offers a breadth of exposure to management in an intensive 12-month program. It was developed at the Sloan School nine years ago to meet both the needs of organizations demanding professional middle management talent with executive potential and the priorities of experienced individuals who, with a concentrated program in management, could assume these responsibilities.

Both programs are designed to educate managers who aspire over their careers to senior positions. The Sloan Master's Program offers students with or without previous work experience a general management education and the opportunity to establish a special competence that may lead them to positions of either general executive responsibility or technical leadership. Graduates with prior experience may build on existing expertise or shift their previous orientation and cross several functional areas during the course of their executive development.

Both Master's programs of the Sloan School are conducted along three distinguishable though closely related lines: theoretical studies, applied studies, and practical exposure.

Theoretical studies aim to improve the student's understanding of certain fundamental phenomena and relations that characterize the world in which the manager must operate. The principal fields covered by these studies are economics, organizational studies, and quantitative methods of analysis. One of the hallmarks of the Sloan School is the emphasis placed on this aspect of training for management. This fact is, however, open to misinterpretation, especially because the Sloan School is part of MIT, an institution devoted largely, though by no means exclusively, to engineering and science. Although the theoretical subjects at the Sloan School have a distinctly analytical flavor, the student need not have an elaborate mathematical training before entering the School; one year of college calculus is a requirement for entrance, but many students in the Master's program come from backgrounds in humanities or non-mathematical sciences.

Applied studies, which occupy the great bulk of a student's time in the Master's programs, link the analytic techniques of the theoretical studies to the practical problems faced by managers. The main applied fields at the Sloan School are Accounting and Control, Applied Economics, Finance, Health-Care Management, Industrial Relations, International Management, Management Information Systems, Management of Technological Innovation, Marketing, Operations Management, Operations Research, Organization Studies, Policy and Strategy, and System Dynamics. Many subjects are available in each of these fields, and the curriculum allows for considerable flexibility of choice by the student. This flexibility enables students to construct programs which introduce them to all or many of the applied fields or, by contrast, enable them to specialize in one or a few of the applied fields. Students are thus able to acquire a broad training, if they are interested in becoming general managers, or quite a specialized training, if they prefer to become experts in one particular aspect or technique of management.

Practical exposure for management takes place, in the Sloan School, through a variety of activities. Students in the Sloan Master's Program are encouraged to spend the intervening summer working in some firm or organization. Some Master's candidates serve as paid research assistants to members of the faculty, or may be involved with them in the practical consulting activities which they carry on for governments, firms, and other public and private bodies. Students in the one-year Accelerated Program have the opportunity, in the course of a trip arranged by the School, to meet with senior executives in firms and senior public officials to discuss practical problems of management. A program of executive lectures brings to the School the heads of many firms and public organizations, with whom students discuss the practice of management.

The Master's thesis provides opportunity for intensive study of a specific management problem selected by the student. Thesis research is conducted under supervision of a faculty committee, whose members share an interest in the topic. Joint theses, which permit attacking problems of somewhat larger scale, are generally encouraged. An alternative type of thesis, known as a "structured thesis," permits a group of students to join in a major project (designed by faculty members), with each student reporting on a specific phase of the study. In addition to the experience offered by the thesis per se, management students may participate in the structuring and solution of real problems through group projects associated with subject offerings.

Doctor of Philosophy

The purpose of the Sloan School's doctoral program is to prepare students for careers in teaching and research or for nonacademic positions requiring advanced research and analytical capabilities.

The program's philosophy is summarized by two propositions. First, advanced analytical work in management is done best by persons trained in an underlying theoretical discipline. Second, such work requires understanding of the structure of managerial practices, as well as knowledge of underlying theory and concepts. Thus the doctoral program provides the opportunity to combine work in theory with work in broadly defined "applied" or "functional" fields.

A candidate entering with a Bachelor's degree should be able to complete the program in three to four years. The first year is devoted to work in the basic disciplines of management and to preliminary work in the student's major and minor fields. The second year is primarily devoted to the major and minor fields. Finally, one to two years are required for the doctoral dissertation. Of course, a candidate entering with an advanced degree may be able to finish in less time depending on previous experience in research.

Breadth Requirement

The basic disciplines referred to above are behavioral science, economics, and quantitative methods. In each of these "breadth" areas students may demonstrate competence by passing a qualifying examination or by successfully completing two subjects specified by the

Ph.D. Committee. Entering students with formal preparation in these disciplines are encouraged to take the qualifying examinations in September, when they enroll, so as to avoid unnecessary delays in progressing through the program.

Major and Minor Fields

Candidates must master the literature, theory, and application of a major field of concentration as well as a minor field. Successful completion of this requirement is determined by General Examinations (see below). The major fields currently available in the Sloan School are:

Applied Economics
Finance
Health Care Management
Industrial Relations and Law
International Management
Management Science
Management of Technological Innovation
Organization Studies
Strategy and Policy
System Dynamics

The Management Science area offers majors in the following fields:

Accounting and Control
Management Information Systems
Marketing
Operations Management
Operations Research and Statistics

When students' objectives do not fall into the usual categories, it is possible to construct other major fields.

Most doctoral students enter the program with a fairly clear idea in mind of a major field of concentration, and it is typically an "applied field." An appropriate minor field is then selected — a theoretical discipline that provides a foundation for research in the major field. The following are examples of natural and usual combinations:

Major Field	Minor Field
Finance	Economics
Industrial Relations	Behavioral Science
Marketing	Statistics
Operations Management	Operations Research
Organization Studies	Behavioral Science
System Dynamics	Economics

There are no rigid subject requirements for the major and minor fields. Naturally, there are normal packages of subjects for the standard fields, but substitutions of other subjects and independent study are possible. Regardless of the major and minor fields chosen, a plan of study designed to prepare the student for General Examinations is worked out by the student and his or her faculty advisor(s) and submitted to the Ph.D. Committee for approval at the beginning of the spring term in the student's first year.

General Examinations

General Examinations normally are taken in late May of the second year of study, after completion of the breadth requirement, major and minor field course work, and a research paper (see below). They are given by faculty working in the student's major and minor fields. The exact form of General Exams varies from area to area and may involve written examinations, critiques of research papers, or review papers on prescribed topics. In all cases, the last stage is an oral examination covering both major and minor fields.

Research

Like the rest of MIT, the Sloan School faculty and administration are deeply committed to research, and the philosophy and structure of the Ph.D. program reflect this professional and organizational commitment. There are two separate research requirements: the research paper and the thesis.

A substantial part of the student's work in the latter half of the first year and in the second is devoted to an independent research project. The topic, design, and execution of the project are left to the student, while advice and criticism are provided by a research advisor and other interested faculty. Upon completion of the project, the student prepares a document which, after the evaluation and approval of faculty members, is published in the Sloan School's Working Paper Series.

The doctoral dissertation consists of significant scholarly research in some area of management. Close working relationships with senior faculty are established early so that the thesis can be defined as a manageable project as early as possible. Candidates typically require one to two years of full-time work to complete their theses

Teaching Apprenticeship

Since the graduates of the doctoral program are almost invariably involved in teaching, whether in a university or in other organizational settings, there is a Teaching Apprenticeship requirement for the degree. Each candidate is given partial responsibility for conducting a Sloan School subject. The apprenticeship offers an opportunity for working closely with a faculty member who can provide constructive feedback and counsel. The apprenticeship is normally undertaken in the third year of study, after General Examinations have been passed, but may be completed earlier if a suitable teaching opportunity is available.

Programs for Executive Education in Management

Language Requirement

There is no language requirement in the Sloan School's doctoral program, although in some cases the student and his or her advisor decide that further study of a foreign language is necessary if the student is to work effectively in his or her major field. Usually this is true, for example, in the field of International Management.

Fellowships, Teaching and Research Assistantships

Except for limited funds designated by donors for aid to disadvantaged students, fellowships for graduate study in management are given only to doctoral degree candidates. All graduate students who have completed a year (or sometimes a term) of graduate study in the Sloan School are eligible to apply for the approximately 100 part-time research and teaching assistantships available each year.

Inquiries

Additional information concerning graduate programs, admissions and financial aid, may be obtained from the Graduate Programs Office, Room E52-480, Sloan School of Management, MIT, Cambridge, Massachusetts 02139, (617) 253-3730.

Alfred P. Sloan Fellows Program

Each year the Alfred P. Sloan Fellows Program admits between 50 and 55 mid-career executives who have demonstrated potential for filling positions of more general and senior management responsibility in the future. These men and women are sponsored by industry, government, and other organizations (or they may apply independently). A limited number are selected from abroad. The 12-month Program, providing regular classroom work plus close contact with business and government leaders here and abroad, is taken in conjunction with the regular graduate program and leads to the degree of Master of Science in Management.

In 1975 the Sloan School initiated a Health Management Option within the Sloan Fellows Program, aimed at mid-career to senior level health-care practitioners, educators, researchers, and administrators. The limited number of health professionals who are admitted each year participate fully in all aspects of the Sloan Fellows Program.

MIT Program for Senior Executives

The Program for Senior Executives is an intensive nine-week course of study designed for the senior level executive already in or preparing for a position of major managerial responsibility. Enrollment in the Program, offered in the fall and spring of each year, is limited to groups of 30. Participants reside at Endicott House in Dedham, Massachusetts, taking their course work on campus at the Sloan School, and at Endicott House. A one week trip to Washington, DC to visit policy makers of the Federal government is an important part of the Program.

Inquiries

Detailed information about these programs may be obtained from the Executive Education Programs Office, Room E52-455, Sloan School of Management, MIT, Cambridge, Massachusetts 02139, (617) 253-7166.

School of Science



Our understanding of the physical and biological worlds continues to increase and to open up new possibilities of applications for the benefit of humanity. The pursuit of this understanding also helps us to better appreciate the world in which we live. Because of the rapid advance of science, our world view is in the process of continuous change. Today we are increasingly dependent on science for the knowledge that allows us to solve practical problems and to find better ways of providing for the world's needs. Modern science has proved useful in many important ways, but the search for understanding also is carried out because people are curious about the world around them.

Training in science provides the basis for many types of careers. People with scientific training are needed for teaching and research, but scientific training provides an opportunity to enter other professions as well. Students with bachelor's degrees in science may go on to medical school, law school, or other professional schools.

The sciences and mathematics form a continuum, but for administrative purposes they are divided into seven departments at MIT. There are many interrelations between the programs of these departments, and the interdepartmental laboratories help to form a bridge between fields and to provide contact with applications.

At MIT, the biological sciences are represented by a wide range of disciplines from cell biology, microbiology, biochemistry, and biophysics, to food science and technology, metabolism and human nutrition, toxicology, and biochemical engineering. The biological sciences have undergone tremendous change since the discovery of the structure of deoxyribonucleic acid. The Cancer Center and the Cell Culture Center are interdepartmental laboratories which are closely related to the Department of Biology. The Clinical Research Center is an interdepartmental laboratory which is closely related to the Department of Nutrition and Food Sci-

ence. The Whitaker College of Health Sciences, Technology, and Management has joint programs with the School of Science.

The physical sciences deal with the physical universe from the shortest distances between particles inside the nucleus to the greatest distances over which we learn of the structure and substance of the universe from astronomy and astrophysics. In physics at MIT, the four main areas are astrophysics; experimental nuclear and particle physics; solid state, laser, plasma, and atomic physics; and nuclear and particle theory. A great deal of physics research is carried out in the interdepartmental laboratories listed below. In chemistry, research and education are carried out in organic, inorganic, physical, analytical, biological, biophysical, and chemical physics. These sciences are heavily involved in industry and many graduates find their careers in applications as well as in research. Science has, of course, contributed in the most fundamental way to the advancement of technology, and technology has contributed importantly to the advancement of science. At MIT, the relationships between science and technology are especially close and mutually reinforcing.

The Earth Sciences include geology, geochemistry, geophysics and planetary science, and meteorology and physical oceanography. The increased understanding of plate tectonics has revolutionized our views of the past and current changes in the structure of the earth. The increased use of computers in atmospheric and oceanographic models has revolutionized our understanding of circulation. The Wallace Astrophysical Observatory and the Wallace Geophysical Observatory provide opportunities for education and research, as do various interdepartmental laboratories. The joint doctoral program with the Woods Hole Oceanographic Institution provides opportunities to be involved in oceanographic research.

Mathematics provides a base and language for all types of research and is an area of active research itself in both the discovery of new mathematics and in applying mathematics in new ways to important applied problems. Pure mathematics is of interest in its own right, and it always has led in unexpected ways to a better understanding of the world. The core of the program in applied mathematics is concerned with the mathematical formulations of propagation, stability, optimization, cybernetics, statistics, and random processes.

The science departments and the related interdepartmental laboratories offer many opportunities for undergraduate research through the Undergraduate Research Opportunities Program. Through this program, students obtain first-hand research experience in fields that interest them, and learn in a different environment from the classroom or instructional laboratory. The Undergraduate Seminar Program provides study and associations with faculty members in smaller and less formal groups.

The School of Science also is involved in providing parts of the general education of undergraduate students through the Science Requirement Subjects, Science Distribution Subjects, and Laboratory Subjects.

Course XXV offers an S.B. degree program in Interdisciplinary Science. This program provides special opportunities for students to arrange their curricula in consultation with faculty advisors in fields involving more than one area of science.

Interdisciplinary laboratories and centers associated with the School include the following:

Francis Bitter National Magnet Laboratory

Cell Culture Center

Center for Cancer Research

Center for Materials Science and Engineering

Center for Space Research

Clinical Research Center

Energy Laboratory

Haystack Observatory

Laboratory for Computer Science

Laboratory for Nuclear Science

Lincoln Laboratory

Research Laboratory of Electronics

Dean of the School of Science

Office of the Dean

Robert Arnold Alberty, Ph.D., Sc.D.
Professor of Chemistry
Dean

Department of Biology

Gene Monte Brown, Ph.D.
Professor of Biochemistry
Head of the Department

Malcolm Lawrence Gefter, Ph.D.
Professor of Biochemistry
Executive Officer

Professors

David Baltimore, Ph.D.
American Cancer Society
Professor of Microbiology

Eugene Bell, Ph.D.
Professor of Biology

David Botstein, Ph.D.
Professor of Genetics

John Machlin Buchanan, Ph.D., D.Sc.
John and Dorothy Wilson Professor of Biochemistry

Herman Nathaniel Eisen, M.D.
Professor of Immunology

Maurice Sanford Fox, Ph.D.
Lester Wolfe Professor of Molecular Biology

Bernard Sidney Gould, Ph.D.
Professor of Biochemistry, Emeritus
Senior Lecturer

Charles Edward Holt III, Ph.D.
Professor of Biology

Vernon Martin Ingram, Ph.D., D.Sc.
Professor of Biochemistry

Har Gobind Khorana, Ph.D.
Alfred P. Sloan Professor of Biology and Chemistry

Jonathan Alan King, Ph.D.
Professor of Biology

Jerome Ysrael Lettvin, M.D.
Professor of Communications Physiology

Harvey Franklin Lodish, Ph.D.
Professor of Biology

Irving M. London, M.D.
Grover M. Hermann Professor of Biology
Director, Joint Harvard-MIT Division of Health Sciences and Technology
Director, Whitaker College of Health Sciences, Technology, and Management

Salvador Edward Luria, M.D., D.Sc.
Institute Professor, Emeritus
Director, Center for Cancer Research

Boris Magasanik, Ph.D.
Jacques Monod Professor of Microbiology

Mary Lou Pardue, Ph.D.
Professor of Biology

Sheldon Penman, Ph.D.
Professor of Cell Biology

Uttam Lal RajBhandary, Ph.D.
Professor of Biochemistry

Alexander Rich, M.D.
Professor of Biophysics
Sedgwick Professor of Biology

Phillips Wesley Robbins, Ph.D.
American Cancer Society Professor of Biochemistry

Robert Daniel Rosenberg, M.D., Ph.D.
Professor of Medicine and Biology

Paul Reinhard Schimmel, Ph.D.
Professor of Biochemistry and Biophysics

Phillip Allen Sharp, Ph.D.
Professor of Biology

Ethan Royal Signer, Ph.D.
Professor of Biology

Lisa Amelia Steiner, M.D.
Professor of Immunology

Susumu Tonegawa, Ph.D.
Professor of Immunology and Cell Biology

Annamaria Torriani, Ph.D.
Professor of Biology

Christopher Walsh, Ph.D.
Professor of Chemistry and Biology
Associate Director, Whitaker College
Uncas and Helen Whitaker Professor in the Whitaker College

David Floyd Waugh, Ph.D.
Professor of Biophysics

Associate Professors

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Nancy Haven Hopkins, Ph.D.
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H. Robert Horvitz, Ph.D.
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David Evan Housman, Ph.D.
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Richard Olding Hynes, Ph.D.
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Frank Solomon, Ph.D.
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Assistant Professors

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Monty Krieger, Ph.D.
Assistant Professor of Molecular Genetics

Robert Thomas Sauer, Ph.D.
Assistant Professor of Biochemistry

Lecturer

Erika A. Hartwieg

Financial and Personnel Administrator

Cynthia Dick

Operations Administrator

Edward Joseph Gaudiano

Senior Research Associate

Daniel H. Levin, Ph.D.

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James L. Crawford, Ph.D.
R. Bruce Credo, Ph.D.
Rakha H. Das, Ph.D.
Rebecca DiLiddo, Ph.D.
Margaret J. Duncan, Ph.D.
Stephen R. Farmer, Ph.D.
Roberta Farrell, Ph.D.
Stephen P. Goff, Ph.D.
Keiichi Hiramatsu, Ph.D.
William Howe, Ph.D.
S. Catherine Hubbard, Ph.D.
Raymond J. Ivatt, Ph.D.
James R. Kamine, Ph.D.
C. Chandra Kumar, Ph.D.
Judith Lahav, Ph.D.
Andrew Laudano, Ph.D.
Robert G. Levenson, Ph.D.
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Dietmar Mischke, Ph.D.
Minora Morikawa, Ph.D.
Werner F. Nader, Ph.D.
Yoshimitsu Onodera, Ph.D.
Juan C. Orrego, Ph.D.
Lakshmi Padhy, Ph.D.
Duncan R. Paton, Ph.D.
Lulu Pickering, Ph.D.
Robert Poss, M.D.
Lawrence J. Reitzer, Ph.D.
Marsha Rosner, Ph.D.
Richard E. Sanders, Ph.D.
Linda Sanders-Haigh, Ph.D.
Michail V. Sitkovsky, Ph.D.
John Tabor, Ph.D.
Martha M. Teeter, Ph.D.
Cek-Fyne Tse, Ph.D.
Vladimir Z. Volloch, Ph.D.
Joseph R. Votano, Ph.D.
Fiona M. Watt, Ph.D.
Teresa A. Webster, Ph.D.
Gary W. Zieve, Ph.D.
Asher Zilberstein, Ph.D.

Professors Emeriti

Bernard Sidney Gould, Ph.D.
Professor of Biochemistry, Emeritus
Senior Lecturer

Salvador Edward Luria, M.D., D.Sc.
Institute Professor, Emeritus
Director, Center for Cancer Research

Francis Otto Schmitt, Ph.D., Sc.D.
Institute Professor, Emeritus
Professor of Biology, Emeritus

Irwin Whiting Sizer, Ph.D.
Professor of Biochemistry, Emeritus

Department of Biology

Undergraduate Study

The Department of Biology offers undergraduate, graduate, and postdoctoral training in basic biology, and in a variety of biological fields of specialization. The quantitative aspects of biology, including molecular biology, biochemistry, biophysics, genetics, and cell biology, represent the core of the program. Students in the Department are encouraged to acquire a solid background in the physical sciences not only to master the applications of mathematics, physics, and chemistry to biology, but also to develop an integrated scientific perspective. The various programs, emphasizing practical experimentation, combine a minimum of formal laboratory exercises with ample opportunities for research work both in project-oriented laboratory subjects and in the Department's research laboratories. Students at all levels are encouraged to acquire familiarity with advanced research techniques and to participate in seminar activities.

Bachelor of Science in Life Sciences Course VII

Two programs are offered leading to the Bachelor of Science in Life Sciences. The curriculum is designed to prepare students for a professional career in the area of the biological sciences. Graduates of this program are well prepared for positions in industrial or research institutes. However, experience has shown that most graduates probably will choose to continue their education at graduate schools in order to obtain a Ph.D. in biochemistry, microbiology, genetics, biophysics, cell biology, or physiology, followed by research or teaching in one of these areas. The undergraduate curriculum is also excellent preparation for students who wish to continue their education toward an M.D., particularly if their career plans include laboratory investigations bearing on human disease.

Bachelor of Science Course VII-A

Course VII-A is designed for students who wish to obtain a background in the life sciences as preparation for careers without laboratory research such as medicine, graduate study of psychology, or management studies. This program, leading to the Bachelor of Science, allows more time for electives so that students can plan their programs to suit their particular goals.

Bachelor of Science in Life Sciences Course VII-B

The curriculum of Course VII-B, Applied Biology, offers specialization in nutrition and food science. Students electing this area should consult with the Department of Nutrition and Food Science before registration.

Although 5.311 Introductory Chemical Experimentation is not a Departmental Requirement, this subject is particularly useful for students whose interest is in biochemistry; it may also be required for admission to medical school. Although 7.01 General Biology is not specifically required, most students find it an important basis for the study of other biology subjects. Only those students with exceptional high school preparation in modern biology should elect *not* to take 7.01. As part of their elective programs, students are encouraged to enroll in the more advanced subjects offered by the Department.

Inquiries

Additional information regarding academic programs, research opportunities, admissions, financial aid, etc. may be obtained from Biology Headquarters, Room 56-509, MIT, Cambridge, Massachusetts 02139, (617) 253-4701.

Bachelor of Science in Life Sciences Course VII

	General Institute Requirements	Total Units
	Specific science and humanities and social science subjects.	132
	The subjects 5.41, 5.60 and 7.05 which are required in the Departmental Program, appear on the list of Science Distribution Subjects and can be used to satisfy the Science Distribution Requirement.[1]	
	The subject 7.011 which is required in the Departmental Program, appears on the list of Laboratory Subjects and can be used to satisfy the Laboratory Requirement.[2]	
	Departmental Program	
	Required Subjects	**74**
5.41	Introduction to Structure, Bonding and Mechanism[1]	5 0 7
5.42	Organic Chemistry	5 0 7
5.60	Chemical Thermodynamics[1]	4 0 8
7.011	Introduction to Experimental Biology[2,3]	2 8 4
7.03	Genetics	4 0 8
7.05	General Biochemistry	5 0 7
	Restricted Electives	**84**
	One of the following subjects:	
18.03	Differential Equations	4 0 8
18.041	Principles of Applied Mathematics	3 0 9
18.05	Introduction to Probability and Statistics	3 0 9
18.055J	Biostatistics I	3 0 9
18.440	Probability and Random Variables	4 0 8
18.700	Linear Algebra	3 0 9
	Restricted Electives (continued)	
	One of the following subjects:	
5.61	Physical Chemistry	4 0 8
5.62	Physical Chemistry	4 0 8
6.071	Introduction to Electronics	4 2 6
7.71J	Biophysical Chemistry[4]	4 0 8
8.03	Physics III	5 0 7
	Three of the following subjects:[5]	
7.01	General Biology[1]	4 0 8
7.04	Cell and Developmental Biology	4 0 8
7.06	Metazoan Cell Biology	3 0 9
7.71J	Biophysical Chemistry[4]	4 0 8
7.21	Microbial Physiology	4 0 8
20.022	Mammalian Physiology	5 0 7
	One of the following subjects:	
7.021	Experimental Immunology	2 16 6
7.031	Experimental Microbial Genetics	2 16 6
7.041	Experimental Cell Biology	2 16 6
7.051	Experimental Biochemistry	2 16 6
	Acceptable research experience[6]	
	Unrestricted Electives[7]	**70**
	Total Units Required for the S.B. Degree	**360**

Bachelor of Science in Life Sciences Course VII-B Applied Biology Curriculum

See Department of Nutrition and Food Science for curriculum requirements.

Bachelor of Science Course VII-A

	General Institute Requirements	Total Units
	Specific science and humanities and social science subjects.	132
	The subjects 5.41, 5.60 and 7.05 which are required in the Departmental Program, appear on the list of Science Distribution Subjects and can be used to satisfy the Science Distribution Requirement.[1]	
	The subject 7.011 which is required in the Departmental Program, appears on the list of Laboratory Subjects and can be used to satisfy the Laboratory Requirement.[2]	
	Departmental Program	
	Required Subjects	**74**
5.41	Introduction to Structure, Bonding and Mechanism[1]	5 0 7
5.42	Organic Chemistry	5 0 7
5.60	Chemical Thermodynamics[1]	4 0 8
7.011	Introduction to Experimental Biology[2,3]	2 8 4
7.03	Genetics	4 0 8
7.05	General Biochemistry	5 0 7
	Restricted Electives	**36**
	Three of the following subjects:[4]	
7.01	General Biology[1]	4 0 8
7.04	Cell and Developmental Biology	4 0 8
7.06	Metazoan Cell Biology	3 0 9
7.71J	Biophysical Chemistry	4 0 8
7.21	Microbial Physiology	4 0 8
20.022	Mammalian Physiology	5 0 7
	Unrestricted Electives	**118**
	Total Units Required for the S.B. Degree	**360**

1
Students who take 5.41 or 5.60 to fulfill the General Institute Requirement for Chemistry/Biology must take 12 additional units of Science Distribution Subjects; if 7.01 is taken to fulfill the General Institute Requirement in Chemistry/Biology, it may not be taken to fulfill part of the Restricted Elective program.
2
It should be noted that either 7.011 or 5.311 satisfies the Institute Laboratory Requirement. However both or their equivalent are required to satisfy medical school entrance requirements.
3
20.002 may be substituted for 7.011.
4
7.71J may be counted toward the fulfillment of only one of the two restricted elective categories in which it appears.
5
A graduate subject from the following list may be substituted for one of the three required subjects: 7.26, 7.27, 7.62, 7.73, 7.75, 7.86, and 5.50J.
6
Procedures for substituting research for the 24-unit laboratory requirement are described in the current UROP booklet.
7
Schedules of students in Course VII may always be arranged to leave available 24 units of Unrestricted Elective in the second year.

1
Students who take 5.41 or 5.60 to fulfill the General Institute Requirement in Chemistry/Biology must take 12 additional units of Science Distribution Subjects; if 7.01 is taken to fulfill the General Institute Requirement in Chemistry/Biology, it may not be taken to fulfill part of the Restricted Elective program.
2
It should be noted that either 7.011 or 5.311 satisfies the Institute Laboratory Requirement. However both or their equivalent are required to satisfy medical school entrance requirements.
3
20.002 may be substituted for 7.011.
4
An approved graduate subject in biology may be substituted for one of the three required subjects.

Graduate Study

The Department of Biology offers graduate work leading to the Doctor of Philosophy in biology, biochemistry, biophysics, or cell biology. Study may be pursued in the following fields of specialization.

Cell Biology, Virology, and Physiology. The study of the biology of cells from multicellular organisms and the viruses which grow in such cells is emphasized in this program. The major areas of research include cell culture, the macromolecular metabolism of cells, cellular genetics and cytogenetics, cellular immunology, tumor immunology, animal virology (both tumor viruses and non-tumor viruses), synthesis and structure of eukaryotic DNA, membrane structure and synthesis, sensory physiology, and differentiation. A major focus of the research in cell biology is the study of growth control and the aberrances of growth control in malignant cells.

Microbiology. The aim of this program is to provide the student with an understanding of the fundamental aspects of the structure, genetics, and physiology of microorganisms. Current research projects are in the areas of the genetics of bacteria, yeast, and bacteriophage; the assembly of bacteriophage; the molecular biology of slime molds; the function of bacterial membranes; the regulation of the biosynthesis of bacterial enzymes; and the biology of animal viruses.

Biochemistry. This program is designed to give the student training in the following areas of biochemistry: the chemistry of proteins and nucleic acids, physical biochemistry, intermediary metabolism, membrane biochemistry, enzymology and molecular biology. Examples of current research are the structure and biosynthesis of macromolecules such as DNA, RNA, and proteins; the biosynthesis of amino acids and coenzymes; the chemical mechanisms underlying the action of enzymes; the regulation of the biosynthesis of macromolecules; membrane biochemistry; the biochemistry of development; and immunochemistry.

Biophysics. The objectives of research in this area are an understanding of the function of biological systems in terms of the structures and interactions of molecules. These objectives are approached through the application of techniques such as X-ray diffraction, electron microscopy, ultracentrifugation, electrophoresis, spectroscopy, genetics, and a variety of other physiochemical and physiological approaches. Current examples of research interests lie in the areas of the mechanisms of formation of tertiary structure of proteins and nucleic acids; the physical chemistry of macromolecules and their interactions; molecular aspects of blood coagulation; molecular biology, including assembly of macromolecular structures such as phage; the mechanism of allosteric control; DNA replication and mechanisms of genetic recombination; biophysical aspects of neurobiology; and communications biophysics. A program is provided whereby students with a variety of educational backgrounds can make the transition into biology (biophysics). For this reason applications are welcome from those who have majored in physical chemistry or physics and also from those holding degrees in medicine. To accomplish the transition, the program in biophysics is deliberately flexible so that complementary education may be obtained as part of the graduate program.

Joint MIT-WHOI Program Course VII-W

Biological Oceanography. MIT and the Woods Hole Oceanographic Institution administer a joint program in biological oceanography leading to a jointly awarded Doctor of Philosophy. For details of this program, see Joint Program in Oceanography with the Woods Hole Oceanographic Institution, following the School of Science.

Entrance Requirements for Graduate Study

In the Department of Biology, the Master of Science is not a prerequisite for a program of study leading to the doctorate.

The Department modifies the General Institute Requirements for graduate study as follows: 18.01, 18.02 Calculus; one year of college physics; 5.41 Introduction to Structure, Bonding and Mechanism; professional subjects including general biochemistry and genetics. Deficiencies in any of these subjects may be removed, if not too extensive, while enrolled in a graduate program.

Doctor of Philosophy

The General Institute Requirements for the Doctor of Philosophy are listed in the Graduate Education chapter. There are no specific Departmental programs for the degree, since the subjects required vary with the field of specialization. Students select their own programs, according to certain broad principles, after consultation with the Graduate Committee of the Department.

Teaching and Research Assistantships

A number of qualified students are appointed each year as teaching or research assistants. Research assistants may be permitted to use the results of their assigned research work in graduate theses, with the possible acceleration of their programs. In addition, a number of predoctoral and postdoctoral fellowships are available in cell biology, microbiology, physiology, biochemistry, and biophysics.

Inquiries

Any additional information regarding graduate academic programs, research activities, admissions, financial aid, assistantships, etc. may be obtained from Biology Headquarters, Room 56-509, MIT, Cambridge, Massachusetts 02139, (617) 253-4701.

Department of Chemistry

James Lloyd Kinsey, Ph.D.
Professor of Chemistry
Head of the Department

Professors

Robert Arnold Alberty, Ph.D., Sc.D.
Professor of Chemistry
Dean of the School of Science

Glenn Allen Berchtold, Ph.D.
Professor of Chemistry

Klaus Biemann, Ph.D.
Professor of Chemistry

George Hermann Büchi, D.Sc.
Camille Dreyfus Professor of Chemistry

Alan Davison, Ph.D.
Professor of Chemistry

John Mark Deutch, Ph.D., Sc.D.
Arthur C. Cope Professor of Chemistry

Carl Wesley Garland, Ph.D.
Professor of Chemistry

Frederick Davis Greene II, Ph.D., Sc.D.
Professor of Chemistry

Daniel Schaeffer Kemp, Ph.D.
Professor of Chemistry

Har Gobind Khorana, Ph.D.
Alfred P. Sloan Professor of Biology and Chemistry

Satoru Masamune, Ph.D.
Professor of Chemistry

William Henry Orme-Johnson, Ph.D.
Professor of Chemistry

Irwin Oppenheim, Ph.D.
Professor of Chemistry

Richard Royce Schrock, Ph.D.
Professor of Chemistry

Dietmar Seyferth, Ph.D.
Professor of Chemistry

K. Barry Sharpless, Ph.D.
Professor of Chemistry

Robert James Silbey, Ph.D.
Professor of Chemistry

Edward Ira Solomon, Ph.D.
Professor of Chemistry

Jeffrey Irwin Steinfeld, Ph.D.
Professor of Chemistry,

Charles Gardner Swain, Ph.D.
Professor of Chemistry

Christopher Thomas Walsh, Ph.D.
Professor of Chemistry and Biology
Associate Director, Whitaker College
Uncas and Helen Whitaker Professor in the Whitaker College

John Stewart Waugh, Ph.D.
Arthur Amos Noyes Professor of Chemistry

George McClelland Whitesides, Ph.D.
Robert T. Haslam and Bradley Dewey Professor of Chemistry

Mark Stephen Wrighton, Ph.D.
Professor of Chemistry

Associate Professors

Robert Warren Field, Ph.D.
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Gregory Anthony Petsko, D.Phil.
Associate Professor of Chemistry

William Harry Rastetter, Ph.D.
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Assistant Professors

Sylvia Teresse Ceyer, Ph.D.
Assistant Professor of Chemistry

Rick Lane Danheiser, Ph.D.
Assistant Professor of Chemistry

Fenton Read McFeely, Ph.D.
Assistant Professor of Chemistry

Keith Adam Nelson, Ph.D.
Assistant Professor of Chemistry

Mary Fedarko Roberts, Ph.D.
Assistant Professor of Chemistry

William Richard Roush, Ph.D.
Roger and Georges Firmenich Career Development Assistant Professor of Natural Products Chemistry

Lecturer

Dagmar Ringe Ponzi, Ph.D.

Principal Research Scientists

Catherine Elizabeth Costello, Ph.D.
Nanette Roberts Orme-Johnson, Ph.D.

Technical Instructors

Stephen Andrew Corteselli
John Robert Linzi
James Alexander Simms

Executive Associate

Lawrence William Ryan, Jr.

Financial Administrator

Patricia Ann Lewis

Personnel Administrator

Anne Marie Lees

Professors Emeriti

Edmund Lee Gamble, Ph.D.
Professor of Inorganic Chemistry, Emeritus

Louis Harris, Ph.D.
Associate Professor of Physical Chemistry, Emeritus

Lawrence Joseph Heidt, Ph.D.
Associate Professor of Physical Chemistry, Emeritus

David Newton Hume, Ph.D.
Professor of Analytical Chemistry, Emeritus

John Withers Irvine, Jr., Ph.D., Sc.D.
Professor of Chemistry, Emeritus

Richard Collins Lord, Ph.D., Sc.D.
Professor of Chemistry, Emeritus
Senior Lecturer

Earl Bowman Millard, Ph.D.
Professor of Physical Chemistry, Emeritus

Avery Adrian Morton, Ph.D.
Professor of Organic Chemistry, Emeritus

John Clark Sheehan, Ph.D., Sc.D.
Professor of Organic Chemistry, Emeritus

Clark Conkling Stephenson, Ph.D.
Professor of Chemistry, Emeritus
Senior Lecturer

Ralph Chillingworth Young, Ph.D.
Associate Professor of Inorganic Chemistry, Emeritus

Department of Chemistry

Undergraduate Study

Bachelor of Science in Chemistry Course V

The Department offers an undergraduate program sufficiently flexible in its electives to provide excellent preparation for careers in many different areas of chemistry. The Course is designed to provide an education based on science for those who intend to go on to graduate study and professional careers in chemistry, or allied fields in which a sound knowledge of chemistry is important. Students receive thorough instruction in the principles of chemistry, supplemented by instruction in mathematics, physics, the humanities, and other subjects. The departmental Program is accredited by the American Chemical Society.

Unrestricted elective time allows students to extend their knowledge in areas of special interest. Those intending to do graduate work may elect subjects in the Department or in other departments which give them more detailed knowledge in the areas in which they wish to specialize. Students who plan to enter industry may elect subjects which offer the fundamentals in a selected field of science, engineering, or the humanities and social sciences. Five-year programs may also be elected which lead to simultaneous Bachelor of Science degrees in two fields of specialization.

The Course also aims to develop the research attitude, and the curriculum may include a research project giving students opportunities to demonstrate aptitude for creative efforts.

Bachelor of Science in Chemistry Course V

	General Institute Requirements	Total Units
	Specific science and humanities and social science subjects.	132
	The Science Distribution Requirement can be satisfied by 5.41 or 5.60, which are required in the Departmental Program, plus appropriate subjects totaling	24
	The subject 5.311 which is required in the Departmental Program, appears on the list of Laboratory subjects and can be used to satisfy the Laboratory Requirement.	
	Departmental Program	
	Required Subjects	**105**
5.03	Principles of Inorganic Chemistry I — 4 0 8	
5.311	Introductory Chemical Experimentation — 2 8 2	
5.32	Intermediate Chemical Experimentation — 0 12 3	
5.33	Advanced Chemical Experimentation — 0 15 3	
5.41	Introduction to Structure, Bonding and Mechanism[1] — 5 0 7	
5.42	Organic Chemistry — 5 0 7	
5.60	Chemical Thermodynamics[1] — 4 0 8	
5.61	Physical Chemistry — 4 0 8	
	Restricted Electives	**21-24**
	At least two of the following subjects:	
5.74	Principles of Inorganic Chemistry II — 3 0 6	
5.43	Organic Chemistry — 4 0 8	
5.62	Physical Chemistry — 4 0 8	
	Unrestricted Electives[3]	**78-75**
	Total Units Required for the S.B. Degree	**360**

1
Students who take either 5.41 or 5.60 to fulfill the General Institute Requirement in Chemistry/Biology must take 12 Additional Units of Unrestricted Elective.

2
The student's Faculty Advisor can offer suggestions for elective subjects, which are offered by this Department and by other departments, that are of value in preparation for specialization in the various broad areas of chemistry. The proper choice of electives is particularly important for students planning to continue their education in a graduate school.

Graduate Study

The Department of Chemistry offers the Master of Science in Chemistry, the Doctor of Philosophy, and the Doctor of Science. The subjects offered for these degrees aim to develop a sound knowledge of fundamentals and a familiarity with current progress in the most active and important areas of chemistry. In addition to studying formal subjects, each student undertakes a research problem which forms the core of graduate work. Through the experience of conducting an investigation leading to the master's or doctoral thesis, a student learns general research attitudes and methods of approach and acquires training in some of the specialized techniques of research.

The areas of research in the Department are organic, inorganic, physical, analytical, biological, and biophysical chemistry, biochemistry, and chemical physics. The thesis frequently involves more than one of these fields. Some of the research activities of the Department are carried out in association with the work of various interdisciplinary laboratories and centers such as the Center for Materials Science and Engineering, the Research Laboratory of Electronics, and the Spectroscopy Laboratory. These interdepartmental research laboratories provide stimulating interaction among the research programs of several MIT departments and give students the opportunity to become familiar with research work in disciplines other than chemistry. There also is an opportunity for research in cooperation with other departments such as Biology, Earth and Planetary Sciences, and Physics. Detailed information on the research activities of the faculty can be found in the *Directory of Graduate Research* published by the American Chemical Society.

During the first term of residence, all graduate students are encouraged to select research supervisors who serve as advisors for the balance of their graduate careers. In particular, the final program of graduate subjects is established by each student and the research supervisor. In planning this program and in establishing the thesis problem, careful consideration is given to the candidate's academic record and professional experience, as well as to long-range objectives.

Entrance Requirements for Graduate Study

Students intending to pursue graduate work in the Department should have excellent undergraduate preparation in chemistry. The Department, however, is flexible in its attitude toward the specific mathematics and physics preparation; the essential requirement is demonstration of ability to progress with advanced study and research in some area of special interest. Mathematics and physics are important prerequisites for graduate work in physical chemistry or chemical physics. On the other hand, less preparation in mathematics and physics is required for work in organic chemistry.

Applicants for financial assistance from the Department of Chemistry are requested to submit scores from the Verbal and Quantitative sections of the Graduate Record Examination. Scores on the Advanced examinations are optional.

Although doctoral studies are the principal focus of the graduate program in the Department of Chemistry, applications are also accepted from students who do not wish to go beyond the Master's degree. Applicants whose ultimate goal is the Ph.D. or Sc.D. should apply as doctoral students from the start, since the Master's degree is not a prerequisite for the Ph.D. or Sc.D. in Chemistry at MIT.

Master of Science in Chemistry

The general requirements for the Master of Science are listed in Chapter IV of this catalogue.

Doctor of Philosophy and Doctor of Science

The Department does not have any formal subject requirements for the doctoral degree. Each student, with the advice of a research supervisor, pursues an individual program of study which is pertinent to long-range research interests. For some students this includes the acquisition of proficiency in reading scientific German.

Written major examinations are cumulative, and a series of examinations is given each term. Separate examinations in physical, organic, and inorganic chemistry are offered each term, and additional examinations in analytical or biochemistry, or other specialized areas also are offered several times during the year. The level of these examinations corresponds to introductory graduate subjects, but they are not based specifically on such subjects. Considerable emphasis is placed on seminars and current literature. Six of these cumulative examinations must be passed to complete the written major examination. No fixed time limit is set for completion of this requirement; however, progress is reviewed periodically. No other general written examinations are required. In particular, no qualifying (or "entrance") examinations are given.

A comprehensive oral examination in the candidate's major field of advanced study is held near the end of the third term of residence. Progress in research is examined at that time. A final oral presentation of the subject of the doctoral research is scheduled after the thesis has been submitted and tentatively evaluated by a committee of examiners.

Teaching and Research Assistantships

The Department appoints a number of degree candidates as teaching assistants who are usually assigned to laboratory subjects or to discussion sections of lecture subjects. Many students receive appointments to research assistantships after their first year, and Departmental fellowships and reappointments to teaching assistantships also are available. Financial support after the first academic year for students who maintain a satisfactory record is provided, subject to the availability of funds for that purpose.

Inquiries

Correspondence about the graduate program or appointments should be addressed to the Chairman of the Departmental Committee on Graduate Students, Chemistry Graduate Office, Room 18-392, MIT, Cambridge, Massachusetts 02139, (617) 253-1845.

Department of Earth and Planetary Sciences

William Francis Brace, Ph.D.
Cecil and Ida Green Professor of Geology
Head of the Department

Professors

Keiiti Aki, Ph.D.
Professor of Geophysics

Burrell Clark Burchfiel, Ph.D.
Professor of Geology

Roger George Burns, Ph.D.
Professor of Geochemistry

John Marmion Edmond, Ph.D.
Professor of Oceanography

Frederick August Frey, Ph.D.
Professor of Geochemistry

Stanley Robert Hart, Ph.D.
Professor of Geology and Geochemistry

John Simpson Lewis, Ph.D.
Professor of Geochemistry

Theodore Richard Madden, Ph.D.
Professor of Geophysics

Gordon Hemenway Pettengill, Ph.D.
Professor of Planetary Physics
(Absent)

John George Sclater, Ph.D.
Professor of Marine Geophysics

Irwin Ira Shapiro, Ph.D.
Schlumberger Professor of Geophysics and Physics

M. Gene Simmons, Ph.D.
Professor of Geophysics

M. Nafi Toksöz, Ph.D.
Professor of Geophysics
Director, George R. Wallace, Jr. Geophysical Observatory

Carl Isaac Wunsch, Ph.D.
Cecil and Ida Green Professor of Physical Oceanography

Associate Professors

Charles Claude Counselman III, Ph.D.
Associate Professor of Planetary Sciences

James Ludlow Elliot, Ph.D.
Associate Professor of Astronomy and Physics
Director, George R. Wallace, Jr. Astrophysical Observatory

Peter Molnar, Ph.D.
Associate Professor of Earth Sciences

William Hamet Pinson, Jr., Ph.D.
Associate Professor of Geology

Sean Carl Solomon, Ph.D.
Associate Professor of Geophysics

John Brelsford Southard, Ph.D.
Associate Professor of Geology

Assistant Professors

Edward Allen Boyle, Ph.D.
Assistant Professor of Chemical Oceanography

Charles C. Eriksen, Ph.D.
Assistant Professor of Physical Oceanography

Timothy L. Grove, Ph.D.
Assistant Professor of Petrology

Frank S. Spear, Ph.D.
Assistant Professor of Geology

Instructor

Edward Dunham, Ph.D.
(Fall)

Honorary Lecturer

Cecil H. Green, S.M., D.S.C., LL.D.

Administrative Officer

Douglas Pfeiffer

Administrative Staff

Deborah W. Gillett
June McLean

Senior Research Associate

Michael A. Chinnery, Ph.D.

Senior Research Scientist

Joseph Broughton Walsh, Ph.D.

Principal Research Scientists

Barry E. Parsons, Ph.D.
Raul I. Madariaga, Ph.D.
Robert D. Reasenberg, Ph.D.
Nobumichi Shimizu, D.Sc.
Director, Ion Probe Facility

Research Associates

Robert Babcock, Ph.D.
Wang Ping Chen, Ph.D.
Bernard Chouet, Ph.D.
Edward Dunham, Ph.D.
Peter Ford, Ph.D.
Richard French, Ph.D.
Sergei Gourevitch, Ph.D.
Hyman Hartman, Ph.D.
Robert Hohlfeld, Ph.D.
Pillalamari Ila, Ph.D.
Robert King, Ph.D.
Lawrence Lawver, Ph.D.
Christopher Measures, Ph.D.
Elaine Padovani, Ph.D.
Michael Ratner, Ph.D.
Brian Tucker, Ph.D.

Postdoctoral Associates

Chuen Hon Cheng, Ph.D.
Guy Consolmagno, Ph.D.
Larry Cox, Ph.D.
Bernard Geldzahler, Ph.D.
Marc Gorenstein, Ph.D.
Richard Langley, Ph.D.
David McTigue, Ph.D.
Steven Roecker, Ph.D.
Roy Wilkens, Ph.D.
Teng Fong Wong, Ph.D.

Visiting Scientists

Dov Bahat
Norbert Bartel
Tianqing Cao
Ming-hui Hu
Peter Morgan
Haruo Sato

Professors Emeriti

Martin Julian Buerger, Ph.D.
Institute Professor, Emeritus
Professor of Mineralogy and Crystallography, Emeritus

Harold Williams Fairbairn, Ph.D.
Professor of Geology, Emeritus

Patrick Mason Hurley, Ph.D.
Professor of Geology, Emeritus

Robert Rakes Shrock, Ph.D.
Professor of Geology, Emeritus

The study of earth and planetary sciences at MIT covers several broad fields — the evolution of the main features of the planetary system; the origin, composition, structure, and state of the atmospheres, oceans, surfaces, and interiors of planets; and the dynamics of planet and satellite motions. At MIT, modern problems that receive special emphasis include mineralogy-crystallography; experimental petrology; rock mechanics; geochemistry; geochronology; seismology; planetary magnetism and electricity; heat flow; high pressure geophysics; geophysical fluid dynamics; optical, radio, and radar astronomy; dynamical astronomy; planetary atmospheres and surfaces; meteoritics; particles in planetary fields; physical and chemical oceanography; and marine geology and geophysics.

These problems are attacked by *in situ* physical and chemical measurements, laboratory studies, and theoretical treatments. Experimental facilities for training and research are available in the Department; in MIT laboratories and centers such as the Center for Space Research, the Lincoln Laboratory, the Haystack radar and radio observatory, and the Wallace Astrophysical and Geophysical observatories; and in cooperating institutions such as the Woods Hole Oceanographic Institution.

Undergraduate Study

Bachelor of Science in Earth and Planetary Sciences Course XII

The Department offers undergraduate preparation for professional careers in the earth and planetary sciences. Some students concentrate in specific fields. Others choose to combine basic studies in mathematics, physics, chemistry, or engineering with applications to the earth and planetary sciences.

Students in each class have a class advisor or registration supervisor, who remains the student's contact for as long as he or she is in the Department. For assistance in program and career planning, each student in Course XII can choose a personal faculty advisor in addition to his or her class advisor.

The curriculum for the Bachelor of Science in Earth and Planetary Sciences contains only a minimum number of specific requirements, to allow maximum flexibility in arranging an individualized program of study. A collection of sample curricula is maintained by a faculty-student committee. Lists of undergraduate research and employment opportunities are also available. Some sample programs are shown under Restricted Elective Requirements below. A variety of other programs can be worked out in consultation with the student's advisor.

Students are encouraged to enter the Department of Earth and Planetary Sciences at the beginning of the second year to obtain maximum benefit from advisor resources; however, an interested student is encouraged to visit Department headquarters at any time to obtain copies of sample programs or to arrange conferences with advisors.

Bachelor of Science in Earth and Planetary Sciences Course XII

	General Institute Requirements	Total Units
	Specific science and humanities and social science subjects.	132
	The subjects 5.60, 8.03, and 18.03, which are required in the Departmental Program, appear on the list of Science Distribution Subjects and can be used to satisfy the Science Distribution Requirement.	
	Laboratory Requirement	12
	Departmental Program	
	Required Subjects	60
5.60	Chemical Thermodynamics[1]	4 0 8
8.03	Physics III	5 0 7
	or	
	One of the following four subjects chosen in consultation with the advisor	
1.60	Fluid Dynamics	4 0 8
3.11	Mechanics of Materials I	4 0 8
5.61	Physical Chemistry	4 0 8
18.354	Fluid Mechanics	3 0 9
12.091-4	Special Problems	0 12 0
	or	
12.UR	Undergraduate Research	0 12 0
12.07	Chemistry and Physics of the Earth	3 0 9
	or	
12.101	Physics of the Earth	3 0 9
18.03	Differential Equations	4 0 8
	Restricted Electives	84
	A coherent program of electives selected with the aid of Faculty Advisors and approved by the Departmental Committee on Undergraduates. See description below.	
	Unrestricted Electives[2]	72
	Total Units Required for the S.B. Degree	360

1
Students who take 5.60 to fulfill the General Institute Requirement in Chemistry/Biology must take 12 additional units of Unrestricted Elective and 12 additional units of Science Distribution subjects.

2
Schedules of students in Course XII may always be arranged to leave available 12 units of Unrestricted Elective in the second year.

Restricted Elective Requirements

Each student's program of restricted electives is individually arranged in consultation with the advisor. For guidance, *examples of programs* in geology, geochemistry, geophysics, planetary physics, and environmental earth science are given below.

Geology: 12.01 Geological Processes, Features, and History, 12.016 Sediments and Sedimentary Rocks, 12.02 Chemistry and Physics of Minerals and Rocks, 12.03 Structural Geology, 12.051 and 12.052 Field Geology I and II (or an equivalent field geology program at another university), 12.061, 12.062 Petrology I and II. Ordinarily 12.01, 12.016, and 12.02 are taken in the sophomore year, and 12.03, 12.051, and 12.052 are taken in the junior year.

Geochemistry: 12.02 Chemistry and Physics of Minerals and Rocks, 12.061 Petrology I, 12.062 Petrology II, 5.41 Introduction to Structure, Bonding and Mechanism, 5.310 Laboratory Chemistry or 5.311 Introductory Chemical Experimentation, 5.03 Principles of Inorganic Chemistry I, and 12.07 Chemistry and Physics of the Earth or physical chemistry subjects beyond 5.60 Chemical Thermodynamics.

Geophysics: Three physics subjects beyond 8.03 Physics III or equivalent courses (chosen in consultation with advisor), 18.075 Advanced Calculus for Engineers (or an equivalent subject in advanced mathematics with approval of advisor), 12.02 Chemistry and Physics of Minerals and Rocks, 12.102 Plate Tectonics and Marine Geophysics, 12.521 Elements of Seismology.

Planetary Physics: Physics and mathematics subjects similar to the program in geophysics, plus 12.131J and 12.132J Planetary Physics and Chemistry I and II, 12.121 Exploration of the Solar System. Physics subjects can be experimental or theoretical or both, according to individual interests.

Physical Oceanography and Meteorology: Physics and mathematics

Graduate Study

subjects similar to the program in geophysics, plus 12.21 Physics of the Ocean or 19.83 Physical Oceanography and one subject in fluid mechanics.

Environmental Earth Science: 1.80 Fundamentals of Ecology, 12.01 Geological Processes, Features, and History, 12.02 Chemistry and Physics of Minerals and Rocks, 12.20J Environmental Chemistry of the Ocean-Atmosphere System, plus 36 credits concentrating in geology, oceanography, meteorology, hydrology, soil science, ecology, or management, chosen in consultation with the advisor. Students in this program may satisfy the 1.60 etc., departmental requirement with 7.01 General Biology. This program is intended for students interested in law school, government service, or certain Master of Science programs in environmental technology. Environmental subjects also can be incorporated into more concentrated programs designed to prepare students directly for advanced graduate study.

The remaining restricted electives in these programs, or any alternate programs submitted, are approved to meet the needs and interests of individual students. Approval of these programs is based on their scope, depth, and relevance to sound preparation in earth and planetary sciences. Programs normally should be submitted to the Departmental Committee on Undergraduates for approval by the middle of the student's third year.

Students who wish to defer choosing a field of concentration within Course XII can prepare for all of the options by completing 5.60 Chemical Thermodynamics, 8.03 Physics III, 12.02 Chemistry and Physics of Minerals and Rocks, and 18.03 Differential Equations during their second year.

Each student is required to undertake a minimum of 12 units of research supervised in the Department. Many students take significantly more, and some who petition the Committee on Curricula to have this research satisfy the Institute Laboratory Requirement using the guidelines set forth by that Committee, may be granted approval for such substitution. By petition to the Departmental Committee on Undergraduates, suitably planned and executed research or individual study also may be substituted for classroom subjects. Also by petition to the Departmental Committee on Undergraduates, students may satisfy the departmental research requirement by means of projects on which they have worked for pay rather than for credit, either within the department or elsewhere, provided that the student can demonstrate by appropriate documentation, that the activity constitutes a substantial research experience.

Fifth-Year Programs

Studies in physics, chemistry, biology, applied mathematics, and electrical or civil engineering are directly relevant preparation for work in earth and planetary sciences. Students from these departments can arrange flexible programs of study in Course XII which lead to a second Bachelor of Science in one of these areas.

Students with strong academic records from the Departments of Chemistry, Electrical Engineering and Computer Science, Physics, Earth and Planetary Sciences, or Mathematics should be able to complete a Master of Science in Earth and Planetary Sciences in one year of additional study, particularly if their programs are arranged for this purpose from the beginning of the fourth year. Applications for graduate enrollment in the Department are considered any time after the beginning of the fourth year. The decision on admission of MIT undergraduates to the graduate program can be made about one month after receipt of the completed application. Students may receive the Bachelor of Science as soon as the requirements are completed, or may elect to defer the award for simultaneous presentation with the Master of Science.

Inquiries

Additional information may be obtained from the Department of Earth and Planetary Sciences, Room 54-912, MIT, Cambridge, Massachusetts 02139, (617) 253-3381.

The Department of Earth and Planetary Sciences offers opportunities for graduate study and research in a wide range of fields, as outlined in Chapter IV of this catalogue and as indicated by the detailed subject descriptions. Advanced work in these fields leads to the Master of Science in Earth and Planetary Sciences, the Doctor of Philosophy, or the Doctor of Science with a thesis in the field of specialization.

Graduate students pursue both theoretical and experimental aspects of these subjects. Modern laboratory facilities, computers, instrumentation, and extensive collections of specimens and data are available to students. Field study is an essential part of the graduate curriculum in geology, geophysics, and geochemistry, and special arrangements may be made for summer employment and field research on Departmental projects and with industrial organizations and government agencies.

Joint MIT-WHOI Program in Oceanography Course XII-W

MIT and the Woods Hole Oceanographic Institution have established a joint program in oceanography which leads to a jointly awarded degree of the Doctor of Philosophy or the Doctor of Science. For details of this program, see Joint Program in Oceanography with the Woods Hole Oceanographic Institution, following the School of Science.

Entrance Requirements for Graduate Study

In addition to the General Institute Requirements for admission, the Department requires preparation equivalent to the curriculum for the Bachelor of Science in Earth and Planetary Sciences at MIT. If students are not fully prepared in certain of the required subjects, they usually are asked to extend their studies in these areas while pursuing advanced work.

The doctoral program can be entered without a Master of Science as a prerequisite.

Master of Science in Earth and Planetary Sciences or in Oceanography

The General Institute Requirements for the degree of Master of Science in Earth and Planetary Science or in Oceanography are described in Chapter IV. An individual program of study and research is arranged to suit the special background, needs, and goals of each student. The program is worked out in detail by the student with his or her personal faculty advisor and a Departmental committee.

Doctor of Philosophy and Doctor of Science

General Institute Requirements for the degree of Doctor of Philosophy or Doctor of Science are given in Chapter IV. A specialized program of study and research is tailored to each student's background, needs, and goals by the student in consultation with a personal faculty advisor and a Departmental committee. A doctoral candidate's program is expected to be broad and to include formal study in other departments in addition to the specialized subjects which prepare the candidate for thesis research. Thesis research normally is begun immediately after successful completion of the general examination, by the end of the second year. The general examination is intended to test the candidate's preparation for, and ability to perform, independent research.

Thesis research is closely supervised by one or more faculty members who are interested and knowledgeable in the research topic, who are chosen by the student, and who may be members of other departments. The thesis is expected to meet high professional standards, and to be a significant original contribution to the scientific field.

Teaching and Research Assistantships

The Department regularly appoints 50 to 60 assistants who are candidates for a graduate degree. Teaching assistants conduct scheduled laboratory sections and examinations, grade papers, and prepare teaching materials. Research assistants work on Departmental research projects. Such work may be closely related to, and even identical to, the student's thesis research.

Inquiries

Additional information regarding academic and research programs in earth and planetary sciences, admission requirements, assistantship appointments, and financial aid may be obtained by writing to the Department of Earth and Planetary Sciences, Room 54-912, MIT, Cambridge, Massachusetts 02139, (617) 253-3381. The Department annually publishes a booklet describing current research activities.

Department of Mathematics

Daniel J. Kleitman, Ph.D.
Professor of Applied Mathematics
Head of the Department

Harvey Philip Greenspan, Ph.D.
Professor of Mathematics
Chairman, Committee on Applied Mathematics

Franklin Paul Peterson, Ph.D.
Professor of Mathematics
Chairman, Committee on Pure Mathematics

Professors

Warren Ambrose, Ph.D.
Professor of Mathematics

Nesmith Cornett Ankeny, Ph.D.
Professor of Mathematics

Michael Artin, Ph.D.
Professor of Mathematics

David John Benney, Ph.D.
Professor of Applied Mathematics

Hung Cheng, Ph.D.
Professor of Applied Mathematics

Herman Chernoff, Ph.D.
Professor of Applied Mathematics

Richard Mansfield Dudley, Ph.D.
Professor of Mathematics
(Absent, spring)

Daniel Z. Freedman, Ph.D.
Professor of Applied Mathematics

Curtis Greene, Ph.D.
Professor of Applied Mathematics
(Visiting)

Victor William Guillemin, Ph.D.
Professor of Mathematics

Sigurdur Helgason, Ph.D.
Professor of Mathematics

Francis Begnaud Hildebrand, Ph.D.
Professor of Mathematics

Kenneth Myron Hoffman, Ph.D.
Professor of Mathematics

Louis Norberg Howard, Ph.D.
Professor of Mathematics

Victor Kač, Ph.D.
Professor of Mathematics

Daniel Marinus Kan, Ph.D.
Professor of Mathematics
(Absent, spring)

Steven Kleiman, Ph.D.
Professor of Mathematics

Bertram Kostant, Ph.D.
Professor of Mathematics

Chia-Chiao Lin, Ph.D.
Institute Professor
Professor of Applied Mathematics
1981-82 James R. Killian, Jr. Faculty Achievement Award Lecturer

George Lusztig, Ph.D.
Professor of Mathematics
(Absent, spring)

Willem Van Rensselaer Malkus, Ph.D.
Professor of Applied Mathematics

Arthur Paul Mattuck, Ph.D.
Class of 1922 Professor of Mathematics

Richard Burt Melrose, Ph.D.
Professor of Mathematics

James Raymond Munkres, Ph.D.
Professor of Mathematics

Steven Alan Orszag, Ph.D.
Professor of Applied Mathematics

Seymour Aubrey Papert, Ph.D.
Professor of Mathematics
Cecil and Ida Green Professor of Education

Daniel Gray Quillen, Ph.D.
Norbert Wiener Professor of Mathematics
(Absent)

Hartley Rogers, Jr., Ph.D.
Professor of Mathematics

Gian-Carlo Rota, Ph.D.
Professor of Applied Mathematics and Philosophy

Gerald Enoch Sacks, Ph.D.
Professor of Mathematical Logic
(Absent)

Richard Donald Schafer, Ph.D.
Professor of Mathematics

Irving Ezra Segal, Ph.D.
Professor of Mathematics

Claude Elwood Shannon, Ph.D.
Donner Professor of Science
(Absent)

Richard Peter Stanley, Ph.D.
Professor of Applied Mathematics

Harold Mead Stark, Ph.D.
Professor of Mathematics
(Absent, spring)

William Gilbert Strang, Ph.D.
Professor of Mathematics

Werner Stuetzle, Ph.D.
Professor of Applied Mathematics
(Visiting)

Alar Toomre, Ph.D.
Professor of Applied Mathematics

Michèle François Vergne, Ph.D.
Professor of Mathematics

George William Whitehead, Ph.D.
Professor of Mathematics

Associate Professors

William Hermas DuMouchel, Ph.D.
Associate Professor of Applied Mathematics
(Absent, spring)

Dorian Goldfeld, Ph.D.
Associate Professor of Mathematics

Gary Lee Miller, Ph.D.
Associate Professor of Mathematics

David Alexander Vogan, Jr., Ph.D.
Associate Professor of Mathematics

Andrew John Wiles, Ph.D.
Associate Professor of Mathematics
(Absent)

Assistant Professors

Gregory Richard Baker, Ph.D.
Assistant Professor of Applied Mathematics

Sy David Friedman, Ph.D.
Assistant Professor of Mathematics

Ira Martin Gessel, Ph.D.
Assistant Professor of Applied Mathematics

Lawrence Gillick, Ph.D.
Assistant Professor of Applied Mathematics
(Visiting)

David S. Jerison, Ph.D.
Assistant Professor of Mathematics
(Absent)

Jeffrey Kahn, Ph.D.
Assistant Professor of Mathematics
(Absent)

Ravindran Kannan, Ph.D.
Assistant Professor of Applied Mathematics

Philip Marcus, Ph.D.
Assistant Professor of Applied Mathematics
(Absent, fall)

Frank Morgan, Ph.D.
Assistant Professor of Mathematics

Manoj Prasad, Ph.D.
Assistant Professor of Applied Mathematics

Shelley L. Rasmussen, Ph.D.
Assistant Professor of Applied Mathematics

Rodolpho Ruben Rosales, Ph.D.
Assistant Professor of Applied Mathematics

Michael Sipser, Ph.D.
Assistant Professor of Applied Mathematics

Ka Kit Tung, Ph.D.
Assistant Professor of Applied Mathematics

Gunther Uhlmann, Ph.D.
Assistant Professor of Mathematics

Lecturers

Gert Heckman, Ph.D.
Gen Nakamura, Ph.D.
Jonathan Sacks, Ph.D.
Gabriel Stoy, Ph.D.
Robert Thomason, Ph.D.

C. L. E. Moore Instructors

Jeffrey Adams, Ph.D.
Kaan Akin, Ph.D.
Dean L. Alvis, Ph.D.
Barry A. Cipra, Ph.D.
Nils J. Dencker, Ph.D.
William M. Goldman, Ph.D.
Marcia J. Groszek, Ph.D.
Philip Hanlon, Ph.D.
Stephen Mitchell, Ph.D.
David J. Pengelley, Ph.D.
Wade C. Ramey, Ph.D.
Susan Szczepanski, Ph.D.
Ross W. Urwin, Ph.D.
Rodney Ian Yager, Ph.D.

Undergraduate Study

Instructors in Applied Mathematics

John Buonchristiani, Ph.D.
Elaine Chandler, Ph.D.
Steven Ellis, Ph.D.
Andrew Fowler, Ph.D.
Marcia Groszek, Ph.D.
Philip Hanlon, Ph.D.
Arthur Rosenthal, Ph.D.
Marius Ungarish, Ph.D.

Senior Research Fellow

Edward Hannon, Ph.D.

Research Associate

Donna S. Neuberg, M.S.

Administrative Officer

James Edward Dalton

Professors Emeriti

Prescott Durand Crout, Ph.D.
Professor of Mathematics, Emeritus

William Ted Martin, Ph.D.
Professor of Education and Mathematics, Emeritus

Isadore Manual Singer, Ph.D.
Norbert Wiener Professor of Mathematics, Emeritus

Dirk Jan Struik, Ph.D.
Professor of Mathematics, Emeritus

George Brinton Thomas, Jr., Ph.D.
Professor of Mathematics, Emeritus

George Proctor Wadsworth, Ph.D.
Professor of Mathematics, Emeritus

Bachelor of Science in Mathematics Course XVIII

An undergraduate degree in mathematics provides an excellent basis, not only for graduate work in mathematics leading to a career as a professional mathematician or statistician, but also for positions in such related fields as actuarial science and computer science, or for further studies in computer science, operations research, and theoretical physics. In addition, students planning careers in law, medicine, or management have found that a mathematics degree provides very good preparation for entering those fields.

Because the career objectives of undergraduate mathematics majors are so diverse, each undergraduate's program is individually arranged through collaboration between the student and his or her faculty advisor. In general, students are encouraged to explore the various branches of mathematics, both pure and applied. This should be done not only to increase the breadth of their knowledge, but also to enable them to evaluate their own interests and abilities, with a view towards settling career objectives and choosing possible areas of specialization.

Considerable elective time is available in each of the mathematics programs so that students may explore their interests within mathematics or in related fields.

Undergraduates wishing to work in small groups under the supervision of a faculty member may elect to participate in a mathematics seminar. This is normally done during the junior year or the first semester of the senior year. The experience gained from active participation in a seminar conducted by a research mathematician is particularly valuable for a student planning to pursue graduate work in some branch of mathematics or a related field.

There are three undergraduate programs: a general mathematics program, a program for those students who wish to specialize in applied mathematics, and a program for those students who expect to pursue graduate work in pure mathematics.

Bachelor of Science in Mathematics Course XVIII

	General Institute Requirements	Total Units
	Specific science and humanities and social science subjects	132
	The Science Distribution Requirement can be satisfied by 18.03, which is among the Restricted Electives, plus appropriate subjects totaling	24
	Laboratory Requirement	12
	Departmental Program	
	Restricted Electives	**108**
18.03	Differential Equations	4 0 8
	12-unit Course XVIII subjects of essentially different content, including at least six with the first decimal digit one or higher[1]	96
	Unrestricted Electives	**84**
	Total Units Required for the S.B. Degree	**360**

This program leads to a general degree in mathematics. The requirements are unspecific in order to accommodate several classes of students: 1) those who need maximum flexibility in order to explore their interests in both pure and applied mathematics, or in order to specialize in a particular branch of mathematics, 2) those who wish to combine their work in mathematics with studies in another field, such as economics, computer science, or physics, and 3) those who wish to use mathematics as a general Institute major.

[1] Advanced standing credit does not fulfill any part of this requirement, but is accepted as Unrestricted Elective.

Applied mathematics is the mathematical study of general scientific concepts, principles, and phenomena which, because of their widespread occurrence and application, relate or unify various disciplines. The core of the program at MIT concerns the following principles and their mathematical formulations: propagation, equilibrium, stability, optimization, cybernetics, statistics, and random processes. The undergraduate program provides a general introduction to most areas of applied mathematics and to several specific areas for study in greater depth.

Freshmen interested in applied mathematics should take 18.001 Calculus and 18.002 Calculus followed as soon as possible by 18.03 Differential Equations. 18.03 and 18.002 may be taken during the same term.

Sophomores interested in applied mathematics typically survey the field of applied mathematics by enrolling in both 18.041 and 18.042 Principles of Applied Mathematics. 18.041, given only in the first term, is devoted to the discrete aspects of the subject and may be taken concurrently with 18.03. 18.042, given only in the second term, is devoted to continuous aspects, and makes considerable use of differential equations. With permission, other appropriate subjects may be substituted (such as an additional subject from Group I for 18.041, or an additional subject from Group II for 18.042).

Bachelor of Science in Mathematics
Course XVIII-A
Applied Mathematics Option

	General Institute Requirements	Total Units
	Specific science and humanities and social science subjects	132
	The Science Distribution Requirement can be satisfied by 18.03, which is required in the Departmental Program, plus appropriate subjects totaling	24
	Laboratory Requirement	12
	Departmental Program	
	Required Subjects	60
18.03	Differential Equations 4 0 8	
18.04	Complex Variables with Applications 4 0 8	
	or	
18.284	Introduction to Functions of a Complex Variable 3 0 9	
18.041	Principles of Applied Mathematics 3 0 9	
18.042	Principles of Applied Mathematics 3 0 9	
18.411	Applied Algebra 3 0 9	
	or	
18.700	Linear Algebra 3 0 9	
	Restricted Electives	48
	At least four subjects from the following two groups of subjects. Of these, at least one must be chosen from each of the groups.	
	Group I	
18.440	Probability and Random Variables 4 0 8	
	or	
18.313	Probability 3 0 9	
18.441	Statistical Inference 4 0 8	
	or	
18.443	Statistics for Applications 4 0 8	
18.314	Applied Combinatorial Analysis 3 0 9	
18.420J	Computability, Automata, and Formal Languages 3 0 9	
	Group II	
18.275	Numerical Analysis 3 0 9	
	or	
18.07	Introduction to Numerical Analysis 3 0 9	
18.301	Introduction to Physical Mathematics I 3 0 9	
18.302	Introduction to Physical Mathematics II 3 0 9	
18.354	Fluid Mechanics 3 0 9	
	Unrestricted Electives	84
	Total Units Required for the S.B. Degree	360

The subjects in Group I of the program correspond roughly to those areas of applied mathematics making heavy use of discrete mathematics, while Group II emphasizes those subjects which deal mainly with continuous processes. Naturally, there is a good deal of overlap; for example, such subjects as probability or numerical analysis have both discrete and continuous aspects. In general, students in the applied mathematics option are encouraged to acquire as good a background as possible in both types of applied mathematics.

Students should also consider taking other subjects from the applied mathematics curriculum. Sample programs emphasizing different specialities — combinatorics, computer science, fluid dynamics, numerical analysis, statistics, theoretical physics — are available in the Undergraduate Mathematics Office.

Theoretical mathematics (or "pure" mathematics) is the study of the basic concepts and structures that underlie the mathematical tools used in science and engineering. Its purpose is to search for a deeper understanding and an expanded knowledge of mathematics itself.

Traditionally, pure mathematics has been classified into three general fields: analysis, algebra, and geometry. Students interested in pure mathematics should become familiar with each of these areas. They may also wish to explore other areas such as logic, number theory, combinatorics, probability, and statistics.

Graduate Study

Bachelor of Science in Mathematics
Course XVIII-B
Theoretical Mathematics Option

	General Institute Requirements		Total Units
	Specific science and humanities and social science subjects		132
	The Science Distribution Requirement can be satisfied by 18.03, which is required in the Departmental Program, plus appropriate subjects totaling		24
	Laboratory Requirement		12
	Departmental Program		
	Required Subjects[1]		72
18.03	Differential Equations	4 0 8	
18.100B	Analysis I	3 0 9	
18.101	Analysis II-M	3 0 9	
	or		
18.102	Analysis II	3 0 9	
	or		
18.103	Fourier Analysis—Theory and Applications	3 0 9	
18.701	Algebra I	3 0 9	
18.702	Algebra II	3 0 9	
18.901	Introduction to Topology I	3 0 9	
	Restricted Electives[1]		36
	An upper level Mathematics Seminar[2]	12	
	Two additional Course XVIII subjects of essentially different content, with the first decimal digit one or higher	24	
	Unrestricted Electives		84
	Total Units Required for the S.B. Degree		360

1
Advanced standing credit does not fulfill any part of this requirement other than 18.03, but is accepted as Unrestricted Elective.

2
These seminars are: 18.104, 18.704, 18.904, and 18.994.

The subject 18.100 Analysis I is basic to the program. Since this subject is strongly proof-oriented, many students find an intermediate subject such as 18.700 Linear Algebra useful as preparation.

Recommended additional subjects, besides those on the preceding list, include 18.115 Functions of a Complex Variable, 18.511 Introduction to Mathematical Logic, 18.781 Theory of Numbers, 18.902 Introduction to Topology II, 18.950 Elementary Differential Geometry, and 18.961 Elementary Differential Topology. Other possibilities are the first-year graduate subjects 18.125 Measure and Integration, 18.705 Commutative Algebra, 18.905 Algebraic Topology, and 18.965 Geometry of Manifolds.

It is also recommended that students broaden their backgrounds by taking subjects in applied mathematics.

Some flexibility is allowed in this program. For instance, students may, with permission, substitute 18.700 Linear Algebra or 18.710 Abstract Linear Algebra, plus 18.703 Modern Algebra, for the recommended algebra sequence 18.701-18.702. Similarly, a student may substitute a thesis or (less desirably) one of the listed first-year graduate subjects for the Seminar.

Inquiries

Inquiries regarding academic programs may be addressed to Joanne Murray, Undergraduate Mathematics Office, Room 2-108, MIT, Cambridge, Massachusetts 02139, (617) 253-2416.

The Department offers programs covering a broad range of subjects which lead to the Master of Science, the Doctor of Philosophy, and the Doctor of Science; however, students are admitted to a master's program only in statistics. Numerous informal seminars, as well as weekly mathematics colloquia sponsored by MIT, Brandeis University, and Harvard University, supplement basic programs.

Candidates whose primary interest is in the field of **pure mathematics (Plan A)** ordinarily take most of their subjects in the Department. In addition to their advanced specialization, students are encouraged to acquire breadth by taking basic subjects in analysis, algebra, geometry, logic, and topology. Candidates whose primary interest is in **applied mathematics (Plan B)** are encouraged to study important aspects of one or more engineering or scientific fields closely related to research in applied mathematics. Assistance or collaboration in problems in pure or applied mathematics which are being investigated by members of the staff may constitute part of a graduate student's program.

Entrance Requirements for Graduate Study

Students are expected to have one year of college-level natural science in addition to an undergraduate mathematics program which approximates that of mathematics majors at MIT. Students may enter the applied mathematics program from any undergraduate field of concentration; however, special consideration is given to students with a strong scientific background.

Master of Science in Mathematics

General requirements for the Master of Science are given in Chapter IV. Specifically, a student must take not less than 72 units, including at least four 12-unit graduate ("A") subjects offered by the Department, as well as submitting an acceptable thesis.

Doctor of Philosophy and Doctor of Science

The basic requirements for these degrees are given in Chapter IV, and the details of the program are outlined in a set of notes available from the Department. The first stage is to prepare for the general qualifying examination, and to fulfill the course requirements (132 hours of graduate credits). Doctoral candidates are required to have a mathematical reading knowledge of French, German, or Russian.

Plan A In pure mathematics, the oral part of the general examination covers three areas chosen by the student in consultation with the Chairman of the Committee on Graduate Students. It must be passed by the end of the second year.

Plan B Students electing applied mathematics as their field of study should normally follow this program. The basic objective is a proper balance of specialization and diversity.

By the end of the first year of study, the degree candidate in consultation with an advisor must submit a "plan of study" for approval by the Applied Mathematics Committee. In addition to a list of subjects related to the major field, this plan must include a minor, or its equivalent, to assure familiarity with the basic concepts of applied mathematics, i.e., propagation, equilibrium, stability, optimization, cybernetics, and random processes. In order to secure maximum flexibility, programs are considered individually.

The *Guideline of Study for Doctoral Candidates in Applied Mathematics* which is distributed to entering students provides more complete information on degree requirements, academic standards, and financial support.

In either Plan A or Plan B, after successfully passing the general examination, the student may officially begin thesis research under the supervision of the thesis advisor. The thesis is expected to represent original research of high quality and should be finished by the end of the fourth year of graduate study. Upon submitting the thesis the student must pass an oral thesis examination.

Teaching and Research Assistantships

A limited number of fellowships, as well as teaching and research assistantships, are available to graduate students in mathematics.

Inquiries

Any additional information regarding academic or research programs in mathematics, admissions, or financial aid, may be obtained from Phyllis Ruby, Graduate Office, Room 2-233, MIT, Cambridge, Massachusetts 02139, (617) 253-2689.

Department of Meteorology and Physical Oceanography

Peter Hunter Stone, Ph.D.
Professor of Meteorology
Head of the Department

Professors

John Vaughan Evans, Ph.D.
Professor of Meteorology

Edward Norton Lorenz, Sc.D.
Professor of Meteorology

Erik L. Mollo-Christensen, Sc.D.
Professor of Oceanography

Reginald Edward Newell, Sc.D.
Professor of Meteorology

Frederick Sanders, Sc.D.
Professor of Meteorology

Carl Isaac Wunsch, Ph.D.
Cecil and Ida Green Professor of Physical Oceanography

Associate Professors

Glenn Richard Flierl, Ph.D.
Associate Professor of Oceanography

Ronald George Prinn, Sc.D.
Associate Professor of Meteorology

Joel Tenenbaum, Ph.D.
Associate Professor of Meteorology (Visiting)

Assistant Professors

Mark Alan Cane, Ph.D.
Assistant Professor of Oceanography

Peter Charles Cornillon, Ph.D.
Assistant Professor of Oceanography (Visiting)

Kerry Andrew Emanuel, Ph.D.
Assistant Professor of Meteorology

Charles Curtis Eriksen, Ph.D.
Assistant Professor of Physical Oceanography

Neil David Gordon, Ph.D.
Assistant Professor of Meteorology (Visiting)

Don Edmunds Harrison, Ph.D.
Assistant Professor of Oceanography (Visiting)

Richard Eugene Passarelli, Jr., Sc.D.
Assistant Professor of Meteorology

Raymond Thomas Pierrehumbert, Ph.D.
Assistant Professor of Meteorology

Paola Malanotte Rizzoli, Ph.D.
Assistant Professor of Oceanography

Administrative Officer

Jane Sinnott McNabb, B.A.

Research Associates

Claude Jean Frankignoul, Ph.D.
James William Anthony Fullmer, Ph.D.
Alfredo Rene Navato, Ph.D.

Postdoctoral Associates

Long Sang Chiu, Ph.D.
Gerard Mark Doherty, Sc.D.
Mostafa Ameen Foda, Sc.D.

Visiting Scientists

Ji-Fan Chou, B.S.
Lee-or Merkine, Ph.D.

Visiting Lecturer

Richard David Rosen, Ph.D.

Research Engineer

Spiros George Geotis

Professors Emeriti

James Murdoch Austin, Sc.D.
Professor of Meteorology, Emeritus

Henry Garrett Houghton, Sc.D.
Professor of Meteorology, Emeritus

Delbar Pouleur Keily, S.B.
Associate Professor of Meteorology, Emeritus

Hurd Curtis Willett, Ph.D.
Professor of Meteorology, Emeritus

Department of Meteorology and Physical Oceanography

Undergraduate Study

Meteorology is the science of the atmospheres, primarily that of the earth but also of other planets. It is one of the sciences which deals with the physical properties of the earth. Many of our unsolved problems depend for their solution upon increased knowledge of our physical environment. The Department's educational aim is to provide its students with a broad background in meteorology and related sciences, which prepares them to meet these challenging problems.

The Department also offers a program in physical oceanography, the study of how oceanic waves, currents, and density fields are created and how they interact with the atmosphere.

Modern professional practice in both fields, at all educational levels from baccalaureate to doctoral, emphasizes the quantitative aspect of the subject. This requires considerable background in the more basic sciences in addition to work in meteorology or oceanography proper. The Department, therefore, does not offer an undergraduate major or Bachelor of Science in meteorology or oceanography. A selection of undergraduate electives is offered instead. These include 19.02 Descriptive Meteorology, 19.05J Environmental Chemistry of the Ocean-Atmosphere System, 19.83 Physical Oceanography, and 19.10 Climate of the Past.

Certain introductory graduate level subjects, such as 19.69 Fluid Dynamics of the Atmosphere and Ocean, 19.70 Oceanic and Atmospheric Models, 19.71J Wave Motions in the Atmosphere and Oceans, and 19.43-19.44 Synoptic Meteorology, also are available to undergraduates who can satisfy the prerequisites. The above subjects, which are described in Chapter VII, are suitable for students who plan to stop at the baccalaureate level with a "minor" in meteorology, for students who plan to continue with graduate studies in meteorology/oceanography, and for students who wish to supplement their basic undergraduate program with an exposure to interesting environmental problems. Department offerings in the Undergraduate Seminar Program and the Undergraduate Research Opportunities Program are listed in advance of each term in the appropriate announcement booklet.

Undergraduate students at MIT who wish to prepare for graduate work in meteorology or physical oceanography are advised to register in the Interdisciplinary Science Program offered by the School of Science. Adequate preparation is also provided by other MIT undergraduate curricula, particularly in the Departments of Mathematics and Physics, and in the Environmental Science program of Course XII.

Advice on registration for this purpose and selection of the above subjects as electives is available from Professor F. Sanders, Room 54-1612, from the faculty member in charge of each subject, or from Departmental Headquarters, Room 54-1712.

Graduate Study

Emphasis in the graduate program is placed on the theoretical and quantitative approach, supplemented by empirical information and quantitative data analysis. This approach is based on the conviction that progress in meteorology and oceanography depends upon the applications of the laws of physics, and that predictive modeling requires more than blind usage of statistical inference.

Graduate study in the Department therefore consists of a mixture of theoretical and descriptive courses, sharing a common appreciation of the dynamics of the underlying process.

Undergraduate Preparation

The most essential element is a sound preparation in mathematics and physics, supplemented if possible by some chemistry. Exposure to subjects in earth sciences is helpful but not required. Students who are taking their undergraduate work at other institutions are advised to include in their programs the equivalent of the mathematics and physics contained in the MIT curricula mentioned earlier. Students with baccalaureate degrees in meteorology or oceanography may be asked to supplement their programs with mathematics and physics during the first year of graduate study, in lieu of some of the introductory meteorology subjects given in the Department.

Meteorology

Formal subjects of instruction are offered in most principal areas of meteorology, and usually are supplemented by reading courses in a student's special area of interest. Subjects commonly taken by graduate students include the following:

19.43	Synoptic Meteorology I
19.44	Synoptic Meteorology II
19.46	Numerical Modeling in Meteorology and Oceanography
19.61	Dynamic Meteorology I
19.62	Dynamic Meteorology II
19.63	Diagnostic Studies of the General Circulation
19.64	Atmospheric Modeling
19.65J	Turbulence and Random Processes in Fluid Mechanics
19.681	Synoptic Scale Dynamics in the Atmosphere and Oceans
19.682	Instability and Turbulence in Geophysical Systems
19.69	Fluid Dynamics of the Atmosphere and Ocean
19.70	Oceanic and Atmospheric Models
19.71J	Wave Motions in the Atmosphere and Oceans
19.72	Atmospheric Radiation
19.73	Chemistry and Dynamics of Upper Atmospheres
19.74	Cloud and Precipitation Physics
19.75	Radar Meteorology

As this list suggests, there are research and educational activities in all the principal areas of meteorology. There is a weather radar system, actively used in research, and equipped with data processing facilities. Current weather data are received from the National Weather Service, and data are kept on file for most areas of the world; some of these data are in computer-compatible formats.

The Department has access to large-scale computing facilities via terminals, and has installed new facilities with the aim of taking better advantage of modern technology and communications in processing weather data and satellite information. The Department also has access to the high-speed computing facilities of the MIT Information Processing Center.

Laboratory facilities include the weather radar and a small fluid mechanics laboratory, and electronics shops used for the assembly and maintenance of measuring equipment.

The Department conducts an extensive program of sponsored research. Graduate students are often able to participate in this program as Research Assistants. Such active participation in research is considered a valuable supplement to formal courses and also provides some financial assistance.

Cambridge and its surroundings contain a number of institutions active in meteorological research, which, in addition to private commercial firms, include Harvard University, Woods Hole Oceanographic Institution, the Air Force Geophysics Laboratory, and the Boston Office of the National Weather Service. Contact with the personnel of these institutions is maintained through seminars and symposia in addition to the many informal contacts.

Oceanography

Joint MIT-WHOI Program Course XIX-W

The Department of Meteorology and Physcial Oceanography is an active participant in the joint MIT-Woods Hole Oceanographic Institution graduate program in oceanography. Except in special circumstances, all students in the Department pursuing a doctorate in oceanography are entered in this joint program. At the present time the Master of Science in Oceanography is offered only by the Department of Meteorology and Physical Oceanography and the Department of Earth and Planetary Sciences. Students pursuing this degree do have access to

the facilities of the joint program, however. The Master of Science is not a prerequisite to the doctorate, but some students find it desirable to earn a Master of Science on the way to the doctorate. The Department of Meteorology and Physical Oceanography is active in physical oceanography; faculty and students are currently engaged in theoretical studies of the oceanic circulation, observational studies at sea, laboratory models and field and laboratory investigations of the interactions between the atmosphere and the ocean. The programs of graduate students in oceanography also include subjects in oceanography and related areas offered by the Department of Earth and Planetary Sciences, several other MIT departments, and the Woods Hole Oceanographic Institution. Further information on the joint programs with Woods Hole may be found at the end of this chapter.

Master of Science in Meteorology or in Oceanography
Course XIX

The graduate ("A") subjects required for the Master of Science may be selected from those offered in meteorology or in oceanography and those in related fields offered by other departments. Undue specialization in one branch of the field is discouraged. There are no foreign language requirements for the degree.

Doctor of Philosophy and Doctor of Science

The general requirements for the degrees of Doctor of Philosophy and Doctor of Science are given in Chapter IV. The Department does not require candidates for the doctorate to present evidence of competence in a foreign language or languages but, because of the importance of communication with foreign scientists, it is strongly urged that candidates for the doctorate acquire intermediate competence in one or more languages.

Teaching and Research Assistantships

The Department offers a considerable number of Research and Teaching Assistantships each year. Research Assistants work on one of the many research projects in the department.

Teaching Assistants assist in laboratory instruction or in the preparation of teaching materials and the grading of papers. Information concerning these appointments may be obtained from the Head of the Department.

The Department offers a few predoctoral fellowships in the atmospheric sciences and oceanography. Announcements and application forms are available from the Head of the Department.

Inquiries

Further information on degree programs, research activities, admission requirements, assistantship appointments, and financial aid may be obtained from the Department of Meteorology and Physical Oceanography, Room 54-1712, MIT, Cambridge, Massachusetts 02139, (617) 253-2281.

Department of Nutrition and Food Science

Gerald Norman Wogan, Ph.D.
Professor of Toxicology
Underwood-Prescott Professor of Nutrition and Food Science
Head of the Department

Daniel I. C. Wang, Ph.D.
Professor of Biochemical Engineering
Chairman, Committee on Food-Related Sciences

Richard Jay Wurtman, M.D.
Professor of Neuroendocrine Regulation
Chairman, Committee on Nutrition-Related Sciences

Professors

John Francis Burke, M.D.
Professor of Experimental Surgery
(Visiting)

Arnold Lester Demain, Ph.D.
Professor of Industrial Microbiology

Samuel Abraham Goldblith, Ph.D.
Professor of Food Science
Vice President, Resource Development

Marcus Karel, Ph.D.
Professor of Food Engineering

Charles J. Kensler, Ph.D.
Professor of Pharmacology
(Visiting)

Robert Spencer Lees, M.D.
Professor of Cardiovascular Disease

Sanford Arthur Miller, Ph.D.
Professor of Nutritional Biochemistry

Hamish Nisbet Munro, M.B., D.Sc.
Adjunct Professor of Physiological Chemistry

Paul Medford Newberne, D.V.M., Ph.D.
Professor of Nutritional Pathology

Nevin Stewart Scrimshaw, Ph.D., M.D., M.P.H.
Institute Professor
Director, Clinical Research Center

Anthony John Sinskey, Sc.D.
Professor of Applied Microbiology
Registration and Admissions Officer

Steven Robert Tannenbaum, Ph.D.
Professor of Toxicology and Food Chemistry

Lance Jerome Taylor, Ph.D.
Professor of Nutritional Economics

George Wolf, D.Phil.
Professor of Physiological Chemistry

Vernon Robert Young, Ph.D.
Professor of Nutritional Biochemistry

Associate Professors

Michael Jay Baum, Ph.D.
Associate Professor of Behavioral Endocrinology

Henri Brunengraber, M.D., Ph.D.
Associate Professor of Physiological Chemistry

Charles Leland Cooney, Ph.D.
Associate Professor of Biochemical Engineering

John Dickson Fernstrom, Ph.D.
Associate Professor of Neuroendocrinology

James Gehan Fox, M.S., D.V.M.
Associate Professor of Laboratory Animal Medicine
Director, Division of Comparative Medicine

Robert Samuel Langer, Sc.D.
Associate Professor of Biochemical Engineering

Richard Alan North, M.D., Ph.D.
Associate Professor of Neuropharmacology

Cho Kyun Rha, Sc.D.
Associate Professor of Food Process Engineering

Noel Willis Solomons, M.D.
Associate Professor of Clinical Nutrition

William George Thilly, Sc.D.
Associate Professor of Genetic Toxicology

Barbara Underwood, Ph.D.
Associate Professor of Nutrition

Assistant Professors

Carolyn F. Craft, D.V.M.
Assistant Professor of Comparative Pathology

John Martin Essigmann, Ph.D.
Assistant Professor of Toxicology

Alexander M. Klibanov, Ph.D.
Doherty Assistant Professor of Applied Biochemistry

Michael Anthony Marletta, Ph.D.
Mitsui Career Development Professor of Contemporary Technology
Assistant Professor of Toxicology

Marsha Rich Rosner, Sc.D.
Assistant Professor of Toxicology

Senior Lecturers

Josef Brozek, Ph.D.
Charles S. Davidson, M.D.
John Everett Gordon, Ph.D., M.D.
Edward S. Josephson, Ph.D.
John Burton Stanbury, M.D.

Lecturers

Mary Ellen Avery, M.R. (Visiting)
Bruce Bistrian, M.D., Ph.D.
George Blackburn, M.D., Ph.D.
James Carpenter, D.V.M. (Visiting)
Francisco R. DelValle, Ph.D. (Visiting)
Andrew G. Ebert, Ph.D.
Ray W. Fuller, Ph.D. (Visiting)
Alan J. Gelenberg, M.D.
John H. Growdon, M.D.
Lars M. Gunne, M.D. (Visiting)
Michael F. Holick, M.D., Ph.D.
Herbert Hultin, Ph.D. (Visiting)
Kenneth R. Kenyon, M.D.
Ronald Kleinman, M.D. (Visiting)
Harry Lynch, Ph.D.
Michael A. Moskowitz, M.D. (Visiting)
William Medden Rand, Ph.D.
Israel A. Saguy, Ph.D. (Visiting)
Andrew Sivak, Ph.D.
John Snyder, M.D.
Bonnie Spring, Ph.D. (Visiting)
Miriam M.H. Thomas, M.S. (Visiting)
John N. Udall, M.D., Ph.D.
William Walker, M.D. (Visiting)
Mitchell B. Wallerstein, Ph.D.
Joe D. Wray, M.D., M.P.H. (Visiting)
Nicholas T. Zervas, M.D. (Visiting)

Administrative Officer

Lydia S. Snover, M.B.A.

Senior Research Scientists

Mary O. Amdur, Ph.D.
Adrianne Ellefson Rogers, M.D.

Research Scientists

William Fisher Busby, Ph.D.
Madeline Hirsch Fernstrom, Ph.D.
Yen Ping Hsieh, Ph.D.
John Sherman Wishnok, Ph.D.
John Williams, Ph.D.
Judith Hirschhorn Wurtman, Ph.D.

Research Associates

Hua-Fuan Lam, Ph.D.
Robert Linhardt, Ph.D.
James Murphy, Ph.D.
Kathleen M. Nauss, Ph.D.
Dina Fragman Ralt, Ph.D.
Paul Skipper, Ph.D.
Leona Zacharias, Ph.D.
Marian F. Zeitlin, Ph.D.

Postdoctoral Associates

Sally Bolmer, Ph.D.
Alistair James P. Brown, Ph.D.
William Dietz, M.D.
Mary S. Erskine, Ph.D.
Jorge A. Funes, Ph.D.
Viktor Goldmakher, Ph.D.
Christine Conlon Hollingshead, Ph.D.
David E. Shuker, Ph.D.
John F. Tomera, Ph.D.
Lisa Weymouth, Ph.D.

Professors Emeriti

Cecil Gordon Dunn, Ph.D.
Associate Professor of Industrial Microbiology, Emeritus

Robert Samuel Harris, Ph.D.
Professor of Nutritional Biochemistry, Emeritus

John Theodore Roosevelt Nickerson, Ph.D.
Professor of Food Technology, Emeritus

Department of Nutrition and Food Science

Undergraduate Study

The research and teaching programs of the Department of Nutrition and Food Science deal with complex problems relating to interactions of people with various factors in the environment. Consequently, approaches to solution of these problems require integration of knowledge from several disciplines including biology, chemistry, engineering, and medicine. Some examples of the generic problems of current interest include the etiology of degenerative diseases and cancer; regulation of metabolic processes in health and disease; role of diet in regulation of metabolic processes in health and disease; role of diet in regulation of brain function; health effects of environmental chemicals; biotechnology and biochemical engineering; development of engineered foods; and food and nutrition policy planning.

In response to such challenges, the Department has developed integrated programs involving a broad range of scientific disciplines. Programs involve both research and educational opportunities through which students can acquire the professional expertise and perspective necessary to contribute meaningfully to the solution of problems of a complex multidisciplinary nature.

Bachelor of Science in Life Sciences Course VII-B Applied Biology Curriculum

The Department of Nutrition and Food Science offers an undergraduate curriculum in Applied Biology as part of the Life Sciences program offered by the Department of Biology. This curriculum in Applied Biology emphasizes fundamental subjects in the physical and biological sciences and permits exploration of a variety of disciplinary areas leading to graduate or professional training including nutritional biochemistry and metabolism, food science, toxicology, animal pathology, human nutrition and metabolism, medicine, mathematical biology, and biochemical engineering. Programs of planned electives are arranged in consultation with an individual faculty advisor in the disciplinary area chosen by the student.

Bachelor of Science in Life Sciences Course VII-B Applied Biology Curriculum

	General Institute Requirements	Total Units
	Specific science and humanities and social science subjects	132
	The subjects 5.41, 7.05 and 20.021, which are required in the Departmental Program, appear on the list of Science Distribution Subjects and can be used to satisfy the Science Distribution Requirement.	
	The subject 20.002, which is required in the Departmental Program, appears on the list of Laboratory Subjects and can be used to satisfy the Laboratory Requirement.[1,2,4]	

	Departmental Program		
	Required Subjects		**98**
5.311	Introductory Chemical Experimentation[2]	2 8 2	
5.41	Introduction to Structure, Bonding and Mechanism[1]	5 0 7	
5.42	Organic Chemistry	5 0 7	
5.60	Chemical Thermodynamics[1]	4 0 8	
7.03	Genetics	4 0 8	
7.05	General Biochemistry[1]	5 0 7	
20.002	Laboratory in Applied Biology[1,2,4]	2 8 4	
20.021	Physiological and Nutritional Biochemistry[1]	4 0 8	
	Restricted Electives		**69-72**
	Any *two* of the following subjects:[3]		
7.06	Metazoan Cell Biology	3 0 9	
7.21	Microbial Physiology	4 0 8	
20.022	Mammalian Physiology	5 0 7	
20.023	Human Nutrition	3 0 6	
	One of the following subjects:		
18.03	Differential Equations	4 0 8	
18.041	Principles of Applied Mathematics	3 0 9	
18.05	Introduction to Probability and Statistics	3 0 9	
18.440	Probability and Random Variables	4 0 8	
18.700	Linear Algebra	3 0 9	
	One of the following subjects:		
5.61	Physical Chemistry	4 0 8	
5.62	Physical Chemistry	4 0 8	
6.071	Introduction to Electronics	4 2 6	
7.71J 5.64J	Biophysical Chemistry	4 0 8	
8.03	Physics III	5 0 7	
10.301	Fluid Mechanics	3 0 6	
	In addition, 24 units as thesis or 20.011, 20.012. (Special Projects in Undergraduate Research.) A final research report or thesis is required.		
	Unrestricted Electives		**61-58**
	Total Units Required for the S.B. Degree		**360**

1
Students who take 5.41 or 5.60, 7.05 or 20.021 to fulfill the General Institute Requirements and 20.002 to fulfill the Laboratory Requirement have an additional 26 units of unrestricted electives.

2
It should be noted that either 20.002 or 5.311 satisfy the Institute Laboratory Requirement and medical school entrance requirements.

3
Graduate courses that may be substituted for *one* course include:

20.211	Regulation of Mammalian Intermediary Metabolism	4 1 7
20.212	Basic and Human Nutrition	4 0 8
20.213	Endocrinology in Nutrition and Metabolism	4 0 8
20.511J	The Neurosciences I	6 0 9
20.611	General Toxicology	3 0 9

4
7.011 may be substituted for 20.002

Graduate Study

The Department offers programs leading to the Master of Science, the Doctor of Philosophy, and the Doctor of Science. The degrees are awarded in five areas — Metabolism and Human Nutrition, Food Science and Technology, Biochemical Engineering, Toxicology, and Neural and Endocrine Regulation.

Excellent facilities are available for research, including well-equipped laboratories for chemical, biochemical, physical, and microbiological research. A clinical research center is available for metabolic studies on human subjects, and modern animal facilities are available for most experimental animal species. Laboratories also exist for research on the effects on various types of food processing (e.g., heat, dehydration, radiation, refrigeration, and freezing), and a modern pilot plant includes equipment for large-scale fermentations and other similar processes. Detailed summaries of research activities of the members of the departmental faculty are available on request.

Food Science and Technology. Academic and research programs are offered in food science and technology. These programs stress fundamental principles in three areas: food chemistry, food engineering, and food microbiology. Current research in food chemistry is concerned with the formation, occurrence, and analysis of chemical substances in foods, and in particular with compounds of toxicological significance and with reactions causing changes in nutritional and organoleptic quality. Another area under investigation is the separation, structure, and physical and biochemical properties of selective food proteins. Also, investigation of the mechanisms of enzyme denaturation, reactivation of inactivated enzymes, immobilized enzymes and enzymes for solar energy conversion and storage are being pursued. Changes in food composition and nutrient value due to processing and storage are also being analyzed, simulated, and optimized. Food engineering research deals with the establishment of the fundamental physical properties of foods and food materials and the identification and characterization of engineering parameters critical for the proper processing, materials handling, storage, and distribution of conventional and unconventional food systems. Food and applied microbiology investigations emphasize the understanding of biological principles concerned with the control of undesirable microorganisms in foods, as well as the utilization of beneficial ones; projects in this area include both aerobic and anaerobic microorganisms.

Metabolism and Human Nutrition. This program offers an S.M. degree in the general area of Metabolism and Human Nutrition, and three tracks within the same area lead to a Ph.D. The first year of the doctoral program is common to all three tracks and provides training in mammalian metabolism, nutrition, endocrinology and statistics, while the second year is taken in one of three tracks, namely nutritional biochemistry, human nutrition, or international nutrition planning. The student's progress is tested by written examinations at the end of the first and during the second year in the program. Thereafter, a thesis topic within one of the three tracks completes the requirements for a doctoral degree.

The Mammalian Metabolism Track is concerned with nutritional, genetic, environmental and endocrine variations in the metabolic processes of humans and various laboratory animals and their alterations in disease states. A program of training in mammalian biochemistry is offered to graduate students who wish to acquire knowledge and research experience in physiological chemistry and biochemistry as it applies to nutritional problems. Current research projects include: biochemical, morphological, and physiological effects of malnutrition; biochemical defects underlying inherited disorders of the endocrine system; endocrine control mechanisms; effect of infection and stress on nutrient requirements and nutritional status; dietary and hormonal factors influencing protein synthesis; environmental factors influencing endocrine rhythms; enzyme synthesis and turnover in tissues; functions of vitamin A in the synthesis of glycoproteins; amino acid metabolism and protein and nucleic acids synthesis and turnover; synthesis and metabolism of fatty acids; effects of nutritional and endocrine variations on the activities of tissue enzymes; metabolism of ethanol; metabolism in perfused organs.

The Human and Clinical Nutrition Track provides graduate students with an opportunity to acquire knowledge and research experience in areas of metabolism and nutrition having direct relevance to the nutrition of humans under conditions of health and in disease. Research projects involve primarily human metabolic and field studies. Typical projects include: studies of nutrient metabolism and requirements in health and disease states, including the effects of age and aging, cancer, physical trauma, and other systemic and metabolic disease conditions; clinical evaluation of new food sources; the regulation of body protein and energy metabolism; the metabolic response to trauma; nutrition and immunocompetence; effects of nutritional state on behavior and performance; nutrition and drug treatment of hyperlipoproteinemia; evaluation of nutritional status; the application of stable isotopes to the study of human metabolic processes.

The International Food and Nutrition Program (IFNP) Track provides an interdisciplinary focus for students interested in nutrition field studies, policy analysis, and evaluation of appropriate nutrition intervention. The Departments of Economics, Political Science, Urban Studies and Planning, and the Anthropology and Archaeology Section of the Department of Humanities also participate. Students must enter through and fulfill all degree requirements of their respective departments. Representative areas in which IFNP works include the following: a) monitoring the nutritional status of populations, including assessing the nature, magnitude, functional significance, and dynamics of malnutrition among vulnerable population groups; b) determination of nutrition program benefits; c) interactions among such factors as nutrition, maternal-child health, infection, socioeconomic and cultural characteristics of the population, agriculture policy, sanitation and other public health problems; d) the effects of income and price changes and of subsidized consumption programs on the nutritional intake of vulnerable popu-

lations; e) food and agriculture policies of food-exporting nations as these relate to international food needs.

Toxicology. A program is offered leading to the Master of Science and doctoral degrees in the field of toxicology. The training program consists of a series of specialized subjects dealing with cellular responses to various chemical and physical agents of toxicological interest. Typical research projects in toxicology include: chemical carcinogenesis; metabolism of carcinogens, toxic compounds, and drugs; isolation and identification of toxic compounds produced by fungi; carcinogenesis and mutagenesis in mammalian and human cells in culture; studies on the mode of action of toxic agents; structure-activity relationships of carcinogens and toxins; and biochemical lesions induced by carcinogens and mutagens.

Biochemical Engineering. A program in biochemical engineering is offered leading to the Master of Science and doctoral degrees. Integration of studies in biological sciences with engineering is emphasized with particular attention to industrial microbiology and fermentation processes. Research projects in biochemical engineering include: continuous culture of microorganisms; dynamics of microbial growth; computer-aided fermentation processes; microbial utilization of renewable resources; microbiology of mixed cultures and multiple substrate utilization; enzyme production and enzyme technology; mass transfer in fermentation vessels; biosynthesis of primary and secondary metabolites; drug development in cancer chemotherapy; and mammalian tissue cultures.

Neural and Endocrine Regulation. A multidisciplinary program is offered, which leads to the Master of Science and Doctoral degrees in Neural and Endocrine Regulation. The program provides graduate students with an opportunity to acquire a broad background in physiologic and metabolic regulation, and a detailed knowledge of brain function in mammals. Its principal objective is the training of independent basic-science and clinical investigators who explore the mechanisms by which the brain and endocrine system maintain homeostasis, control endocrine and reproductive function, and mediate the responses of the body to such environmental inputs as foods, drugs, and light. The program requires basic subjects in mammalian biochemistry and physiology, and offers, in addition, advanced study in the fields of neuroendocrinology, neuropharmacology, neurochemistry, and psychopharmacology.

Entrance Requirements for Graduate Study

To qualify for graduate study in the Department, applicants should possess a Bachelor of Science with a major in the life sciences, chemistry, food science, or chemical engineering or a professional degree such as the M.D., D.D.S., or D.V.M. The General Institute Requirements for graduate study are outlined in Chapter IV. Additional details concerning individual degrees given by this Department are summarized below.

Master of Science

Students who do not already possess a Master of Science or a professional degree are normally registered as S.M. candidates during their first year of graduate study. However, the S.M. is not a prerequisite for doctoral candidacy, and students may change to a doctoral program, by permission, based on academic performance during the first year. Each of the five curricula — Metabolism and Human Nutrition, Food Science and Technology, Biochemical Engineering, Toxicology, and Neural and Endocrine Regulation — consists of a limited number of recommended graduate subjects supplemented by sufficient elective units selected by the student in consultation with his or her advisor to fulfill the Institute Requirements. A thesis conducted under the direction of a Departmental faculty member, or as part of an interdepartmental program, is required of all Master of Science candidates.

Doctor of Philosophy and Doctor of Science

These programs consist of programs of course study together with an original thesis. A limited number of required subjects are suppiemented by electives.

Written doctoral qualifying and general examinations, taken during the second year of graduate study, establish competence with reference to a basic scientific background as well as in specialized areas of knowledge related to the specific degree programs. The written examination is followed by an oral presentation and defense of a research proposal on which the thesis research is based.

Thesis research is done under the supervision of faculty members in the various areas of specialization described above. Research progress is evaluated periodically by the thesis advisory committee, which also conducts an oral defense of the completed thesis.

The written general examination for students in Biochemical Engineering is prepared by faculty members from the Departments of Nutrition and Food Science, Biology, and Chemical Engineering. Also, faculty members from these Departments make up the Thesis Committee for students in Biochemical Engineering.

Assistantships and Fellowships

Financial assistance is available to qualified applicants in the form of research assistantships, traineeships, and a limited number of fellowships, subject to availability of funds. Research assistantships are provided from grants obtained by members of the faculty for work on specific research projects.

Inquiries

Additional information concerning academic programs, research activities, admissions, financial aid, assistantships and fellowships may be obtained by writing to the Student Office, Department of Nutrition and Food Science, Room 16-318, MIT, Cambridge, Massachusetts 02139, (617) 253-5804 or 253-1712.

Department of Physics

Herman Feshbach, Ph.D.
Cecil and Ida Green Professor of Physics
Head of the Department

Anthony Philip French, Ph.D.
Professor of Physics
Academic Officer

Professors

Michel Baranger, Ph.D.
Professor of Physics

Walter Carlisle Barber, Ph.D.
Professor of Physics

Alan Hildreth Barrett, Ph.D.
Professor of Physics

Ulrich Justus Becker, Ph.D.
Professor of Physics

George Bekefi, Ph.D.
Professor of Physics

George Bernard Benedek, Ph.D.
Alfred H. Caspary Professor of Physics
(Absent)

Aron Myron Bernstein, Ph.D.
Professor of Physics

William Bertozzi, Ph.D.
Professor of Physics

Robert Joseph Birgeneau, Ph.D.
Professor of Physics

Hale Van Dorn Bradt, Ph.D.
Professor of Physics

Herbert Sage Bridge, Ph.D.
Professor of Physics
Director, Center for Space Research

Bernard Flood Burke, Ph.D.
Professor of Physics
William A.M. Burden Professor of Astrophysics

Wit Busza, Ph.D.
Professor of Physics

George Whipple Clark, Ph.D.
Professor of Physics

Bruno Coppi, Ph.D.
Professor of Physics

Eric Richard Cosman, Ph.D.
Professor of Physics
(Absent)

Ronald Crosby Davidson, Ph.D.
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Director, Plasma Fusion Center

Peter Theodore Demos, Ph.D.
Professor of Physics
Director, Bates Linear Accelerator

Martin Deutsch, Ph.D., Sc.D.
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Thomas Henderson Dupree, Ph.D.
Professor of Physics
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(Absent)

Harald Anton Enge, Dr. Phil.
Professor of Physics

Bernard Taub Feld, Ph.D.
Professor of Physics

Michael Stephen Feld, Ph.D.
Professor of Physics
Director, Spectroscopy Laboratory

Jerome Isaac Friedman, Ph.D.
Professor of Physics
Director, Laboratory for Nuclear Science

David Henry Frisch, Ph.D.
Professor of Physics

Jeffrey Goldstone, Ph.D.
Professor of Physics

Thomas John Greytak, Ph.D.
Professor of Physics

Lee Grodzins, Ph.D.
Professor of Physics

Kerson Huang, Ph.D.
Professor of Physics

Robert Inslee Hulsizer, Jr., Ph.D.
Professor of Physics

Karl Uno Ingard, Ph.D.
Professor of Physics and Aeronautics and Astronautics
(Absent)

Roman Wladimir Jackiw, Ph.D.
Professor of Physics

Ali Javan, Ph.D.
Francis Wright Davis Professor of Physics

Kenneth Alan Johnson, Ph.D.
Professor of Physics
(Absent)

Henry Way Kendall, Ph.D.
Professor of Physics

Arthur Kent Kerman, Ph.D.
Professor of Physics
Director, Center for Theoretical Physics

John Gordon King, Ph.D.
Francis Friedman Professor of Physics

Vera Kistiakowsky, Ph.D.
Professor of Physics
(Absent)

Daniel Kleppner, Ph.D.
Professor of Physics

George Fred Koster, Ph.D.
Professor of Physics

Benjamin Lax, Ph.D.
Professor of Physics

Walter Hendrik Gustav Lewin, Dr. Tech. Sci.
Professor of Physics
(Absent)

James David Litster, Ph.D.
Professor of Physics

Earle Leonard Lomon, Ph.D.
Professor of Physics

Francis Eugene Low, Ph.D.
Karl Taylor Compton Professor of Physics
Provost

Philip Morrison, Ph.D.
Institute Professor
Professor of Physics

John William Negele, Ph.D.
Professor of Physics

Stanislaw Olbert, Ph.D.
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Louis Shreve Osborne, Ph.D.
Professor of Physics

Irwin Abraham Pless, Ph.D.
Professor of Physics

Miklos Porkolab, Ph.D.
Professor of Physics

David Edward Pritchard, Ph.D.
Professor of Physics

Saul Alan Rappaport, Ph.D.
Professor of Physics

Lawrence Rosenson, Ph.D.
Professor of Physics

Irwin Ira Shapiro, Ph.D.
Schlumberger Professor of Physics and Geophysics

Clifford Glenwood Shull, Ph.D.
Professor of Physics

Malcom Woodrow Pershing Strandberg, Ph.D.
Professor of Physics

Samuel C. C. Ting, Ph.D.
Professor of Physics
Holder of the Thomas Dudley Cabot Institute Chair

Felix Marc Hermann Villars, D.Sc.
Professor of Physics
Chairman of the Faculty

Rainer Weiss, Ph.D.
Professor of Physics

Peter Adalbert Wolff, Ph.D.
Professor of Physics
Director, Francis Bitter National Magnet Laboratory

Richard Kumeo Yamamoto, Ph.D.
Professor of Physics

James Edward Young, Ph.D.
Professor of Physics

Associate Professors

Charles Alcock, Ph.D.
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John Winston Belcher, Ph.D.
Associate Professor of Physics

Judith Louise Bostock, Ph.D.
Associate Professor of Physics

Claude Roger Canizares, Ph.D.
Associate Professor of Physics
(Absent)

Min Chen, Ph.D.
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Lennox L. Cowie, Ph.D.
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James Ludlow Elliot, Ph.D.
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Alan Harvey Guth, Ph.D.
Associate Professor of Physics

Robert Loren Jaffe, Ph.D.
Associate Professor of Physics

John Dimitris Joannopoulos, Ph.D.
Associate Professor of Physics
(Absent)

Paul Christopher Joss, Ph.D.
Associate Professor of Physics

Marc Aaron Kastner, Ph.D.
Associate Professor of Physics

Margaret Love Agnes MacVicar, Sc.D.
Associate Professor of Physical Science and Cecil and Ida Green Professor of Education
Director, Undergraduate Research Opportunities Program

June Lorraine Matthews, Ph.D.
Associate Professor of Physics

Ernest Moniz, Ph.D.
Associate Professor of Physics

Philip Cherdak Myers, Ph.D.
Associate Professor of Physics

Stephen Geoffrey Steadman, Ph.D.
Associate Professor of Physics

Toyoichi Tanaka, D.Sc.
Associate Professor of Physics

Scott D. Tremaine, Ph.D.
Associate Professor of Physics

Edward Leonard Wright, Ph.D.
Associate Professor of Physics

Assistant Professors

Thomas Marbory Antonsen, Ph.D.
Assistant Professor of Physics

Ahmet Nihat Berker, Ph.D.
Assistant Professor of Physics

James Gordon Branson, Ph.D.
Assistant Professor of Physics

Richard Jonathan Cohen, Ph.D., M.D.
Assistant Professor of Physics and Hermann von Helmholtz Assistant Professor of Health Sciences and Technology

Roscoe C. Giles, Ph.D.
Assistant Professor of Physics (Absent)

Elizabeth Scott Hafen, Ph.D.
Assistant Professor of Physics

Shimon Levit, Ph.D.
Assistant Professor of Physics (Absent)

Robert Page Redwine, Ph.D.
Assistant Professor of Physics

Margaret Horton Weiler, Ph.D.
Assistant Professor of Physics

John Scott Whitaker, Ph.D.
Assistant Professor of Physics

Lecturer

Frederic John Eppling, Ph.D.
Associate Director, Laboratory for Nuclear Science

Technical Instructors

Angelo DeLara Larraga, B.S.E.E., J.D.

Harold Adolph Lundquist

Jan Orsula

Thomas Joseph White, Jr.

Senior Research Scientists

Roshan Lal Aggarwal, Ph.D.
Associate Director, Francis Bitter National Magnet Laboratory

Joseph Dennis Burger, Ph.D.

Thomas William Donnelly, Ph.D.

Stanley Benedict Kowalski, Ph.D.

Alan Jay Lazarus, Ph.D.

Paul David Luckey, Jr., Ph.D.

Charles Philip Sargent, Ph.D.

Edwin Floriman Taylor, Ph.D.
Director, Educational Video and Video Operations

William Ernest Turchinetz, Ph.D.
Associate Director, Bates Linear Accelerator

Claude Finley Williamson, Ph.D.

Principal Research Scientists

Jeffrey Eugene McClintock, Ph.D.
George Rollins Ricker, Jr., Ph.D.
Kosta Tsipis, Ph.D.
Anna Zytkow, Ph.D.

Research Associate

John Irwin Clark, Ph.D.

Postdoctoral Associates

Aleksander Futro, Ph.D.
Nishio Izumi, D.Sc.
Ahmet Refik Kortan, Ph.D.
Paul S. Linsay, Ph.D.
Stephan Schutzmeister Meyer, Ph.D.
Peter Stohr, Ph.D.
James S. Walker, Ph.D.

Executive Officer

Daniel Henry Gould

Professors Emeriti

William Phelps Allis, Sc.D.
Professor of Physics, Emeritus

Sanborn Conner Brown, Ph.D.
Professor of Physics, Emeritus

William Weber Buechner, Ph.D., Sc.D.
Professor of Physics, Emeritus

Robley Dunglison Evans, Ph.D.
Professor of Physics, Emeritus

Nathaniel Herman Frank, Sc.D.
Professor of Physics, Emeritus

George Graham Harvey, Ph.D.
Professor of Physics, Emeritus

Albert Gordon Hill, Ph.D.
Professor of Physics, Emeritus
Consultant to the President

Milton Stanley Livingston, Ph.D., Sc.D.
Professor of Physics, Emeritus

Philip McCord Morse, Ph.D., Sc.D.
Professor of Physics, Emeritus

Bruno Benedetto Rossi, Ph.D.
Institute Professor, Emeritus
Professor of Physics, Emeritus

Laszlo Tisza, Ph.D.
Professor of Physics, Emeritus

George Edward Valley, Ph.D.
Professor of Physics, Emeritus

Bertram Eugene Warren, Sc.D.
Professor of Physics, Emeritus

Victor Frederick Weisskopf, Ph.D., Sc.D.
Institute Professor, Emeritus
Professor of Physics, Emeritus

Jerrold Reinach Zacharias, Ph.D., L.H.D., Sc.D.
Institute Professor, Emeritus
Professor of Physics, Emeritus

Department of Physics

The programs of study and research in the Department of Physics emphasize fundamental principles but recognize the continually increasing connections of physics with other scientific fields. The Department is organized into the four main areas of research outlined below.

Astrophysics

The Astrophysics Division of the Department has a varied program of observations across the entire electromagnetic spectrum, with principal emphasis in the radio, infrared, and X-ray parts of the spectrum, where modern electronic methods must be used. This work is complemented by theoretical work emphasizing high-energy phenomena, stellar evolution and galactic structure. Astrophysical plasmas are also an important area of study, both through the use of space probes and by complementary theoretical study. Research in astrophysics is a rapidly growing field at MIT, and, because of the strongly interdisciplinary and interdepartmental character of work in this area, a fuller description of it is found in a separate section entitled Astronomy and Astrophysics at the end of this chapter.

Experimental Nuclear and Particle Physics

Research activities in the Division of Nuclei and Particles include the broad fields of nuclear reaction and heavy ion physics, intermediate-energy nuclear structure physics, and high-energy fundamental particle physics. The experimental research in these areas is based on MIT's 400 MeV Bates Linear Accelerator and on the accelerators at Brookhaven National Laboratory, the Fermi National Accelerator Laboratory in Batavia, Illinois, the Stanford Linear Accelerator, CERN (Geneva), and the National Bureau of Standards.

Solid-State, Laser, Plasma, and Atomic Physics

The large and active program in solid-state, laser, plasma, and atomic physics provides students with ample opportunities for study in these fields. Equipment is available for spectroscopic studies at radio, microwave, infrared, and optical frequencies. Currently available are facilities for the production of low temperatures, high pressures, and magnetic fields up to 100,000 gauss and for the study of matter using neutron diffraction techniques. A magnet capable of producing a steady magnetic field of 250,000 gauss is available at the Francis Bitter National Magnet Laboratory. The 5,000 kw MIT Research Reactor is used for neutron diffraction studies, and the extensive facilities of the Information Processing Center and the Laboratory for Computer Science are available for research involving high-speed computation.

Nuclear and Particle Theory

The chief emphasis of the research at the Center for Theoretical Physics is on the understanding of the fundamental particles of nature, as revealed by their interactions and by their decay, and on the characteristic quantum modes of motion of systems composed of strongly interacting particles such as atomic nuclei. Work is also conducted on theoretical astrophysics, as well as on the properties of other forms of matter. In all of this research, close contact is maintained with experimentalists, both within MIT and elsewhere.

The Center for Theoretical Physics houses a fairly large group of theorists including professional staff, postdoctoral fellows, senior visitors, and graduate students engaged in research in theory. Opportunities for communication and collaboration are maximized within the Center; lively interaction among the many specialists in the various areas of interest is unique to this MIT group and is one of the major sources of the Center's strength.

Much of the research in the Department is carried out as part of the work of various interdepartmental laboratories and centers, including the Laboratory for Nuclear Science, the Research Laboratory of Electronics, the Spectroscopy Laboratory, the Center for Materials Science and Engineering, the Center for Space Research, and the Francis Bitter National Magnet Laboratory. These facilities provide close relationships among the research activities of a number of MIT departments and give students opportunities for contact with research carried out in disciplines other than physics.

Undergraduate Study

Bachelor of Science in Physics Course VIII

An undergraduate degree in physics provides a good basis, not only for further work in physics, but also for professional work in such fields as astronomy, biophysics, engineering and applied physics and geophysics. Many students have also found it to be an excellent preparation for subsequent graduate work in professional schools of medicine, law, and management. The undergraduate curriculum in physics offers students the opportunity to acquire basic competence in the fundamentals of both experimental and theoretical physics. The central core of requirements for the Bachelor of Science is designed not only to accomplish this objective but also to allow plenty of scope for students to select from a considerable variety of subjects and to proceed at the pace and degree of specialization best suited to their individual capabilities.

It is suggested that students in the second year take 6.071 Introduction to Electronics or 6.002 Circuits and Electronics in the second term in order to acquire a familiarity with and a knowledge of some topics in electrical engineering. Adequate elective time is made available in the second year, and students may wish to take a mathematics subject beyond 18.03 Differential Equations at this time. During the second year, the prospective physics major should also take a project laboratory (preferably, but not necessarily, the project laboratory administered by the Department) or some departmentally approved substitute.

The departmentally prescribed subjects 8.04 and 8.05 Quantum Mechanics I and II, 8.13 Experimental Atomic Physics I, and 8.14 Experimental Atomic Physics II are normally taken in the third year. This is also an appropriate time for students to take some of the restricted elective subjects. It is usual to begin the theoretical physics sequence with 8.06 Mechanics II in the second term of the third year. Students are urged to explore with faculty advisors possibilities of electing those subjects which are best suited to individual needs at this stage of study.

Bachelor of Science in Physics Course VIII

(Classes of 1982-83)

	General Institute Requirements	Total Units
	Specific science and humanities and social science subjects.	132
	The Science Distribution Requirement can be satisfied by 8.03 and 18.03, which are required in the Departmental Program, plus appropriate subjects totaling[1]	12
	Laboratory Requirement[2]	12
	Departmental Program	
	Required Subjects	**90**
8.03	Physics III	5 0 7
8.04	Quantum Physics I	5 0 7
8.05	Quantum Physics II	5 0 7
8.13	Experimental Atomic Physics I	0 6 9
8.14	Experimental Atomic Physics II	0 6 9
18.03	Differential Equations	4 0 8
	Thesis[3]	12
	Restricted Electives	**48**
	Two subjects given by the Department of Mathematics beyond 18.03	24
	Two subjects given by the Department of Physics in addition to those listed above[4]	24
	Unrestricted Electives[5]	**66**
	Total Units Required for the S.B. Degree	**360**

Bachelor of Science in Physics Course VIII

(Class of 1984)

	General Institute Requirements	Total Units
	Specific science and humanities and social science subjects	132
	The Science Distribution Requirement can be satisfied by 8.03 and 18.03, which are required in the Departmental Program, plus appropriate subjects totaling[1]	12
	Laboratory Requirement[2]	12
	Departmental Program	
	Required Subjects	**102**
8.03	Physics III	5 0 7
8.04	Quantum Physics I	5 0 7
8.05	Quantum Physics II	5 0 7
8.08	Statistical and Quantum Physics	4 0 8
8.13	Experimental Atomic Physics I	0 6 9
8.14	Experimental Atomic Physics II	0 6 9
18.03	Differential Equations	4 0 8
	Thesis[3]	12
	Restricted Electives	**36**
	Two subjects given by the Department of Mathematics beyond 18.03	24
	At least one subject given by the Department of Physics in addition to those listed above[4]	12
	Unrestricted Electives[5]	**66**
	Total Units Required for the S.B. Degree	**360**

1
Students may find it advantageous to elect 6.071 Introduction to Electronics (4-2-6) or 6.002 Circuits and Electronics (4-2-9) in the second term of the second year. This would complete the Science Distribution Requirement.

2
8.11 or 8.12 is suggested. The Institute Laboratory Requirement will not be satisfied by 8.13 or 8.14.

3
A thesis of 12 units is required. Not more than 30 units of thesis credit may be included in the minimum of 360 units required for the S.B. degree.

4
Students should check catalogue descriptions for subjects which cannot be used for this purpose. Students planning to do graduate work in physics would normally take the theoretical sequence 8.06, 8.07 and 8.08.

5
Schedules of students in Course VIII may always be arranged to leave available 12 units of Unrestricted Electives in the second year.

Graduate Study

In the fourth year, the theoretical sequence can be continued with 8.07 Electromagnetism II. Students intending to continue with graduate studies in Physics are encouraged to take both parts of this theoretical physics sequence.

An important component of the physics program is the undergraduate thesis, which is a project carried out under the guidance of a faculty member. Many thesis projects in the recent past have grown out of the Undergraduate Research Opportunities Program. It is advisable that students have some idea of a thesis topic by the middle of their junior year; they are expected to submit a thesis proposal by the end of the junior year. In order to introduce students to the research activities in the department, undergraduate physics colloquia are held weekly at a time so that all physics majors can attend.

A relatively large amount of elective time usually becomes available during the fourth year and can be used effectively in a variety of ways, in physics or on other subjects.

Inquiries

Additional information concerning degree programs, admissions and financial aid may be obtained by writing to the Physics Undergraduate Office, Room 4-352, MIT, Cambridge, Massachusetts 02139, (617) 253-4841.

The Department of Physics offers graduate work leading to the Master of Science in Physics, the Doctor of Philosophy, and the Doctor of Science. No stated curriculum of subjects is required for any of these degrees; rather, individual curricula are chosen in consultation with the Registration Officer in accordance with certain broad principles. Subjects of study include work in almost all of the experimental fields described in the Department's introduction, as well as in the various branches of theoretical physics. Graduate students are expected to gain familiarity with several of the branches of physics, not merely with one specialty. Students will be well prepared for either academic work or industrial research, since the training includes a broad and thorough understanding both of the fundamentals of physics and of some advanced applications.

Students should also note the possibilities of interdisciplinary research, particularly in Astronomy and Astrophysics and in biophysical or biomedical areas (see the Interdepartmental Study and Research chapter for further details).

Entrance Requirements for Graduate Study

Students intending to pursue graduate work in physics should have as a background the equivalent of the requirements for the Bachelor of Science in physics from MIT. However, some deficiencies may be removed in the course of graduate work.

Master of Science in Physics

The requirements for the Master of Science are the General Institute Requirements listed in Chapter IV. The Department has no language requirement for this degree.

Doctor of Philosophy and Doctor of Science

Candidates for the Doctor of Philosophy or the Doctor of Science are expected to take graduate subjects to prepare for the General Examination; however, there are no stated required subjects, and no language requirement.

Teaching and Research Assistantships

A number of research assistantships and teaching assistantships are available each year for graduate students.

Inquiries

Additional detailed information concerning degree programs, research activities, admissions, financial aid, teaching and research assistantships may be obtained by writing to the Physics Graduate Office, Room 6-107, MIT, Cambridge, Massachusetts 02139, (617) 253-4851.

Interdisciplinary Science Program

In addition to the Bachelor of Science programs offered by the Departments of Biology, Chemistry, Earth and Planetary Sciences, Mathematics, and Physics, the Interdisciplinary Science Program (Course XXV) is sponsored by the School of Science. The Program, leading to the Bachelor of Science without designation of field, is intended to provide special opportunities for students interested in science programs which differ significantly from established departmental offerings. For example, students may concentrate in fields such as astronomy, meteorology, oceanography, environmental sciences, neurosciences and behavior, perceptual systems, human cognition and artificial intelligence, medical science, and nutrition and food science. Students arrange their own curricula in consultation with faculty advisors, subject to the approval of a faculty committee. This committee, which includes representatives from Psychology and all departments in the School of Science, also helps students find suitable advisors.

The Interdisciplinary Science curriculum must include a strong and coherent set of science subjects going beyond the level of the Institute Science Distribution Requirement and, specifically, cannot be restricted to a sampling of introductory subjects. It is strongly recommended that 12 units of faculty supervised undergraduate research or thesis be included. In completing General Institute Requirements and the "core" subjects basic to their fields, students in the Interdisciplinary Science Program are expected to make progress which would be normal for a departmental curriculum. It is always possible for second-year students to arrange their course study so that they have 12 units of elective freedom each semester.

Registration procedures for the Interdisciplinary Science Program are like those of regular departmental programs. However, before registering in the program, students must prepare a written plan for satisfying the Restricted Elective requirement of 84 units or more, as required, and if possible find a faculty member willing to serve as advisor. Since the Restricted Electives serve the function of core requirements in regular departments, continued registration is contingent on the approval of this program by the Course XXV committee. Such approval must be obtained before registration day of the senior year. General advice on possible curricula, help in preparing a detailed plan, and names of interested faculty members are available from Ms. Shawnee Wieder, Room 6-219, MIT, Cambridge, Massachusetts 02139, (617) 253-5723. Professor John M. Buchanan, faculty member in charge of the program, serves as registration officer for the purpose of signing forms on registration day and formal approval of course changes. The individual advisors provide contact with a faculty member interested in the student's special field who can help in planning the overall program and suggest modifications in it.

Bachelor of Science
Interdisciplinary Science Program
Course XXV

General Institute Requirements	Total Units
Specific science and humanities and social science subjects	132
Science Distribution Requirement	36
Laboratory Requirement	12
Restricted Electives	
A coherent set of science subjects beyond the introductory level which, together with the remaining portions of the student's program, is aimed at a well-defined educational goal. The Restricted Electives are to be planned by the student with the Faculty Advisor and must be approved by the Interdisciplinary Science Faculty Committee.	84
Unrestricted Electives	**at least 96**
Total Units Required for the S.B. Degree	**360**

Joint Programs in Oceanography with the Woods Hole Oceanographic Institution

MIT and the Woods Hole Oceanographic Institution (WHOI) on Cape Cod offer joint programs of graduate study and research for students with special interests in biological oceanography, chemical oceanography, marine geology, marine geophysics, oceanographic engineering, and physical oceanography. These graduate programs are administered by committees drawn from the faculty and staff of both institutions. Students accepted to the Joint Program have access to the extensive intellectual and physical resources available for advanced study at both Woods Hole and MIT.

The Woods Hole Oceanographic Institution operates three ocean-going research ships, a deep-submergence research vehicle, and several inshore boats. A resident staff of more than 800 scientists, engineers, and support personnel conduct a wide range of ocean-related studies in biology, chemistry, physical oceanography, geology, geophysics, and oceanographic engineering from extensive laboratory facilities at Woods Hole. A marine facility is maintained by MIT in Boston Harbor consisting of dock space and a small research vessel capable of coastal work. Subjects in various aspects of oceanography as well as a large number of subjects directly applicable to ocean science and engineering are offered by many MIT departments and by the WHOI staff. These include:

1.19	Introduction to Technology and Law
1.59J	Materials of Construction
1.62	Free Surface Hydraulics
1.64	Dynamics of Stratified Fluids (A)
1.67	Sediment Transport and Coastal Processes (A)
1.68	Physics of Natural Water Bodies (A)
1.69	Introduction to Coastal Engineering (A)
1.691	Wave Dynamics in Coastal Engineering (A)
1.692	Wave Dynamics in Oceanographic Engineering (A)
1.697J	Oceanographic Systems I
1.698J	Oceanographic Systems II
1.699J	Special Projects in Oceanographic Engineering (A)
1.75	Limnology and Wetland Ecology (A)
1.76	Aquatic Chemistry (A)
1.79	Plankton Ecology (A)
1.80	Fundamentals of Ecology
2.065J	Flow Noise (A)
2.071J	Introduction to Structural Mechanics
2.131	Ecodynamic Systems I
2.132	Ecodynamic Systems II
2.63	Energy Production from Renewable Resources (A)
3.20	Thermodynamics of Materials (A)
3.21	Kinetic Processes in Materials (A)
3.35	Solidification Processing (A)
3.36J	Welding Engineering (A)
3.39	Mechanical Behavior of Materials (A)
3.54	Corrosion—The Environmental Degradation of Materials (A)
3.90J	Fracture of Structural Materials (A)
3.93J	Materials Science of Polymers (A)
6.455J	Marine Data Systems (A)
7.411-7.419	Seminars in Biological Oceanography (A)
7.421	Special Problems in Biological Oceanography (A)
7.43	Phytoplankton Ecology (A)
7.44	Ecology of Oceanic Zooplankton
7.45	Benthos and Fish (A)
7.46	Topics in Physiology and Biochemistry of Marine Animals (A)
7.491	Research in Biological Oceanography (A)
10.803	Introduction to Technology and Law
11.362	Land Use and Environmental Policy Implementation (A)
11.365J	Coastal Zone Management (A)
12.007	Dynamics of the Earth: Plate Tectonics and Continental Drift
12.011	Sedimentary Processes: Rivers
12.102	Plate Tectonics and Marine Geophysics (A)
12.20J	Environmental Chemistry of the Ocean-Atmosphere System
12.21	Physics of the Ocean
12.221-12.229	Project Studies in Oceanography
12.32	Mechanics of Sedimentary Processes (A)
12.56	Advanced Seminar in Plate Tectonics (A)
12.72	Oceanic Volcanology and Petrology (A)
12.73	Introduction to Marine Geology (A)
12.74	Marine Micropaleontology (A)
12.75	Marine Sediments (A)
12.76	Plants, Animals, and Sediments (A)
12.77	Marine Geophysics (A)
12.781	Special Problems in Chemical Oceanography at Woods Hole (A)
12.79	Marine Sediments Laboratory (A)
12.791	Special Problems in Marine Geology and Geophysics at Woods Hole (A)
12.80	Marine Chemistry (A)
12.810J	Wave Motions in the Atmosphere and Oceans (A)
12.822	Paleoceanography (A)
12.83	Marine Geochemistry (A)
12.87	Equatorial Physical Oceanography (A)
13.014	The Oceans
13.021	Marine Hydrodynamics I (A)
13.07	Free Surface Hydrodynamics (A)
13.08	Stability and Motion Control of Ocean Vehicles (A)
13.09	Potential Flows (A)
13.10J	Introduction to Structural Mechanics
13.112J	Analysis and Design of Offshore Structures (A)
13.15	Materials for Ocean Engineering
13.441	Offshore Engineering Design (A)
13.442J	Interdisciplinary Design of Wave-Power Conversion Devices
13.74J	Marine Data Systems (A)
13.76	Introduction to Random Processes in Ocean Engineering (A)
13.84J	Flow Noise (A)
13.85	Fundamentals and Applications of Underwater Sound (A)
13.86	Ocean and Seabed Acoustics (A)
13.87	Wave Propagation in Random Media (A)
13.92	Public Policy and Use of the Sea (A)
13.94J	Ocean Engineering and Law Seminar (A)
13.961J	Resources Management (A)
13.962	Legal Aspects of Ocean Resources and Systems Management (A)
13.97	Introduction to Technology and Law
13.98J	Coastal Zone Management (A)
13.990J	Oceanographic Systems I
13.991J	Oceanographic Systems II
13.994	Buoy Engineering (A)
13.998	Principles of Oceanographic Instrument Systems—Sensors and Measurements (A)
13.999J	Special Projects in Oceanographic Engineering (A)

15.228J	Ocean Engineering and Law Seminar (A)
16.082J	Flow Noise (A)
16.792	Introduction to Technology and Law
17.326	International Organization, Legal and Political Response to Science and Technology (A)
19.05J	Environmental Chemistry of the Ocean-Atmosphere System
19.10	Climate of the Past
19.46	Numerical Modeling in Meteorology and Oceanography (A)
19.65J	Turbulence and Random Processes in Fluid Mechanics (A)
19.681	Synoptic Scale Dynamics in the Atmosphere and Oceans (A)
19.682	Instability and Turbulence in Geophysical Systems (A)
19.69	Fluid Dynamics of the Atmosphere and Ocean (A)
19.70	Oceanic and Atmospheric Models (A)
19.71J	Wave Motions in the Atmosphere and Oceans (A)
19.77	Introduction to Physical Oceanography (A)
19.78	Dynamics of Shelf Circulation (A)
19.79	Numerical Modeling in the Oceanographic Sciences (A)
19.83	Physical Oceanography
19.842	Dynamics of Eddies and Circulation (A)
19.851	Circulation in the Coastal Ocean (A)
19.86	The General Circulation of the Oceans (A)
19.87	Physical Properties of Seawater (A)
19.891-19.899	Special Problems in Oceanography (A)
19.97	Laboratory Course in Geophysical Fluid Dynamics (A)
19.98	Air Sea Interactions (A)
19.99	Experimental Physical Oceanography
20.111	Analytical Practices in Biochemistry (A)
20.611	General Toxicology (A)
20.612	Biochemistry of Xenobiotics (A)
20.811	Biochemical Engineering (A)
20.821	Industrial Microbiology (A)
22.085	Introduction to Technology and Law

Subjects, seminars, and opportunities for research participation are offered at both institutions. Students live in either Cambridge or Woods Hole, and transportation is provided for them to commute the 80 miles between institutions so they can take advantage of all available resources. Students have the opportunity to participate in oceanographic cruises during graduate studies. Depending upon individual study and research programs, students are encouraged to reside for at least one year at each place. Upon admission, students register in the appropriate MIT department and are assigned academic advisors at each institution.

The Joint Program involves several departments at MIT — Biology, Earth and Planetary Sciences, and Meteorology and Physical Oceanography in the School of Science, and Chemical Engineering, Civil Engineering, Electrical Engineering and Computer Science, Materials Science and Engineering, Mechanical Engineering, and Ocean Engineering in the School of Engineering. Details concerning entrance requirements, examinations and financial aid may be found in the descriptions of each individual department.

Chemical Oceanography, Marine Geology, Marine Geophysics and Physical Oceanography

The Department of Earth and Planetary Sciences and the Department of Meteorology and Physical Oceanography offer programs with WHOI in chemical oceanography, marine geology, marine geophysics, and physical oceanography. The programs are coordinated by either department and may involve other departments (such as Chemistry) at MIT. The programs all lead to the Doctor of Philosophy or the Doctor of Science.

Biological Oceanography

Programs in biological oceanography are offered jointly with WHOI and lead to the degree of Doctor of Philosophy or Doctor of Science. The programs are coordinated by the Department of Biology and may involve research at WHOI or other departments at MIT such as Nutrition and Food Science. Program requirements are tailored to individual needs and include preparation in basic areas of biology and marine ecology.

Astronomy and Astrophysics

Teaching and research in astronomy at MIT are truly interdepartmental, involving more than 25 faculty members of the Departments of Physics, Earth and Planetary Sciences, Mathematics, Electrical Engineering and Computer Science, Chemistry, and Meteorology and Physical Oceanography. The subjects offered and the opportunities for thesis research cover a correspondingly broad spectrum.

The observational astronomy program emphasizes the application of modern technology: objects as diverse as quasars, pulsars, supernova ejecta, and the planets are being investigated throughout the spectrum at X-ray, optical, and radio wavelengths. Radio galaxies, the cosmic microwave background, stars in the process of formation, and molecules in space are being studied with radio telescopes, often involving very-long-baseline interferometers; pulsating stars, galactic nuclei, and an unresolved background have all been detected at X-ray wavelengths; the properties of the interplanetary medium are being explored with particle detectors on spacecraft; planets are being viewed with radar, both from the earth and from spacecraft, and by optical telescopes, in both the visible and the infrared.

Some of the theoretical astronomy work relates directly to these observations, as in testing general relativity in the solar system or in trying to understand the complex interactions of the solar wind with our own planet. A major theoretical effort lies in intensive studies of the structure and evolution of stars, the dynamics of spiral galaxies and the solar system, the origin of the solar system, composition and structure of meteorites, origin, evolution, and general circulation of planetary atmospheres, and problems of relativistic astrophysics or high-energy astrophysics as diverse as the origin of cosmic rays, the evolution of supernova events, and the formation of galaxies.

Opportunities for student research include the use of the Haystack radio telescope and the unique electronic instrumentation of the nearby 24-inch and 16-inch optical telescopes at our Wallace Observatory. MIT is a joint participant, with Dartmouth College and the University of Michigan, in operating the 52-inch McGraw-Hill telescope at Kitt Peak in Arizona. Active experimental programs with student participation also involve instruments launched in balloons, rockets, satellites, and interplanetary spacecraft. MIT experiments are operating on an X-ray observatory now in orbit, and students are participating in its operation and in the interpretation of the data. In addition, MIT students and staff observe at other installations such as the National Radio Astronomy Observatory in West Virginia and the National Astronomy and Ionospheric Observatory in Arecibo, Puerto Rico, and they use the telescopes of both the Kitt Peak National Observatory and the Cerro-Tololo Inter-American Observatory in Chile.

The following astronomy subjects are offered by the various departments. The asterisks mark subjects that are offered in 1981-82.

Undergraduate Study

8.282*	Introduction to Astrophysics and Astronomy
8.285*	Topics in Astrophysics
12.002*	The Earth and the Planets
12.111*	Survey of Astronomy I
12.112*	Survey of Astronomy II
12.113*	Astronomy I
12.114*	Astronomy II
12.115J* 8.293J*	Dynamical Astronomy
8.287J* 12.117J*	Observational Techniques of Optical Astronomy
12.121*	Exploration of the Solar System
12.131J* 8.291J*	Planetary Physics and Chemistry I
12.132J* 8.292J*	Planetary Physics and Chemistry II

Graduate Study

12.631	Planetary Atmospheres
12.636*	Current Research in Meteoritics
6.661	Receivers, Antennas and Signals
8.910*	Astrophysics I
8.911*	Astrophysics II
8.913	Cosmic Electrodynamics I
8.914*	Cosmic Electrodynamics II
8.921*	Stellar Structure and Evolution
8.942*	Cosmology
8.962*	General Relativity and Gravitation
8.981*	Selected Topics in Astrophysics
8.982*	Selected Topics in Astrophysics
12.54	Planetary Interiors
6.664J* 8.952J* 12.626J*	Radio Interferometry
6.663J* 12.627J*	Techniques of Radar Astronomy
18.259*	Theoretical and Observational Cosmology
18.375	Stellar Dynamics, Galaxies, and Plasmas
19.64*	Atmospheric Modeling
19.72*	Atmospheric Radiation
19.73	Chemistry and Dynamics of Upper Atmospheres

The Whitaker College of Health Sciences, Technology, and Management and the Harvard-MIT Division of Health Sciences and Technology

In 1977, MIT established the Whitaker College of Health Sciences, Technology, and Management to provide a major academic and administrative focus for the extensive development of health-related activities at the Institute. The educational and research activities of Whitaker College are expected to include new and enlarged programs in human biology, physiology, experimental medicine, and health care policy and management. The MIT components of the Biomedical Sciences (M.D.) Program and the Medical Engineering and Medical Physics (Ph.D.) Program of the Harvard-MIT Division of Health Sciences and Technology are an integral part of Whitaker College.

The College represents a major commitment by MIT to marshal its resources and strengths in science, engineering, and management in order to foster progress in the health and medical sciences and to improve the quality of health care. Since health-related activities in education and research transcend the concerns of any single department or School of the Institute, the term "College" is being used for the first time at MIT.

The program in human biology will include educational and research opportunities for undergraduate and graduate students in human genetics, the biology of human behavior, and environmental biology and toxicology. In the laboratories of human physiology and experimental medicine, research on major human health and medical problems will range from the most fundamental studies to clinical investigation in humans in normal and in disease states.

In health care policy and management, the Whitaker College will seek to enhance and complement the activities in the Sloan School of Management and in the Departments of Economics and Political Science. In addition, a new Ph.D. program is being planned which will combine education in health and medical systems with policy analysis and management. The program will include subjects in health policy analysis, management information systems, health economics, government regulation, the sociology of the health professions, epidemiology, human biology, and the elements of clinical medicine.

The officers of Whitaker College are:

Director: Irving M. London, M.D.
Grover M. Hermann Professor
of Health Sciences and Technology
Professor of Biology
Professor of Medicine
Harvard University and MIT
Director, Harvard-MIT Division
of Health Sciences and Technology

Associate
Directors: Ernest G. Cravalho, Ph.D.
Matsushita Professor of Mechanical
Engineering in Medicine
Associate Director for Medical
Engineering-Medical Physics,
Harvard-MIT Division
of Health Sciences and Technology

Christopher T. Walsh, Ph.D.
Uncas A. and Helen Whitaker
Professor in Whitaker College
Professor of Biology and Chemistry

Planning of the educational and research programs of Whitaker College is being conducted with the help and advice of the faculty committee whose members are:

Kenneth A. Smith, Sc.D. (Chairman)
Joseph R. Mares Professor of
Chemical Engineering
Associate Provost

Gene M. Brown, Ph.D.
Professor of Biochemistry
Head, Department of Biology

Herman Feshbach, Ph.D.
Cecil and Ida Green Professor of
Physics
Head, Department of Physics

Lawrence S. Frishkopf, Ph.D.
Professor of Electrical and Bioengineering
Department of Electrical Engineering
and Computer Science

Ann M. Graybiel, Ph.D.
Professor of Neuroanatomy
Department of Psychology

William H. Orme-Johnson, Ph.D.
Professor of Chemistry
Department of Chemistry

Edward B. Roberts, Ph.D.
David Sarnoff Professor of
Management of Technology
Sloan School of Management

Harvey M. Sapolsky, Ph.D.
Professor of Public Policy and Organization
Department of Political Science

Ascher H. Shapiro, Sc.D.
Institute Professor
Department of Mechanical Engineering

Peter Temin, Ph.D.
Professor of Economics
Department of Economics

James Wei, Sc.D.
Warren K. Lewis Professor of
Chemical Engineering
Head, Department of Chemical
Engineering

Gerald N. Wogan, Ph.D.
Professor of Toxicology
Underwood-Prescott Professor of
Nutrition and Food Science
Head, Department of Nutrition and Food Science

Harvard-MIT Division of Health Sciences and Technology

Professors

Walter H. Abelmann, M.D.
Professor of Medicine
Beth Israel Hospital and
Harvard Medical School

Richard B. Adler, Sc.D.
Professor of Electrical Engineering
MIT Department of Electrical Engineering
and Computer Science

Ronald A. Arky, M.D.
Professor of Medicine
Mount Auburn Hospital and
Harvard Medical School

G. Octo Barnett, M.D.
Professor of Medicine
Massachusetts General Hospital
Harvard Medical School
Lecturer, MIT Department of Electrical Engineering and Computer Science

William S. Beck, M.D.
Professor of Medicine
Harvard Medical School

Baruj Benacerraf, M.D.
George Fabyan Professor of Comparative Pathology
Harvard Medical School

George B. Benedek, Ph.D.
Alfred H. Caspary Professor of Physics
MIT Department of Physics
Lecturer on Physics
Faculty of Medicine,
Harvard Medical School

William Berenberg, M.D.
Professor of Pediatrics
Children's Hospital and
Harvard Medical School

Emilio Bizzi, M.D.
Eugene McDermott Professor in the Brain Sciences and Human Behavior
MIT Department of Psychology

Eugene Braunwald, M.D.
Hersey Professor of the Theory and Practice of Physic
Harvard Medical School

Gordon L. Brownell, Ph.D.
Professor of Nuclear Engineering
MIT Department of Nuclear Engineering
Lecturer on Radiology
Harvard Medical School

Clark K. Colton, Ph.D.
Bayer Professor of Chemical Engineering
MIT Department of Chemical Engineering

Ramzi S. Cotran, M.D.
Frank Burr Mallory Professor of Pathology
Harvard Medical School

Ernest G. Cravalho, Ph.D.
Associate Director, Harvard-MIT Division of Health Sciences and Technology
Associate Director,
Whitaker College
Matsushita Professor of Mechanical Engineering in Medicine
MIT Department of Mechanical Engineering

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Research Associate in Pathology
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Harvard Medical School

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Professor of Immunology
MIT Department of Biology

M. Judah Folkman, M.D.
Julia Dyckman Andrus Professor of Pediatric Surgery
Harvard Medical School

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Paul M. Gallop, Ph.D.
Professor of Biological Chemistry
Harvard School of Dental Medicine

Norman Geschwind, M.D.
James Jackson Putnam Professor of Neurology
Harvard Medical School
Professor of Health Sciences and Technology and Psychology
MIT Department of Psychology

Harvey Goldman, M.D.
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Ann Graybiel, Ph.D.
Professor of Psychology and Brain Science
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Alice S-H. Huang, Ph.D.
Professor of Microbiology and Molecular Genetics
Harvard Medical School

Sidney H. Ingbar, M.D.
William Bosworth Castle Professor of Medicine
Harvard Medical School

Farish A. Jenkins, Jr., Ph.D.
Professor of Biology
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Homayoun Kazemi, M.D.
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Richard J. Kitz, M.D.
Henry Isaiah Dorr Professor of Research and Teaching in Anaesthetics and Anaesthesia
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Richard E. Kronauer, Ph.D.
Gordon McKay Professor of Mechanical Engineering
Harvard University

Samuel A. Latt, M.D., Ph.D.
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Harvard Medical School

Alexander Leaf, M.D.
Jackson Professor of Clinical Medicine
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Director, Whitaker College
Professor of Medicine at Harvard University and MIT
Grover M. Hermann Professor of Biology
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Boris Magasanik, Ph.D.
Jacques Monod Professor of Microbiology
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Robert W. Mann, Sc.D.
Uncas A. Whitaker Professor of Biomedical Engineering
MIT Department of Mechanical Engineering

Thomas A. McMahon, Ph.D.
Gordon McKay Professor of Applied Mechanics
Harvard University

Borivoje B. Mikić, Sc.D.
Professor of Mechanical Engineering
MIT Department of Mechanical Engineering

Frederic R. Morgenthaler, Ph.D.
Professor of Electrical Engineering
MIT Department of Electrical Engineering and Computer Science

Walle J. H. Nauta, M.D., Ph.D.
Professor of Neuroanatomy
Institute Professor
MIT Department of Psychology

Sanford Palay, M.D.
Bullard Professor of Neuroanatomy
Harvard Medical School

William T. Peake, Sc.D.
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MIT Department of Electrical Engineering and Computer Science

Robert M. Rose, Sc.D.
Professor of Materials Science and Engineering
MIT Department of Materials Science and Engineering

Phillip A. Sharp, Ph.D.
Professor, Center for Cancer Research and MIT Department of Biology

William M. Siebert, Sc.D.
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John B. and Buckminster Brown Professor of Orthopedic Surgery
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(Visiting)

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Lecturer, MIT Department of Electrical Engineering and Computer Science

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Harvard Medical School

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Harvard University
Visiting Assistant Professor of Health Sciences and Technology
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Senior Lecturer

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Lecturer on Medicine
Harvard Medical School
Officer of Instruction
Harvard-MIT Division

Lecturers

Sissela Bok, Ph.D.
Lecturer on Medical Ethics
Department of Social Medicine and Health Policy
Harvard Medical School

James C. Weaver, Ph.D.
Lecturer and Officer of Instruction
Harvard-MIT Division

Senior Research Associate

Philip A. Drinker, Ph.D.
Senior Research Associate in Surgery (Bioengineering)
Harvard Medical School
Senior Lecturer, MIT Department of Mechanical Engineering
Officer of Instruction
Harvard-MIT Division

Principal Research Associates

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Harvard Medical School
Lecturer, MIT Department of Electrical Engineering and Computer Science
Officer of Instruction
Harvard-MIT Division

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Officer of Instruction
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Robert E. Zimmerman, M.S.E.E.
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Tutor in Medical Sciences
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Harvard Medical School

James H. Philip, M.D.
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Harvard Medical School

Mark Phillippe, M.D.
Instructor
Harvard Medical School

Edwin D. Trautman, Ph.D.
Instructor
Harvard Medical School

Postdoctoral Associates

Jane-Jane Chen, Ph.D.
Harvard-MIT Division

Robert Matts, Ph.D.
Harvard-MIT Division

Raymond A. Petryshyn, Ph.D.

The Harvard-MIT Division of Health Sciences and Technology M.D., Ph.D., Sc.D.

Harvard University and MIT are engaged in a major collaborative effort, the Harvard-MIT Division of Health Sciences and Technology, designed to focus science and technology on human health needs. In this Division, the complementary resources and strengths of both institutions are being directed to the education of physicians with a strong base in quantitative science, biomedical engineers, and other health scientists, and to the effective application of modern science and technology to major health problems. The Division represents a fusion of the growing interests of the faculties, students, and Corporations of both MIT and Harvard in the development of new patterns of education and research in health and medicine and in the more effective utilization of science and engineering in meeting important health needs.

The Division's activities cover the three broad areas of education, research, and development. The curricula are designed to achieve progressive penetration of the physical sciences and engineering into biology and medicine and to develop an informed social and behavioral analysis of the human goals and costs and the meaning of health activities. The Division is an evolving one in which both faculty and students help shape the direction and content of curricula.

Subjects are presented in a pattern that conforms to the term schedules of MIT and Harvard University insofar as possible so that students can take advantage of the regular offerings at each institution and continue further study in areas of special interest. The subjects in human biology are available to qualified graduate and undergraduate students who may be interested in particular aspects of the biomedical sciences curriculum.

Students may select a program of study in biomedical sciences leading to the M.D. degree or in Medical Engineering and Medical Physics leading to the Ph.D. degree.

The educational program in **Biomedical Sciences** is oriented toward students with a strong interest and background in quantitative science, especially in the biological, physical, engineering, and chemical sciences. The subjects in human biology developed for this curriculum represent the joint efforts of life scientists and physicians, physical scientists and engineers, selected from the faculties of both universities. The subjects are presented at Harvard Medical School or at MIT.

The programs of study are formulated to meet the interests and needs of the individual student. The student is encouraged to pursue advanced study in areas of interest that may complement the courses offered in the Division. Such study may be undertaken as part of the curriculum leading to the M.D. degree or may be pursued in a combined M.D.-master's degree or M.D.-Ph.D. program. Students in the Program join the students of the regular Harvard Medical School curriculum in the clinical clerkships. Division students are expected to choose a field of concentration in which they spend approximately one half of their elective time. Faculty tutors provide guidance in the choice of subjects and in the pursuit of independent study. Prior to graduation, Division students are expected to present evidence of scholarly work in the form of a thesis based on laboratory research, clinical investigation, critical analysis of a significant medical problem, or other activities approved by the faculty tutors.

The programs of study are designed to develop physicians with a strong quantitative science base, e.g., a cardiologist with knowledge of fluid mechanics and electrophysiology; an internist with experience in molecular biology and biochemistry and qualified to study and treat metabolic disorders; a neurologist well versed in circuit theory or the physics of communications science; an orthopedic surgeon with extensive knowledge of mechanical engineering; a physician-administrator with extensive knowledge of the planning and management of health services.

Twenty-five students are admitted each year as candidates for the M.D. degree at Harvard Medical School. Qualified undergraduates at Harvard, Radcliffe, and MIT are eligible to apply to the Division in the junior or senior year. Juniors who apply and are not admitted into the Harvard-MIT Division are eligible to apply the following year to Harvard Medical School for the Harvard-MIT program or the regular Harvard Medical School curriculum or both without prejudice to their candidacy. Early admission permits them to begin studies in the medical curriculum while still engaged in undergraduate studies. For these students, it is not essential that all requirements for admission to Harvard Medical School be completed prior to enrollment in the Division; undergraduates are required, however, to satisfy those requirements as part of their curriculum in the preclinical years of the program. Such applicants are urged to take the Medical College Admission Test in April or October of the year in which they apply. Their scores on the Test are considered with those of other junior applicants. Students who gain early admission are registered simultaneously as candidates for the M.D. degree at Harvard Medical School and as candidates for a baccalaureate degree. Interested applicants may obtain application forms from the Office of Admission, Harvard Medical School, 25 Shattuck Street, Boston, MA 02115. *Applications must be submitted by October 15 of the year prior to desired matriculation.*

Further information about the Division may be obtained from the office of the Director of the Division, Room 16-512 at MIT, (617) 253-4305.

Doctor of Science or Doctor of Philosophy in Medical Engineering or Medical Physics

The curriculum in **Medical Engineering and Medical Physics** is intended to educate individuals who will be well qualified, as engineers and/or physicists with extensive knowledge of human biology and medicine, to engage in clinical investigation on important problems in medicine. These individuals will serve to develop the profession of medical engineering and medical physics, a profession focused on the application of science and technology to clinical medicine and the provision of health services.

There are four major components to the curriculum: 1) an S.M. degree program in engineering or physics; 2) advanced subjects in human biology and medical engineering developed specifically for this program; 3) a clinical year in which students participate in both patient care activities and clinical research activities under the supervision of engineer/physicist-physician teams; and 4) doctoral thesis research on a fundamental and clinically important problem in medical engineering or medical physics.

Medical Engineering/Medical Physics Curriculum

	Departmental Requirements	Total Units
	Specific subjects in engineering or physics to satisfy departmental requirements for the S.M. degree	66
	S.M. Thesis	24
	Program Requirements	**146**
HST 010	Functional Anatomy of Man	2 9 10
HST 030	Human Pathology	4 4 8
HST 060	Endocrinology	6 0 6
HST 090	Cardiovascular Pathophysiology	3 3 9
HST 100	Respiratory Pathophysiology	1 2 5
HST 110	Renal Pathophysiology	2 1 5
HST 130J	The Human Nervous System	6 3 6
HST 580J	Medical Engineering Measurements	3 0 9
HST 581J	Medical Engineering Measurements Laboratory	0 4 2
HST 590	Biomedical Engineering Seminar	1 0 0
	Four clinical experiences, one of which must be in the field of Medicine	
	Doctoral Thesis	

Summary of Graduate Degree Opportunities in Biomedical Engineering at MIT

Students and faculty in many departments at MIT are conducting research in biomedical engineering. These research interests, spanning the life sciences, physics, and engineering, have led to the development of new programs of graduate study for students wishing to pursue careers in these rapidly evolving fields. Each of these programs, although strongly interdepartmental in nature, has evolved out of the interests and professional specialties of the participating faculty. Many are based primarily in the academic departments of the School of Engineering and, therefore, are available to students as regular departmental activities. Virtually all of the engineering studies are in collaboration with life scientists, many of whom are members of medical faculties and affiliated with teaching hospitals in the Boston area.

There are presently four graduate programs in biomedical engineering available to graduate students at MIT. These are:

1
Departmental programs in the School of Engineering

2
MIT Interdepartmental Doctoral Program in Biomedical Engineering

3
Harvard-MIT Division of Health Sciences and Technology Doctoral Program in Medical Engineering and Medical Physics

4
Combined M.D.-Ph.D. programs in the Harvard-MIT Division of Health Sciences and Technology

Specific details for each of these graduate programs are given in *A Guide to Biomedical Engineering and Physics at Massachusetts Institute of Technology and Harvard University*. This booklet, prepared by the Harvard-MIT Division of Health Sciences and Technology Committee on Medical Engineering and Physics, may be obtained from the Committee office, Room 16-512, MIT, Cambridge, Massachusetts 02139. The choice among the first three of these programs which have certain commonalities and notable differences, depends on the desired breadth of exposure to the medical and life sciences and the career goals of the student, particularly with respect to the clinical aspects of biomedical engineering.

A student who is primarily attracted by a basic engineering discipline which is applicable to biological problems and who intends to pursue a professional engineering career which may lie outside the field of biomedical engineering is advised to apply for the departmental program. A background in mathematics and the physical sciences is a necessary prerequisite for graduate study in the School of Engineering departmental biomedical engineering programs; preparation in the biological sciences, though desirable, is not required.

A student who wishes a broader exposure to the life sciences as preparation for a career in the application of engineering and physics to a wide range of living systems is advised to apply for the Interdepartmental Doctoral Program in Biomedical Engineering, administered by the MIT Committee on Biomedical Engineering. Graduate students from any department who possess an engineering Master's degree may apply for admission. Students should normally apply for admission to the MIT engineering department most closely related to the field of their undergraduate major, and should contact the MIT Committee on Biomedical Engineering office in Room 37-219, MIT, Cambridge, Massachusetts 02139.

A student who wishes intensive exposure to the medical sciences as preparation for a career of research on important clinical problems is advised to apply for the HST Doctoral Program in Medical Engineering and Medical Physics.

The biomedical sciences curriculum of the Harvard-MIT Division of Health Sciences and Technology leads to the M.D. degree at Harvard Medical School and may be combined with studies leading to the S.M. or the Ph.D. in one of the MIT departments. Students interested in such combined degree programs must apply independently to the department of interest and to Harvard Medical School.

Center for Health Effects of Fossil Fuels Utilization

The Harvard-MIT Division of HST and MIT's Energy Laboratory have established a Center for Health Effects of Fossil Fuels Utilization and associated research programs. The Center and the research programs are funded by grants from the National Institute of Environmental Health Sciences and from other government and private agencies. The Center provides support for a comprehensive program of interdisciplinary research, involving a core of senior scientific staff and a number of postdoctoral, graduate, and undergraduate students. Participants include members from the MIT Departments of Nutrition and Food Science, Chemical Engineering, Mechanical Engineering, Biology, Chemistry, Materials Science and Engineering, Aeronautics and Astronautics, and the Harvard Medical School.

Areas of research include efforts to determine the extents and mechanisms of formation of combustion-generated emissions products; to evaluate these species for mutagenic and/or carcinogenic potential; to evaluate respiratory effects of inorganic combustion-generated particulates; and to develop combustion control methods to mitigate any hazards identified. The Center also supports feasibility projects in new research areas such as the health effects of diesel exhaust, the use of bacterial virus to explore the toxicology of compounds in combustion-generated soots, the development of a lung perfusion model for toxicologic studies, toxicity and carcinogenicity of fuel combustion products, *in vivo* release of polynuclear hydrocarbons from soot in mammal respiratory systems, and relating emissions to mutagens in ambient aerosols.

The Center also cooperates closely with other MIT and Harvard University investigators who are conducting research in areas related to health effects of fossil fuels utilization. Current research results and new developments in the field are presented through a program of seminars. An annual report discussing Center research projects is available upon request.

The Director of the Center is Dr. Gerald N. Wogan, Professor of Toxicology and Head of the Department of Nutrition and Food Science; the Associate Director is Dr. Jean F. Louis, Professor of Aeronautics and Astronautics and Associate Director of the MIT Energy Laboratory; the Executive Officer is Dr. Irving A. Berstein, Assistant Director for Research Program Development, Harvard-MIT Division of Health Sciences and Technology. Further information may be obtained by contacting Dr. Berstein, Room 26-165, MIT, Cambridge, Massachusetts 02139, (617) 253-8800.

ROTC Programs

Air Force ROTC Program

Joel S. Hetland, M.S.
Colonel, US Air Force
Visiting Professor of Aerospace Studies
Director, Office of Aerospace Studies

Stephen L. Wallace, M.S.
Major, US Air Force
Technical Instructor

Frederick K. Arzt, M.S.
Captain, US Air Force
Technical Instructor

L. Gail McCoy, M.S.
Captain, US Air Force
Technical Instructor

Thomas M. Jones
Technical Sergeant, US Air Force
Technical Instructor

John F. MacPherson
Technical Sergeant, US Air Force
Technical Instructor

Rachel I. Calcari
Staff Sergeant, US Air Force
Technical Instructor

Sylvester E. Dublin
Staff Sergeant, US Air Force
Technical Instructor

The Air Force ROTC program is designed to prepare students for commissions in the United States Air Force upon successful completion of an MIT Course. The Office of Aerospace Studies offers two programs — one of four years and one of two years — for MIT students to qualify for commissions.

The Four-Year Program

The four-year program consists of classroom and Leadership Laboratory work during the four undergraduate years and one summer training period of four weeks between the sophomore and junior years at a United States Air Force Base. It is possible for students with three academic years remaining to enroll in the four-year program by combining the first two years.

While in Air Force ROTC, students are furnished uniforms and equipment required for the program. Undergraduate students enrolled in the four-year program are offered an opportunity to compete, on a nationwide basis, in the college scholarship program. These scholarships provide full coverage for tuition, required books, and required Institute fees plus $100 monthly for subsistence. At MIT, the four-year Air Force ROTC Scholarship is worth approximately $35,000. Scholarships are also available for 3½, 3, 2½, and 2 years. Non-scholarship students in the final two years of the program also receive the $100 per month subsistence allowance.

Unless the student accepts a scholarship, there is no obligation to the Government for the first two years of the four-year program. At the beginning of the junior year all students who have not already done so are required to sign a formal agreement that they will complete the last two years of Air Force ROTC and accept a commission as a Second Lieutenant in the United States Air Force when granted a degree from MIT. The term of active duty commitment after commissioning varies depending upon the professional area chosen. For those entering research and development, engineering, or any other non-flying field, the term of service is four years. For pilots, the required term of service is six years after completion of flight training; for navigators it is five years.

Students wishing to pursue an advanced degree may apply for delayed entry to active duty.

The Two-Year Program

The two-year program is for those students who do not complete the first two years of the four-year Air Force ROTC program. Such students may apply as undergraduates (during their sophomore or subsequent years) or graduates if they have a minimum of two years remaining in their academic program at MIT. In lieu of completing the freshman and sophomore years of the four-year program, these students receive six weeks of field training at an Air Force base during the summer preceding their entry into Air Force ROTC at MIT. They receive the same benefits and complete the same academic program required of the upperclass four-year students. Students applying for the two-year program may also compete for scholarships.

Eligibility Requirements

To be eligible to compete for a commission through the Air Force ROTC program at MIT students must be: 1) citizens of the United States by the time they sign a formal agreement with the Government; 2) physically qualified in accordance with existing Air Force regulations; 3) enrolled at MIT as a full-time student or enrolled at a neighboring university, such as Harvard University or Wellesley College, where a consortium or cross-town agreement allows cross-enrollment into AFROTC at MIT.

Application Procedure

Eligible freshmen can sign up for the AFROTC Program by simply electing AFROTC subjects (AS11 and AS111) when they arrive on campus; however, it is advisable that interested students contact the AFROTC office as soon as they have

Army ROTC Program

been notified of admission to the Institute. Other interested students can make application by a personal visit to the Office of Aerospace Studies, 20E-111, MIT, Cambridge, Massachusetts 02139, or by calling (617) 253-3755.

Program of Instruction

The program of instruction is listed below. In addition to this Air Force curriculum the student will take desideratum subjects prior to graduation from an approved list of MIT elective subjects.

	First Year
AS11	The Air Force Today (1-0-1) (no MIT credit)
AS111	Leadership Laboratory (0-1-0) (no MIT credit)
AS12	The Air Force Today (1-0-1) (no MIT credit)
AS121	Leadership Laboratory (0-1-0) (no MIT credit)

	Second Year
AS21	The Development of Air Power (1-0-1) (no MIT credit)
AS211	Leadership Laboratory (0-1-0) (no MIT credit)
AS22	The Development of Air Power (1-0-1) (no MIT credit)
AS221	Leadership Laboratory (0-1-0) (no MIT credit)

	Third Year
AS31	Management and Leadership (3-0-3) (no MIT credit)
AS311	Leadership Laboratory (0-1-0) (no MIT credit)
AS32	Management and Leadership (3-0-3) (no MIT credit)
AS321	Leadership Laboratory (0-1-0) (no MIT credit)

	Fourth Year
AS41	The Military in American Society (3-0-3) (no MIT credit)
AS411	Leadership Laboratory (0-1-0) (no MIT credit)
AS42	US National Security (3-0-3) (no MIT credit)
AS421	Leadership Laboratory (0-1-0) (no MIT credit)

George S. Smith, Jr., M.S., M.B.A.
Lieutenant Colonel,
Corps of Engineers
Visiting Professor of Military Science
Director, Office of Military Science

William P. Roe, B.S.
Major, Corps of Engineers
Technical Instructor

Thomas D. Bortner, M.B.A.
Captain, Ordnance
Technical Instructor

Daniel L. Johnson, B.A.
Captain, Air Defense Artillery
Technical Instructor

Richard C. Oertel, B.S.
Captain, Field Artillery
Technical Instructor

Gary A. Ross, A.A.S.
Sergeant First Class, US Army
Technical Instructor

Paul Scheideberg, B.A.
Staff Sergeant, US Army
Technical Instructor

Cezar T. Mendoza, B.S.
Staff Sergeant, US Army
Technical Instructor

Patrick F. McDonough
Staff Sergeant, US Army
Technical Instructor

Army ROTC Program

All students at MIT and Wellesley College are eligible to enroll in the Army ROTC Program, the completion of which leads to a commission as a Second Lieutenant in the Regular Army, Army Reserve, or Army National Guard. Freshmen and sophomores should enroll in the standard four-year program, while graduate students and selected undergraduates with two or more academic years remaining may apply for the Army ROTC two-year program. Successful completion of both academic requirements and summer training requisites qualifies the student for commission upon graduation.

The academic portion of the ROTC program consists of one military science subject and one related elective subject offered by another MIT or Wellesley teaching department per year, plus a one-hour leadership development subject in each term. Although the normal pattern is for the student to progress through the Military Science programs sequentially, individual students may, on a case-by-case basis, be granted credit for part or all of the basic program for appropriate academic or military work experience. Selected subjects are also offered during the Summer Session. Elective subjects accepted for the ROTC program are derived primarily from the humanities, political science, management, and psychology areas, and are intended to instill in the potential officer a balanced appreciation of the development and dynamics of military and social institutions and their interrelationship with society, as well as an understanding of the interactions and management of individuals in groups. The purpose of this integrated approach to ROTC is to develop officers skilled not only in the pragmatics of military science, but in the related human and social institutions as well. The selection of approved elective subjects is by no means rigid, and any relevant subjects may be selected on the student's initiative and approved by his or her ROTC faculty advisor.

Students completing the ROTC program will receive their commissions upon graduation and go on to serve a specified period of active duty ranging from three months to four years, depending upon the student's choice of commissioning program, scholarship status, and the needs of the service. Commissions are offered in all of the Army's functional branches with actual branch assignment determined by the needs of the Army, the desires of the student, and his or her academic background and experience. Commissions may be awarded in any of the following branches: Infantry, Armor, Field Artillery, Air Defense Artillery, Chemical Corps, Signal Corps, Corps of Engineers, Military Intelligence, Transportation Corps, Quartermaster Corps, Finance Corps, Adjutant General's Corps, Ordnance Corps, and the Military Police Corps.

Commissions are also available in the Medical Service Corps and the allied health professions.

Enrollment in the first two years of the four-year program, called the Basic Course, is entirely voluntary and does not obligate the student to any type of active duty or reserve commitment. Those students desiring to continue in the program beyond the sophomore year must apply for and be selected to the advanced Course, which comprises the junior and senior years. It is only at this point that the student incurs an active duty obligation.

Summer training requirements for students in the four-year program are limited to the six-week ROTC Advanced Camp which normally is completed between the junior and senior years. Students at the Advanced Camp are paid at the rate of half the pay of a Second Lieutenant, plus mileage to and from the camp location. All students in the final two years of the program receive a stipend of $100 per month.

One-, two-, three-, and four-year scholarships are available each year, and are awarded on the basis of a national competition. In general, the scholarships cover the cost of tuition, books, laboratory fees, and related expenses, plus a stipend of $100 per month. Full details on the scholarship program may be obtained by contacting the Director of Military Science.

In addition to the requirements outlined above, Army airborne and ranger training programs are also available to interested students on an optional, voluntary basis. Full details on these programs are also available from the Director of Military Science.

Eligibility Requirements

There are no formal eligibility requirements for entry into the Basic Course of the four-year program except that the student must be able to qualify for commission before reaching his or her 28th birthday. Non-citizens may enroll in and complete the program, but must become US citizens in order to receive a commission.

Qualified applicants for the two-year program must successfully pass an aptitude test and an Army physical examination. Two-year applicants must also be able to qualify for commission before reaching their 28th birthday.

Application Procedures

Application for the four-year program is effected by enrollment in MS 11 and MS 111. Students enroll in these courses during the regular registration period at MIT. The student should contact the Office of Military Science if additional information is desired.

Students interested in the two-year program should apply through the Military Science Office. Further details may be obtained from the Office of Military Science, 20E-126, MIT, Cambridge, Massachusetts 02139.

Naval ROTC Program

Program of Instruction

One Institute elective subject is required for each year in addition to the following:

	First Year
MS11	Civil-Military Relations (2-0-1) (no MIT credit)
MS111	Introduction to ROTC and the Army (0-1-0) (no MIT credit)
MS121	Land Navigation (0-1-0) (no MIT credit)

	Second Year
MS21	Leadership and Ethics (2-0-1) (no MIT credit)
MS211	Instructional Methodology (0-1-0) (no MIT credit)
MS221	Branches of the Army (0-1-0) (no MIT credit)

	Third Year
MS31	Military Management (2-0-1) (no MIT credit)
MS311	Small Unit Tactics I (0-1-0) (no MIT credit)
MS321	Small Unit Tactics II (0-1-0) (no MIT credit)

	Fourth Year
MS41	Miiitary Law and Administration (2-0-1) (no MIT credit)
MS411	Advanced Leadership Practicum I (0-1-0) (no MIT credit)
MS421	Advanced Leadership Practicum II (0-1-0) (no MIT credit)

David V. Burke, Jr., Ph.D.
Captain, US Navy
Visiting Professor of Naval Science
Director, Office of Naval Science
Professor of Naval Architecture

Michael J. Wojdyla, M.S.
Commander, US Navy
Executive Officer, NROTC

Guy Durant
Captain, US Marine Corps
Technical Instructor

Thomas Q. Bakke
Lieutenant, US Navy
Technical Instructor

Thomas S. Charis
Lieutenant, US Navy
Technical Instructor

John Garretta
Lieutenant, US Navy
Technical Instructor

Frank L. Mellow
Senior Chief, US Navy
Technical Instructor

Philip A. Zeman
Chief Yeoman, US Navy
Technical Instructor

Arthur R. Little
Chief Quartermaster, US Navy
Technical Instructor

The purpose of the Naval ROTC program is to provide instruction and training in essential Naval Science subjects, which when coupled with the prescribed MIT engineering or science curricula, qualify selected students for commissions in one of the many specialties in the Navy.

The MIT Navy unit is one of the nationwide Naval ROTC programs which offers the opportunity for its graduates to request commissioning as "engineering duty" officers who may serve their active duty aboard ship, in naval shipyards, or in other technical assignments. This option is in addition to other officer programs, such as Navy Nuclear Propulsion training, submarine or flight training, the Civil Engineers Corps, or the Marine Corps.

The Naval ROTC unit at MIT offers two officer development programs. The Scholarship Program provides full tuition, certain fees, use of books and uniforms, and $100 per month for two, three, or four years. All scholarship students incur a four-year active duty obligation.

The College Program consists of both four-year and the two-year programs. These students receive Naval Science books and all uniforms in addition to $100 per month during the last two academic years. Students in this program must complete one summer cruise after their junior year and incur a three-year active duty obligation.

NROTC Navy-Marine Corps College Program students may apply for the NROTC Three-Year Scholarship Program during their freshman year of a four-year curriculum (or second year of a five-year curriculum). If selected as scholarship students through the annual competitive selection procedures, they receive scholarship benefits for the last three years of college. College Program students may also gain scholarship status by competing for one of the Chief of Naval Education and Training scholarships, normally offered semi-annually, by obtaining a Professor of Naval Science nomination.

Two-year Scholarship and College Program students attend the six-week Naval

Science Institute at Newport, Rhode Island prior to beginning the junior year. This is to bring their training up to the point of the four-year students before entering the advanced course. All students receive travel costs to and from their homes in connection with the summer cruises, as well as the current active duty pay rate during the cruises.

Upon completion of the program and receipt of a Bachelor of Science from MIT, the student is commissioned as an Ensign, US Navy or 2nd Lieutenant, USMC, in the case of Scholarship Program students, and as Ensign, US Naval Reserve or 2nd Lieutenant, USMC Reserve in the case of College Program students. All newly commissioned officers report directly to active duty. Upon completion of the active duty period, the officer may be released to inactive duty, but must retain the commission for a total of six years from the date of its original acceptance.

Eligibility Requirements

To be eligible for the four-year Naval ROTC program, an entering student must be: 1) a citizen of the United States; 2) at least 17 years of age and not more than 25 years of age by June 30 of the year of your college graduation; 3) physically qualified, and that total visual acuity must meet the current standards, correctable to 20-20 by the use of lenses.

Cross-Enrollment

Harvard, Wellesley College, and Boston University students are eligible for both the Scholarship and College Programs.

Application Procedure

Further inquiries regarding the MIT program should be addressed to the Commanding Officer, NROTC and Naval Administrative Unit, 20E-125, MIT, Cambridge, Massachusetts 02139, or any local US Navy Recruiting Station.

Program of Instruction

The NROTC program of instruction encompasses not only the science of nautical matters but also international affairs, national security policy, and principles of management — all vital to the art of being a naval officer. The program has three interacting and equally important aspects. The first aspect consists of the professional academic subjects taught by the Office of Naval Science. The second aspect consists of the academic subjects taught by the Institute. These subjects comprise those outlined, as well as one year of calculus and physics. The third aspect consists of the professional training gained from leadership laboratories (one hour a week throughout the year), from tours conducted to local naval facilities, from short cruises aboard naval vessels, and from practical navigation and piloting practice conducted aboard training craft at Newport, Rhode Island.

Students entering their sophomore year, who are eligible for the four-year College Program, can complete the requirements for commissioning in three years. This is accomplished by beginning with the second-year Naval Science curriculum and making up the two missed Naval Science subjects.

While completing degree requirement in one of the MIT Courses, all students in the Naval ROTC program, must take the following subjects prior to graduation.

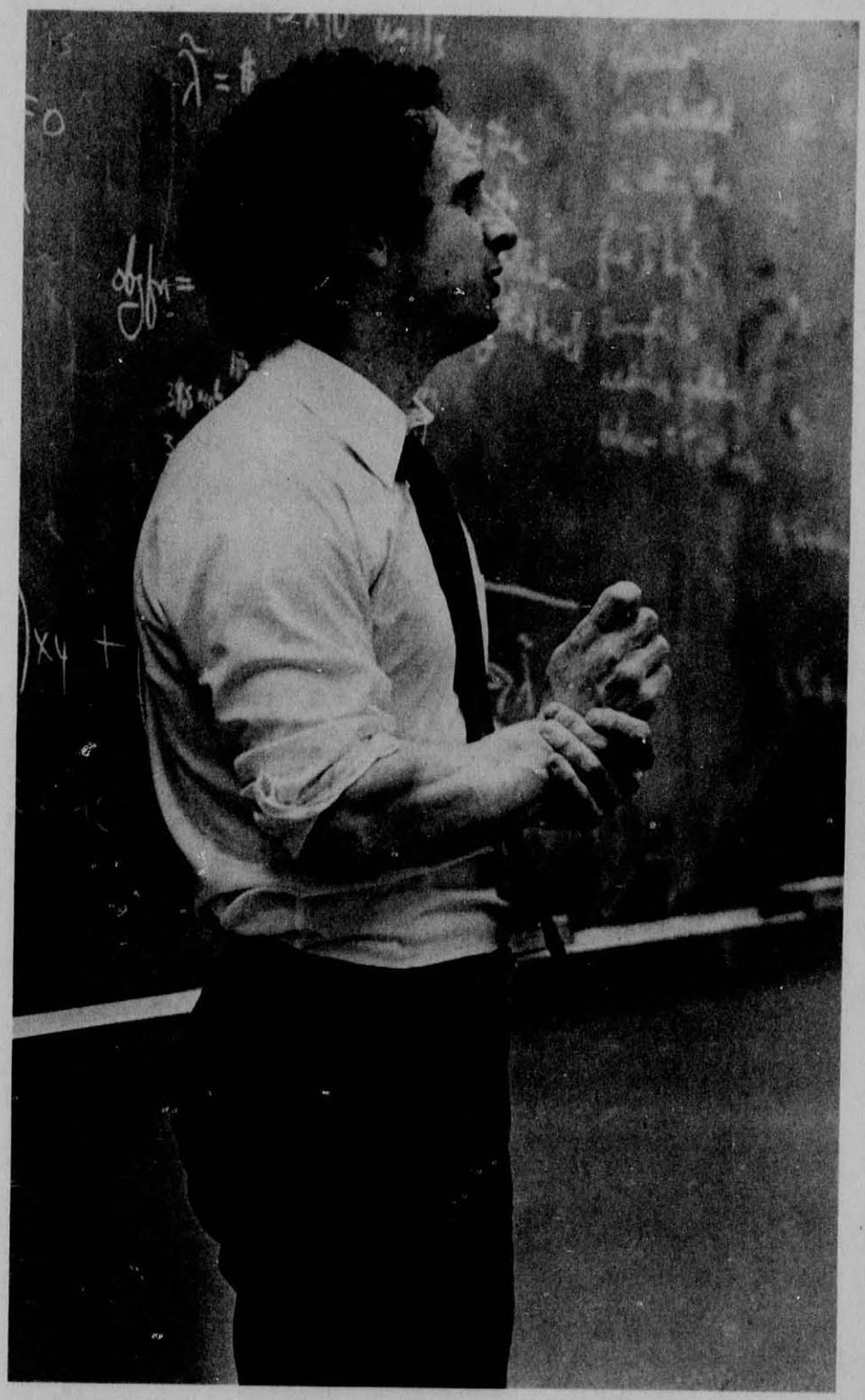
	First Year
NS11	Introduction to Naval Science (2-0-1) (no MIT credit)
NS12*	Naval Ships Systems I (3-0-3) (no MIT credit)
13.013J NS51J	Water, Air and Interface Vehicles (3-0-9) (Optional, except for Engineering Duty candidates)

	Second Year
NS21*	Naval Ships Systems II (2-2-2) (no MIT credit)
NS22	Seapower and Maritime Affairs (2-0-2) (no MIT credit)
	A staff-specified MIT subject on Military History/ International Relations

	Third Year
NS31	Navigation and Naval Operations I (3-0-3) (no MIT credit)
NS32*	Navigation and Naval Operations II (2-2-4) (no MIT credit)
NS33	Modern Warfare (2-0-2) (Marine option only, in lieu of NS31 and NS32) (no MIT credit)
NS34	Marine Corps Doctrine and Tactics (2-0-2) (Marine Option only, in lieu of NS32) (no MIT credit)
	A staff-specified MIT subject on Defense Policy Formulation

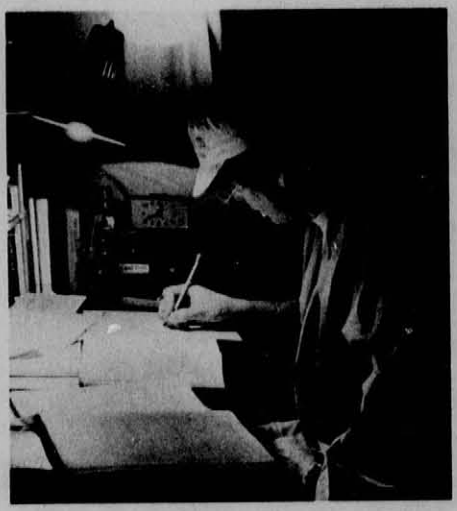
	Fourth Year
NS41	Leadership and Management I (2-0-2) (no MIT credit)
NS42	Leadership and Management II (2-0-2) (no MIT credit)
NS43	Amphibious Warfare (2-0-2) (Marine option only, in lieu of NS42) (no MIT credit)

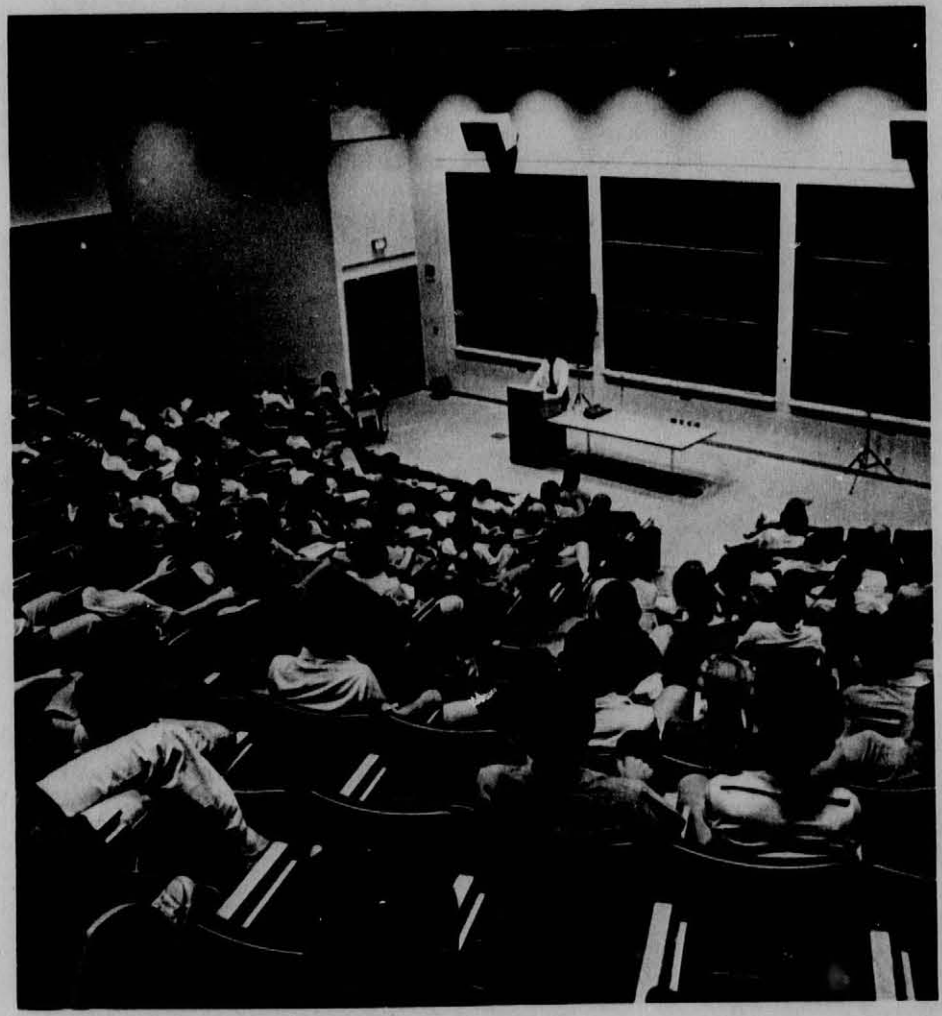
*These are normally given in conjunction with MIT accredited seminars.



Descriptions of Subjects







Explanatory Notes

The subject descriptions given in this chapter are subject to change. The final list of subjects to be given in 1981-82 will be published with the class schedules booklet prior to the beginning of each term.

The information given below the **number and name of the subject** is as follows:

The number(s) of **prerequisite subjects,** if any. Numbers in italics indicate subjects which may be taken simultaneously with the subject described. Prerequisites may be waived by the instructor in charge for particularly well-qualified students.

The **year classification (and term)** in which the subject is normally scheduled. "U" is an undergraduate subject; "G" is a subject given primarily for graduate students.

SD or LAB or HUM-D following the term indicates that the subject is on the approved list for Science Distribution, Laboratory, or Humanities Distribution credit.

The **time distribution of the subject,** showing in sequence the units allotted to: recitation and lecture; laboratory, design, or field work; and preparation. Each unit represents 14 hours of work. The total unit credit for a subject is obtained by adding together all the units shown. One unit of lecture or recitation credit is equivalent to one semester hour. "Arr." indicates that time units are specially arranged.

The **name of the instructor(s)** in charge, when known at press time.

(New) below the subject number and title indicates a new offering.

(Revised Unit) or **(Revised Content)** below the subject number and title indicates a change from the previous catalogue.

A **renumbered subject** is so indicated in parentheses below the current number.

J at the end of a subject number indicates that the subject is offered jointly by more than one department. The subject numbers of the other departments are indicated—(Same subject as _____J)

(A) following the name of a subject indicates that it is an approved subject for a graduate degree and is given primarily for graduate students.

All subjects open only to special groups are so noted at the end of the description of the subject.

1 Civil Engineering

Fundamentals

1.UR Research in Civil Engineering

Prereq.: —
Year: U (1, 2)
Arr.

Individual participation in an ongoing research project. (For students in the Undergraduate Research Opportunities Program.)
Staff

1.00 Principles of Computer-Based Engineering Problem Solving

Prereq.: —
Year: U (2) SD
3-1-8

Principles of computer hardware and software organization and the principles and methods of structuring, implementing, and modifying programs and data for computer solution of engineering problems. Methods for use of storage devices such as tapes and disks. Interfacing with various operating systems, including virtual memory systems. Principles of dynamic structuring of programs and data. Problems involving design, implementation, and modification assigned throughout subject. Extensive interaction with and use of digital computers, employing the FORTRAN programming language. Students without prior experience in FORTRAN are introduced to it in parallel with the first sessions of the subject. (Knowledge of some programming language assumed.)
B. Schumacker

1.01J Engineering Aspects of Economic Analysis

(Same subject as 14.014J)
Prereq.: —
Year: U (1)
4-0-8

Same subject as 14.01 with additional recitation sections scheduled for Civil Engineering majors to relate the concepts covered in lectures to engineering problems and applications. (Credit is not given for both 14.01 and 14.014J or 1.01J. May be counted toward Humanities Requirement.)
M. E. Patè, Staff

1.02 Civil Engineering Systems Analysis I

Prereq.: 18.02, *1.01J*
Year: U (1)
3-1-8

Two-term overview of Civil Engineering Systems Analysis (with 1.03) in terms of identifying problem elements, system modeling, generation of alternatives and evaluation. First term presents approaches to structuring, analyzing and optimizing deterministic processes. Emphasis on the application to a broad range of civil engineering problems. Topics include: engineering production functions, cost functions and expansion paths, marginal analysis, linear programming, dynamic programming, nonlinear techniques and basic random processes. Applications illustrated by mini-projects carried out during required recitation period in conjunction with 1.04. (Simultaneous registration with 1.04 required, except for students in Course 1-A Option 2 or by permission of instructor.)
D. H. Marks, S. R. Lerman

1.03 Civil Engineering Systems Analysis II

Prereq.: 1.02, *18.03*
Year: U (2)
3-1-8

Second term of a two-term sequence (with 1.02) presents a continuation of analysis methods in Civil Engineering Systems with an emphasis on probabilistic methods, statistical analysis, system modeling and project evaluation methods. Topics in stochastic analysis include: discrete and continuous random processes, expectation and other moments, derived distributions, basic statistics, hypothesis testing and confidence intervals and regression. System modeling methods include simulation, optimization and simultaneous equation models. Evaluation methods include decision analysis and multi-objective evaluation. Applications illustrated by mini-projects carried out during required recitation period in conjunction with 1.05. (Simultaneous registration with 1.05 required, except for students in Course 1-A Option 2 or by permission of instructor.)
S. R. Lerman, D. H. Marks

1.04 Behavior of Physical Systems I

Prereq.: 18.02
Year: U (1) SD
3-1-8

First term of two-term sequence (with 1.05). Applies basic physical principles to the engineering analysis of solids. Topics include a thorough consideration of the equilibrium of simple structural systems such as beams and trusses, mechanical properties and details of the stress-strain curves of wood, steel, and concrete, and elements of strength of materials including the concepts of stress and strain, stress-strain relations, Mohr's circle and principal stresses. Failure criteria discussed and the principles of dynamic equilibrium introduced, with particular reference to the single degree of freedom oscillator. Applications illustrated by mini-projects carried out during required recitation period in conjunction with 1.02. (Simultaneous registration with 1.02 required, except by permission of instructor.)
H. M. Irvine

1.05 Behavior of Physical Systems II

Prereq.: 1.04, *18.03*
Year: U (2)
3-1-8

Second term of a two-term sequence (with 1.04). Continues the application of basic physical principles to the engineering analysis of solid and fluid systems. Topics include static equilibrium of fluids, conservation of mass and momentum of moving fluids, fluid viscosity, thermodynamic properties, and first and second laws of thermodynamics. Applications of these principles made to problems involving fluid forces on structures, flow in conduits and channels, temperature changes in solids and fluids, mechanical and thermodynamic energy cycles. Mini-projects carried out during required recitation period in conjunction with 1.03. (Simultaneous registration with 1.03 required, except by permission of instructor.)
K. D. Stolzenbach

1.102 Transportation Laboratory

Prereq.: —
Year: U (1, 2) LAB
0-3-3

Laboratory experience with the properties of transportation systems and their effects on urban and regional development. Students formulate an experiment based upon readings and discussions of current transportation problems. Emphasis on formulation of hypotheses about properties and effects of different types of transportation systems; planning of experiments and data collection in the field to test these hypotheses; analysis of results; development of recommendations for changes in transport systems plans and policies.
Staff

1.103 Geotechnical Engineering Laboratory

Prereq.: —
Year: U (2) LAB
0-3-3

Develops principles of rational experimental design through laboratory work on geotechnical problems. Students design and perform experiments, analyze and evaluate results, and prepare reports.
G. B. Baecher

1.104 Materials of Construction Laboratory

Prereq.: —
Year: U (1) LAB
0-3-3

Students measure several engineering properties of basic construction materials — concrete, steel, aluminum, wood and glass— during the first half of the term. During the second half, students select a current problem in the area of construction materials, perform the necessary experiments in order to solve it, and finally analyze and evaluate the results of the experiment.
M. N. Fardis

1.105J Structural Engineering Laboratory

(Same subject as 4.315J)
Prereq.: —
Year: U (1) LAB
0-3-3

Introduces students to properties of structural materials and behavior of simple structural elements and systems through a series of experiments. Several laboratory projects involve the student as both the designer and fabricator of a structure.
W. P. Zalewski

1.106 Laboratory Projects in Environmental Fluid Mechanics

Prereq.: Permission of Instructor
Year: U (1) LAB
0-3-3

The measurement, analysis, and modeling of physical parameters such as velocity, salinity, temperature, dissolved solids, etc., in natural water bodies. Application of these techniques in the context of a case study involving field measurements and associated laboratory experiments.
E. E. Adams

1.107 Laboratory Projects in Aquatic Biology and Chemistry

Prereq.: —
Year: U (2) LAB
2-6-4

Field and laboratory techniques for measurement of chemical and biological parameters in aquatic systems. Focuses on interactions between microbiota and chemical constituents of natural waters particularly problems associated with pollution. During the second half of the subject a case study is carried on as individual student projects dealing with the trophic status of a particular body of water. (Some preparation in general chemistry or biology preferable. Enrollment limit: 12)
H. F. Hemond, S. W. Chisholm

1.12J Ethics and Technocrats

(Same subject as STS 412J)
Prereq.: —
Year: U (2)
4-0-8

Explores issues about ethics and social values central to the work of engineers, planners, systems analysts, economists, and other technical professionals. The primary objective is to assist the student in clarifying the ethical commitments of his/her own professional life. Examines several models of the decision-making and problem-solving processes commonly employed in these professions. Analyzes how particular professions construct images of reality, the implications of these images for what is considered to be appropriate professional work, and the social value assumptions implicit in these images. Selected case studies from transportation, environmental engineering, urban planning, and other fields are used to illustrate the issues. (May be counted toward Humanities Requirement.)
M. L. Manheim

Systems Methodology

1.143J Mathematical Optimization Techniques (A)

(Same subject as 13.622J)
Prereq.: Permission of Instructor
Year: G (1)
3-0-6

Systematic survey of theory and application of mathematical optimization techniques to engineering problems. Emphasis on general problem formulation and application of techniques. Linear programming and network algorithms covered in depth. Survey material in various nonlinear topics, such as, classical optimization methods, dynamic programming, integer programming, separable programming, search methods, and geometric programming. (For graduate students and advanced undergraduates. Some knowledge of linear algebra, matrix manipulation, calculus, and computer science assumed. Please see instructor if there is any question about prerequisites.)
D. H. Marks, H. N. Psaraftis

1.146 Engineering Systems Analysis (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-6

Synthesis of analytic procedures for identification and selection of optimal systems. Review of economic framework for analysis. Systematic survey of theory and applications of mathematical optimization to engineering problems. Evaluation procedures for single and multiattributed problems covering utility theory and decision analysis in addition to standard procedures. Application of this material to real problems in planning and design stressed throughout term. This subject is an Engineering School-Wide Elective. (Open to qualified undergraduates. Knowledge of probability, microeconomics, and computer systems at an undergraduate level required.)
R. de Neufville, J. P. Clark

1.153 Random Processes in Civil Engineering (A)

Prereq.: —
Year: G (1)
Arr.

Provides an introduction to modeling and analysis of probabilistic phenomena in civil engineering applications. Organized into an accelerated 3-unit (1-0-2) mini-subject in elementary probability theory and a following 6-unit (2-0-4) mini-subject on random processes. Depending on their needs, however, students may register for only the first third or only the second two-thirds of the subject. The first third or a first subject in probability is prerequisite to the second two-thirds. *Part I:* Brief review of fundamental concepts of probability theory: events and their probability; elementary operations with events; Bayes' theorem. Random variables, random vectors, and probability distributions. Transformations of random variables; derived distributions. Expectation, moments. Probabilistic models: Bernoulli, Poisson, Exponential, Normal, Lognormal, Extreme. *Part II:* Second-moment analysis of random processes, including functions, linear systems response, and vector and field processes. Generalized Poisson models. Discrete-state Markov models. Analysis of extremes of processes. Examples and problems taken from civil engineering literature. Definition of an individual project, which may, if desired, be pursued during IAP under faculty direction.
C. A. Cornell, D. Veneziano

1.154 Assessment of System Behavior (A)

Prereq.: 1.161, 1.03
Year: G (2)
3-0-6

Types of uncertainty and inference schools; emphasis on Bayesian methods. Second-moment models of random vectors, sequences, functions, and fields. Random vibration of linear and nonlinear systems. Simulation of multidimensional and multivariate random functions; simulation of system response. Time invariant estimation of vectors; parametric and nonparametric estimation of functions. Collection of information through nonsequential and sequential sampling; design of experiments. Utility states and performance evaluation: extremes of random functions; Poisson and Markov processes with reward.
(Not offered 1981-82.)
D. Veneziano

1.158 Studies in Advanced Systems Methodology (A)

Prereq.: Permission of Instructor
Year: G (1)
Arr.

Consists of three specialized mini-subjects to aid students in systems methodology applications areas in Civil Engineering. Depending on individual interests and needs, and on the sections offered, students could take this subject as a whole for (3-0-6) units or can register for only one mini-subject (1-0-2) or two (2-0-4). *Part I: Introduction to Mathematical Optimization Techniques*—An introduction to linear and nonlinear optimization techniques. Topics include: necessary and sufficient conditions for an unconstrained maximum; necessary and sufficient conditions for an equality constrained maximum; formal statement of the general problem of mathematical programming; the Kuhn-Tucker conditions; linear programming and the simplex algorithm. Heuristic rather than rigorous mathematical proofs used. *Part II: Elements of Queueing Theory*—Fundamental concepts of queueing theory. Markovian, semi-Markovian and non-Markovian queues; priority queues; queueing networks. Selected applications. *Part III: Introduction to Simulation*—Introduction to simulation of discrete, probabilistic systems. Computer languages designed to facilitate simulation experiments. Statistical issues inherent in simulation modeling. Selected applications.
Staff

Physical Systems

1.16 Computer Models of Physical and Engineering Systems (Revised Unit)

Prereq.: 18.02, 8.01
Year: U (1) SD
3-0-9

Reduction of physical and engineering systems to simplified physical and mathematical models; representation using networks; graphs, and finite element methods. Process simulations using random variables (Monte-Carlo techniques) and Linear and Dynamic Programming. Manipulation of the resulting models using algorithms on digital computers. Examples drawn from fields primarily of interest to scientists and engineers, with some attention to styles of problem solving. Extensive "hands-on" computing experience. (Working knowledge of FORTRAN expected.) This subject is an Engineering School-Wide Elective.
B. Schumacker, R. Kaplow, K. J. Bathe

1.161 Numerical Modeling of Physical Systems (A)

Prereq.: 18.03, 1.04
Year: G (1)
3-0-6

Introduction to computational methods for predicting the response of physical systems. Provides numerical analysis background for structural, geotechnical, hydrodynamics, and environmental modeling subjects. Lectures cover matrix algebra, solution techniques for algebraic equations, eigenvalue problems, finite difference techniques, quadrature, numerical integration of time-dependent equations, variational calculus, weighted residual methods, finite element methods.
J. J. Connor, Jr.

Social and Management Systems

1.181 Ethical Issues in Professional Work (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Exploration of the roles of professionals in reaching decisions about large-scale technological projects with significant societal impacts. The primary objective is to assist the student in clarifying his/her own personal and professional objectives. Presents theories and techniques for relating technical studies to their social and political contexts, with examples from engineering, planning, and systems analysis. Design as process. Social choice as process: the problem of evaluating large-scale technological projects with social consequences; benefit-cost analysis and other conventional evaluation techniques and their limitations; community participation techniques; normative models. Technocrats and ethics: value perspectives of technocratic professionals; alternative models of professional roles in societal change. Poses the question, should there be a "code of ethics" for technocrats?
M. L. Manheim

1.182J Applied Microeconomic Analysis (A)

(Same subject as 14.110J, CTS 110J)
Prereq.: 14.01 or 1.01J
Year: G (1)
3-0-6

Designed for students with primary interests outside of economics but who wish to acquire some expertise in applied economic analysis. The development of microeconomic theory at an intermediate level, including consumer and producer theory, imperfect competition, capital and welfare economics, with emphasis on applications of particular relevance to engineers, such as problems related to transportation, energy, water resources, and constructed facilities. (Credit not given for this subject and 14.03, 14.04.)
C. Winston, D. L. McFadden

1.184J Economics of Project Evaluation (A)

(Same subject as 14.111J)
Prereq.: 14.03 or 14.120
Year: G (2)
3-0-6

Economic concepts of costs and benefits: consumers' and producers' surplus; shadow prices and valuation of non-market costs and benefits. Investment criteria and the discount rate: static and dynamic; treatment of risk and uncertainty. Pricing policies and investment rules. Case studies in developed and underdeveloped countries: transportation, water resources, pollution abatement, energy, etc.
A. F. Friedlaender

1.19 Introduction to Technology and Law

Prereq.: —
Year: U (1)
3-0-9

An introduction to basic principles and functions of law, using legal cases and materials arising from scientific and technical issues. Provides an understanding of law and legal processes as they impact upon the work of engineers and scientists. Study of judicial lawmaking focuses on elementary civil procedure and how change in legal doctrine takes place. Examination of statutory lawmaking shows how Federal and state power to govern grows as technology grows. Administrative lawmaking focuses on the regulatory agencies' role in controlling and supporting technology as well as the extent and curbs on their power. Study of law cases, using so-called "Socratic method," and of legal processes and doctrines provides insight into the lawyer's working methods. Law's task of resolving conflicts found in scientific and engineering alternatives sensitizes students to choice of values questions. This subject is an Engineering School-Wide Elective. ***(Not offered 1981-82.)***
J. D. Nyhart

Transportation

1.201J Basic Concepts in the Analysis of Transportation Systems (A)

(Same subject as CTS 100J)
Prereq.: Permission of Instructor
Year: G (1)
2-0-4

Introduction to the analysis of transportation systems. Interaction of demand for service and system performance. Determinants of demand and models for demand forecasting. Performance characteristics of transportation systems and models of performance. Analysis of transportation networks including prediction of flow patterns and service quality. Evaluation of impacts and decision making in public and private transportation organizations. The basic analysis concepts illustrated through case studies in which different transportation problems are analyzed.
N. H. M. Wilson

1.202J Transportation Demand and Activity Analysis (A)

(Same subject as CTS 150J)
Prereq.: 1.182J; CTS 100J or 1.201J or 1.211
Year: G (2)
3-0-6

Introduction to the analysis and forecasting of demand for transportation services and location of activities. Subject is explicitly multimodal and includes urban, intercity, freight, and passenger demand. Activity analysis includes firm and household location at urban and regional scale. Topics include theory of transportation demand for individuals and firms, location theory, aggregate and disaggregate methods for location and demand analysis, forecasting methods, applications to various sectors such as air passenger demand, retail firm location, freight demand, residential location, and urban travel demand. A term paper is required. (Subject assumes knowledge of probability and statistical inference at an introductory level. Prerequisites may be met by subjects equivalent to those listed.)
S. R. Lerman

1.203J Logistical and Transportation Planning Methods (A) (New)

(Same subject as 6.281J, 11.526J, 13.665J, 15.078J, 16.76J, TPP 43J)
Prereq.: 6.431, 15.075
Year: G (1)
3-0-6

Quantitative techniques of operations research with emphasis on applications in transportation systems analysis (urban, air, ocean, highway, pick up and delivery systems) and in the planning and design of logistically oriented urban service systems (e.g., fire and police departments, emergency medical services, emergency repair services). Unified study of functions of random variables, geometrical probability, multi-server queueing theory, spatial location theory, network analysis and graph theory, and relevant methods of simulation. Discussion of implementation difficulties. Examples of applications: design of ambulance systems having both specialized and general-purpose vehicles; emergency response to oil spills; estimation of energy consumption by commuters in a metropolitan area; design of dial-a-ride transportation systems; controlling randomness in mass transit systems; evaluation of technologies for vehicle location, routing and control.
A. R. Odoni, A. I. Barnett, R. C. Larson, H. N. Psaraftis

1.205 Advanced Transportation Demand Modeling (A)

Prereq.: 1.202J or CTS 150J
Year: G (1)
3-0-6

In-depth consideration of theories and applications of travel and mobility behavior models. Topics covered include: probabilistic choice models, structure of multi-dimensional choice models, statistical estimation techniques, aggregate forecasting and updating procedures. Issues in model specification, including treatment of intra-household interactions and complex travel patterns. Review of recent modeling efforts to improve existing travel forecasting systems. A term paper is required.
S. R. Lerman, C. Winston

1.206 Transportation and Urban Activity Modeling (A)

Prereq.: 1.202J or CTS 150J
Year: G (1)
3-0-6

Consideration of the interaction between the nature of urban transportation system design and the spatial distribution of urban activities, with emphasis on modeling approaches. Topics covered: economic, demographic, and psychological theories of location, existing comprehensive urban land use models, impact-oriented studies, behavioral models using choice theoretic approaches, optimization models, and methods of forecasting variables exogenous to existing models. A term paper is required. ***(Not offered 1981-82.)***
S. R. Lerman

1.207 Transportation Networks Equilibrium Analysis (A)

Prereq.: 1.143J, 1.153
Year: G (1)
3-0-6

A study of analytical and algorithmic approaches to the formulation and solution of transportation network equilibrium assignment problems. Topics include mathematical programming formulation of user equilibrium and stochastic user equilibrium problem; volume-delay functions and their estimation; multimodal network assignment; combined modal split, distribution and assignment formulation; spatial aggregation in traffic assignment (e.g., the convex combinations method and the convex simplex method); stochastic assignment algorithms (e.g., STOCH algorithm, simulation-based algorithms); algorithmic approaches to stochastic equilibrium assignment (algorithms with predetermined step size). Some of the topics vary from year to year. Term paper required. (Alternate years. ***Not offered 1981-82.***)
Y. Sheffi

1.208 Topics in the Analysis of Transportation Systems (A)

Prereq.: CTS 100J or 1.211
Year: G (1)
Arr.

Case studies and special topics.
M. L. Manheim

1.209 Traffic Engineering (A) (New)

Prereq.: Permission of Instructor
Year: G (1)
3-0-6

Traffic flow theories and their applications to traffic engineering and control. Topics include deterministic and stochastic models of traffic flow and traffic phenomena. Applications include most common traffic engineering problems such as delay estimation, signal optimization, signals coordination, capacity analysis, large scale traffic models, analysis of TSM measures. Some knowledge of statistics and systems analysis techniques assumed.
Y. Sheffi

1.211 Analysis of Transportation Systems

Prereq.: —
Year: U (1)
5-0-7

Basic concepts in the analysis of transportation systems. The basic paradigm: demand, supply, and equilibrium. Predicting the demand for transportation, changing patterns of demand, and their relation to the socioeconomic system. Predicting transportation system performance, transportation technologies, introduction to the service attributes of air, rail, highway, and marine transportation. Actors and their perceptions of transportation impacts. Social, environmental, and political consequences of transportation decisions. Basic transportation problems; urban development, intercity freight and passenger transportation, regional and national economic development, regulation, transportation, and national energy.
M. L. Manheim, C. D. Martland

1.212 Transportation and the Environment

Prereq.: 1.02, 1.03, 1.211
Year: U (2)
4-0-8

Explores relationship between the provision of transportation services and the environment. Considers five major environmental impacts: energy, air, noise, social, and the specific localized impacts associated with a facility's location (e.g., drainage). Attention given to both current policy and analytical techniques for estimating impacts in each area. Preparation of an Environmental Impact Statement (EIS) considered. ***(Not offered 1981-82.)***
M. D. Meyer

1.213 Introduction to Freight Transportation

Prereq.: —
Year: U (1)
3-0-9

Basic structure of the transportation system is discussed along with the philosophy of its regulation and control. Demand for transportation is described in terms of the requirements for the movement of goods in the production process of the economy. Supply side is discussed from the viewpoint of the provision of transport services and infrastructure. Finally, the role of the various public and private enterprises which make up the freight transportation system is discussed and analyzed. Basic elements of public policy are then summarized and the options for the future of the system discussed.
P. O. Roberts

1.214 Public Transportation

Prereq.: 1.211
Year: U (2)
4-0-8

Planning, design, operations, and management of public transportation. Includes evolution of various forms of public transit including bus, rapid transit, light rail, paratransit, and special services; examination of various functional components of transit including propulsion, vehicles, guidance and control system; vehicle design and dynamics; capacity analysis for various components of transit systems; network planning; methods for comparison and selection of alternative modes; maintenance policies and practices; economics of transit; marketing; fare policy; transit management techniques. (Alternate years. ***Offered 1981-82.***)
N. H. M. Wilson, B. Day

1.215 Traffic Flow: Theory and Engineering Application

Prereq.: 1.03
Year: U (1)
3-0-9

Traffic flow theories and their applications to traffic operation and control. Deterministic-models of traffic-flow: the integral and differential conservation equations; density waves and shock waves (the hydrodynamics analogue). Measurement of traffic variables. Stochastic models of traffic flow: queueing phenomena; vehicular and pedestrian delay problems; maximum likelihood estimation of gap acceptance functions. Engineering applications: traffic signal optimization; bus pre-emption design; dilemma zone determination; traffic light synchronization; traffic-actuated signals; capacity analysis of freeways and urban streets; accidents analysis. Related issues: rationale of traffic laws and ordinates (including signing, marking, lighting); use of large-scale traffic simulation models. (Alternate years. ***Offered 1981-82.***)
Y. Sheffi

1.218 Case Study in Transportation Planning

Prereq.: 1.211
Year: U (2)
3-3-9

In-depth study of large-scale transportation project in a real world environment. Review and application of transportation systems analysis techniques and related methodologies. Identification of overall objectives, generation and evaluation of alternative solutions. Design of specific alternatives, and development of implementation strategies. Shows how various technical, economic, social, institutional, and political factors must be considered in the problem-solving process. A new problem is selected each year which involves the use of innovative transportation technologies and service methods. ***(Not offered 1981-82.)***
Staff

1.219 Field Experience in Transportation

Prereq.: 1.211, 1.02, 1.03
Year: U (2)
Arr.

Students participate in ongoing studies at selected transportation consulting firms, planning agencies, and operations. An average level of 12 hours per week anticipated, but alternative levels of involvement possible. Subject participants meet at MIT once each week to review objectives of work, discuss problems encountered, and exchange perceptions of actual transportation planning and design in different contexts.
Staff

1.231J Planning and Design of Airport Systems (A)

(Same subject as 16.781J)
Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Equal emphasis on current practice and advanced concepts. Airport location and planning with full consideration of economic, environmental, and other impacts. Examination of techniques for predicting demands. Determination of capacity of the airfield and of terminal facilities, estimation of levels of congestion and consideration of their optimal design. Configuration and design of terminals. Role of

airports in the aviation and transportation system. Airport access problems. Optimal configuration of air transport networks and implications for airport development. Economics of the airport Financing and institutional aspects. Special attention to advanced concepts for the design and operation of airport systems in the United States and in Europe and the insight they provide for the planning and design of future airport systems. Illustration through cases in airport master planning, site selection, and expansion planning.
R. de Neufville, A. R. Odoni

1.233J Seminar in Air Transportation Analysis and Planning

(Same subject as 16.704J)
Prereq.: —
Year: G (1)
1-0-5

A review of current issues facing the airline industry in operational, economic, financial, regulatory, and institutional areas. Seminars are presented on alternative weeks by leading speakers from airlines, aircraft manufacturers, major airports, regulatory agencies, and national and international aviation organizations. Preparatory lectures precede each seminar. Opportunity for students to conduct studies on particular topics with readings guided by staff. Term paper required.
A. R. Odoni, H. S. Marcus, C. O. Carey

1.242 Highway Engineering and Management Policy (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Interactions between highway engineering (design, construction) and management policy (maintenance, taxation and tolls, load limits, speed limits) explored in terms of engineering performance, financial and economic costs, and impacts to users for the intercity case. Topics include provision of highway capacity in response to demand through investment or administrative actions, design-maintenance tradeoffs; road taxes and financing; market and oporating regulations; construction and maintenance technology; and computerized procedures for planning and analysis. Implications toward both industrialized and developing countries to be presented.
M. J. Markow

1.251J Transportation Institutional Analysis and Policy (A)

(Same subject as 11.382J, CTS 120J)
Prereq.: Permission of Instructor
Year: G (1)
3-0-6

Introduction to policy and institutional analysis in the transportation sector. Principal policy-making actors and interest groups at national, state, and local levels. Emphasis placed on developing a basic understanding of organizational behavior and implications for policy formulation and implementation. General policy analysis framework developed with specific attention given to problem definition, selection of alternatives, and implementation considerations. Comparison made between strategic planning in the private sector and policy analysis in the public sector.
M. D. Meyer

1.252J Urban Transportation Planning (A)

(Same subject as 11.380J)
Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Begins by summarizing the historical development of urban transportation planning over the past two decades. Particular attention given to the movement of the transportation policy perspective from limited interpretations to multi-objective planning, and from an emphasis on large-scale facility planning toward an increased reliance on small-scale, traffic management techniques. The methodological change that has accompanied this evolution in transportation planning discussed in detail. Promising theories for understanding institutional relations and change also presented. Discussion of newly proposed methodological approaches to urban transportation planning which respond to the multiple objectives of the activity. The consequences of certain planning approaches highlighted in selected case studies of corridor and project planning in the Boston Metropolitan area.
M. D. Meyer, R. A. Gakenheimer

1.254J Transportation Policy and Planning in Developing Countries (A)

(Same subject as 11.384J)
Prereq.: Permission of Instructor
Year: G (1)
3-0-6

Research seminar on policy and technical issues in transportation in developing countries. Major policy and planning issues. Political and cultural factors influencing transportation planning and decision making. Institutional arrangements, coordination of transportation planning with other sectors, integration of programming and planning. The influence of foreign and international actors in transportation policy. Technical methods: demand analysis, technological tradeoffs, evaluation procedures, large-scale models, simple policy-analysis techniques. Participation of guest lecturers from MIT, international organizations, and developing countries. ***(Not offered 1981-82.)***
M. L. Manheim, R. A. Gakenheimer

1.255 Transportation Policy Analysis (A)

Prereq.: 1.251J or CTS 120J, CTS 100J
Year: G (1)
3-0-6

Case studies of transportation issues in the public and private sectors used to illustrate specific elements of policy analysis. Focus on problem identification, formulation and evaluation of alternatives, and organizational capabilities for implementation. Special consideration given to the analysis process associated with innovative transportation projects. A term project required.
M. D. Meyer

1.258 Public Transportation (A)

Prereq.: 1.201J or CTS 100J; 1.251J or CTS 110J
Year: G (2)
3-0-6

Overview of public transportation technology, planning, design, operations, and administration. Evolution and role of public transportation modes, systems, and services including bus, rapid transit, light rail, paratransit, and special modes; functional components of urban public transportation systems; descriptions of propulsion, guidance and control systems; vehicle design, and dynamic characteristics; capacity analysis for vehicles, stations, and travel way; station spacing and design; network planning; methods for mode evaluation, comparison and selection; approaches to major capital investment decisions; maintenance practices and policies; economics of transit systems and services; system organization and administration; mode integration; fare policy; marketing; transportation system management techniques.
N. H. M. Wilson, B. Day

1.261 Transportation Workshop (A)

Prereq.: 1.201J or CTS 100J
Year: G (2)
3-0-6

Integration of technical tools in concerted attack on a specific major transportation problem, such as development of a transportation plan for a carrier or a portion of a metropolitan area. Emphasis on generation and evaluation of alternative transportation solutions and on the ability to adapt technical analysis to data limitations, political considerations, and other realities. (Enrollment limited. ***Not offered 1981-82.***)
Staff

1.27 Studies in Transportation Engineering (A)

Prereq.: Permission of Instructor
Year: G (1, 2, S)
Arr.

Individual advanced study of a topic in transportation systems selected with the approval of the instructor.
Staff

1.271 Research Seminar in Transportation

Prereq.: 1.201J or 1.211 or CTS 100J
Year: G (1, 2)
Arr.

Research seminar for graduate students in transportation. Discussion of current research at various stages of development, including general problem area, methodology, and evaluation of results. Intended to improve students' research and presentation capabilities. Preparation for doctoral general examination. (Limited to advanced doctoral students.)
Staff

1.282 Structure and Operational Characteristics of Transportation Services (A)
(Revised Content)

Prereq.: 1.201J or 1.211; *1.285J*
Year: G (2)
3-0-6

Transportation operations management: analysis, organizational and management issues in transportation operations. Applications of systems analysis and organizational approaches to control of current operations, operations planning, and midrange planning in freight and passenger carriers. Reviews the structure of the US transport industry, then examines specific issues such as vehicle utilization, pricing, and labor. Builds upon and links basic concepts of transportation systems analysis and transportation management with emphasis on the use of analysis to support decisions made by carrier officials. Students review case studies involving all modes.
C. D. Martland, M. L. Manheim

1.283J Urban Economic Analysis I (A)

(Same subject as 11.410J, 14.573J)
Prereq.: 14.03 or 14.04
Year: G (1)
3-0-9

Patterns and processes of growth and structural change within metropolitan areas. The land use market, spatial structure of the metropolitan community and the transportation system. Congestion, indivisibilities, and optimal pricing and investment policies. Analysis of modal demand. Models of the metropolis and the transport system. Relationships between the housing market and the transport network.
W. C. Wheaton

1.284J Topics in Transportation Economics (A)

(Same subject as 14.576J)
Prereq.: 14.03 or 14.04
Year: G (2)
3-0-9

Theory and behavior of large transportation systems: urban and intercity, passenger and freight; estimation and application of production, cost, and demand functions. Evaluation of governmental transportation policies: economic regulation, infrastructure investments, pricing and financing; cost-benefit analysis, and impacts upon economic efficiency, X-efficiency, and the income distribution.
C. Winston

1.285J Issues in Transportation Management (A)

(Same subject as 13.681J, CTS 130J)
Prereq.: Permission of Instructor
Year: G (2)
3-0-6

An introduction to problems facing transportation management. A brief description of basic managerial tools and the industry characteristics of each transportation mode. Focus on specific managerial issues facing the transportation industry, including technological, economic, marketing, labor-related, legal, institutional, and political aspects. Similarities and dissimilarities among the modes analyzed. Problems viewed from the managerial perspective of both private and public sectors.
P. O. Roberts, H. S. Marcus

1.286 Freight Transportation (A)

Prereq.: 1.01J
Year: G (1)
3-0-6

An exposition of the quantitative and qualitative characteristics of commodity flows, primarily within the United States. Emphasis on responses of shipping firms, and carriers to changes in technology, government regulations, and investment policies. Topics: survey of statistical sources for commodity flow data; use of models for economic analysis of commodity flows; managerial concepts influencing modal choice among transportation services; and impacts of government intervention on the distribution process. Students organize teams to play "The Distribution Game."
P. O. Roberts

1.287 Public Policy Toward the Transportation Industry: Theory and Institutions (A)

Prereq.: 1.182J
Year: G (2)
3-0-6

Analysis of the impact of government policy on allocative efficiency and distribution of goods and services with special emphasis on the transportation industry. Topics include the determinants of market structure, theories of firm conduct, and the effect of government policy through regulation and anti-trust on performance of the transportation industry.
C. Winston

1.290J Transportation Performance and Technology (A)

(Same subject as 2.120J, CTS 140J).
Prereq.: 1.201J or CTS 100J
Year: G (2)
3-0-6

Transportation system performance measures: energy, pollution, safety, noise, ride quality, speed, reliability. Vehicle technology: propulsion systems, vehicle dynamics (ground, ocean, and air vehicle performance), automatic control and guidance. Vehicle flow in channels: traffic flow, scheduled carrier flow. Intersections and terminals: non-signalized intersections, queueing phenomena, terminals operation. Transportation Networks — the traffic assignment problem. Operating Plans — scheduled carrier networks. (Subject assumes knowledge of probability and statistical inference at an introductory level.)
Y. Sheffi, J. K. Hedrick

Constructed Facilities

1.298 Research in Transportation

Prereq.: —
Year: G (1, 2, S)
Arr.

For research assistants in transportation, when assigned research is not used for thesis, but is approved for academic credit. (Credits for this subject may not be used for any degree granted by Course I.)
Staff

1.299 Teaching in Transportation

Prereq.: —
Year: G (1, 2)
Arr.

For teaching assistants, in recognition of the educational value derived from satisfactory performance of assigned duties, and for other qualified students interested in teaching in this area as a career. Laboratory, tutorial, or classroom teaching under supervision of a faculty member. (Credits for this subject may not be used for any degree granted by Course I.)
Staff

Geotechnical Engineering

1.30 Soil Mechanics

Prereq.: 1.04
Year: U (1)
3-0-9

Fundamental principles of soil behavior. Composition and structure of soils; phase relationships and unit weights; classification systems. Influence of pore pressure on strength and compressibility; effective stress, effect of flowing water on stability. Drained and undrained strength. Theory of consolidation. Principles of limit analysis for soil masses. Methods for estimating soil deformations.
Staff

1.311 Geotechnical Engineering

Prereq.: 1.30
Year: U (2)
2-0-4

Application, at an introductory level, of fundamental principles of soil mechanics to engineering problems involving foundations, retaining walls, slope stability, and earth dams.
Staff

1.312 Geotechnical Laboratory

Prereq.: 1.30
Year: U (2)
0-3-3

Methods of soil classification and identification. Simple techniques for measurement of strength, compressibility, and permeability of soils. During later part of semester, students develop and carry out projects of their own design.
Staff

1.32 Introduction to Engineering Geology

Prereq.: —
Year: U (1) SD
3-3-6

Basic principles of physical geology, with emphasis on topics pertinent to civil engineering, and a brief overview on mineral resources. Identification of minerals, igneous, metamorphic, and sedimentary rocks. Alluvial, glacial, eolian, lacustrine, marine, and colluvial sediments. Weathering. Rock defects. Earthquakes. Air photos and geologic maps. Field trips.
G. B. Baecher

1.322 Soil Behavior (A)

Prereq.: 1.361
Year: G (2)
3-1-5

Detailed study of soil properties with emphasis on interpretation of field and laboratory test data for use in practice. Topics include: consolidation and secondary compression; basic strength principles; stress-strain strength behavior of clays, emphasizing effects of sample disturbance, anisotropy and strain rate; strength and compression of granular soils; engineering properties of compacted soils. Laboratory on consolidation and strength testing. (Some knowledge of field and laboratory testing assumed; 1.37 desirable.)
C. C. Ladd

1.331 Soil Dynamics (A)

Prereq.: 1.30
Year: G (1)
3-0-6

Design of foundations for machinery; effects of earthquakes upon structures and earth dams, other selected applications. Stress-strain behavior of soil during transient and repeated loadings; relation of soil properties to wave velocity. Theory of wave propagation and dynamics of lumped systems as applied to problems in soil dynamics.
R. V. Whitman

1.34 Reliability in Geotechnical Engineering (A)

Prereq.: 1.30
Year: G (1)
Arr.

Organized into a 3-unit mini-subject in elementary probability theory (in common with 1.153) followed by a 6-unit offering on applications to geotechnical engineering problems. Students may register for entire subject or (pending instructor approval) for the last two-thirds of the subject only. Part I (1-0-2): Brief review of fundamental concepts of probability theory: events and their probability; elementary operations with events; Bayes theorem. Random variables, random vectors, and probability distributions. Transformations of random variables; derived distributions. Simple probabilistic models. Part II (2-0-4): Quantitative treatment of uncertainty in soil behavior and the performance of geotechnical facilities. Probabilistic description of soil properties and of loadings and environmental conditions affecting soil behavior. Reliability of predictions of deformation, stability, and seepage. Reliability versus factor of safety. Design decision making accounting for performance uncer-

tainty and failure consequences. Applications to earth structures, foundations, dams, underground construction. (Alternate years. ***Not offered 1981-82.***)
E. Vanmarcke

1.351 Theoretical Soil Mechanics (A)

Prereq.: 1.30
Year: G (1)
3-0-6

Discussion of elementary theories important in soil mechanics. Theories of elastic half-space and elastic layers. Applications of elastic theories, especially to settlement problems. Use of limit analyses for active and passive stresses, bearing capacity, and slope stability. Theory of consolidation for one-dimensional problems and introduction to three-dimensional consolidation. Mathematics, construction, and interpretation of flow nets. Introduction to finite element methods and their use.
M. M. Baligh

1.361 Advanced Soil Mechanics and Engineering (A)

Prereq.: 1.30
Year: G (1)
3-0-6

Consideration of the following fundamentals of soil mechanics: the nature of soil; the effective stress principle; permeability and seepage; stress-strain-strength behavior of cohesionless and cohesive soil; lateral earth stresses; bearing capacity and slope stability; consolidation theory; settlement analyses.
C. C. Ladd

1.362 Earth Structures (A)

Prereq.: 1.361
Year: G (2)
3-0-6

Design and construction of earth structures, especially earth dams. Seepage and stability problems in dams, foundations, and natural slopes, measurements of deformations and stresses in field.
W. A. Marr, T. W. Lambe

1.364 Foundation Engineering (A)

Prereq.: 1.361
Year: G (2)
3-0-6

Types of foundation systems and design criteria. Design of shallow foundations (footings and rafts), and deep foundations (piles and caissons). Construction methods, problems and effects on nearby structures. Special topics and case studies.
M. M. Baligh

1.366 Geotechnical Engineering (A)

Prereq.: 1.30
Year: G (1)
3-0-6

Identification, presentation and illustration of principles of soil mechanics. Consideration of the following topics: the nature of soil; the effective stress principle; permeability and seepage; stress-strain-strength behavior of soil; lateral earth stresses. Application of principles to stability and deformation problems. (Restricted to graduate students not specializing in Geotechnical Engineering. Same lectures as for 1.361.)
C. C. Ladd

1.37 Geotechnical Measurements and Exploration (A)

Prereq.: 1.30
Year: G (1)
2-4-3

Students exposed to geotechnical exploration, field instrumentation, and in situ and laboratory testing procedures. Emphasis on measurement of strength-deformation characteristics and presentation of test results.
Staff

1.38 Engineering Geology (A)

Prereq.: 1.30, 1.32
Year: G (2)
3-0-6

Effect of geologic features on constructed facilities. Geologic aspects of subsurface exploration. Interaction between man-made structures and the geologic environment. Emphasis on sediment engineering geology with an overview of hard-rock engineering geology. (Alternate years. ***Not offered 1981-82.***)
H. H. Einstein

1.381 Rock Mechanics I (A)

Prereq.: 1.30, 1.32; or 12.01
Year: G (2)
3-0-6

Introduction to geologic and theoretical aspects of rock mechanics: exploration; geologic and engineering classification; laboratory and field testing; strength, deformability and permeability of intact rock and rock masses. Application of geologic and theoretical principles to the solution of basic rock engineering problems. (Alternate years. ***Offered 1981-82.***)
G. B. Baecher

1.382 Rock Mechanics II (A)

Prereq.: 1.381
Year: G (2)
3-0-6

Advanced treatment of theoretical and experimental aspects of rock mechanics: fracture mechanics, mechanics of discontinuities, rock dynamics. Rock engineering involving advanced analytical and design aspects of rock slopes, foundations on rock, underground openings and blasting of rock. ***(Not offered 1981-82.)***
H. H. Einstein

1.383 Underground Construction (A)

Prereq.: 1.361, 1.381
Year: G (1)
3-0-6

Familiarization with the most important aspects of planning, design, and construction of underground openings in soft ground and rock. Detailed engineering analysis and design. Major aspects of construction techniques and construction planning. General planning and economic problems. (Alternate years. ***Not offered 1981-82.***)
H. H. Einstein

1.384J Introduction to Mining and Mineral Technology (Revised Unit)

(Same subject as 2.742J, 3.095J, 12.043J)
Prereq.: —
Year: U (1)
3-0-6

A basic introduction to mining and the minerals industry with emphasis on state-of-the-art technology. Includes mineral exploration, surface and underground mining, extractive metallurgy, health and safety, and environmental considerations. Integration of diverse

subject matter stressed. Guest lectures by a variety of faculty members; classroom discussions based on assigned reading.
G. B. Baecher, R. G. Lundquist, J. F. Elliott, C. R. Peterson, R. G. Burns

1.39 Studies in Geotechnical Engineering (A)

Prereq.: Permission of Instructor
Year: G (1, 2, S)
Arr.

For graduate students desiring further individual study of special topics.
Staff

Construction Engineering and Project Management

1.40 Project Management

Prereq.: 1.30, 1.50
Year: U (2)
3-2-7

Location of a project, selection of structural system, and choice of construction method are examples of decisions faced by project managers which require more than a technical analysis. Considerations of laws, regulations, project organization structure, information quality, resource availability, as well as cost and time, must all be included in the development of an effective constructed facility. Evaluation focuses, at each phase of project development, on integrating these factors and others with technical analyses already mastered by the student. The envisioned construction project is characterized as a series of decisions involving different participants and based on varied quality and quantity of data. Traditional project and construction management methodologies are thus presented in accordance with project phase, data availability, and participants' goals.
R. D. Logcher

1.411J Basic Building Construction

(Same subject as 4.402J)
Prereq.: —
Year: U (1)
3-3-6

Basic methods of building construction, wood, masonry, steel, and concrete. Materials, foundations, framing systems, systems of roofing and cladding, insulation, vapor control, interior finish materials, stairs, fireplaces. Building trades and assembly processes. Problems, laboratory projects, and field trips to illustrate principles.
E. B. Allen, Staff

1.412J Design of Building Systems

(Same subject as 4.403J)
Prereq.: 1.59J, 1.50, 1.30; or 4.402J, 4.30
Year: U (2)
3-2-7

Exploration of problems found in the design of major physical systems associated with buildings, including structure (foundation, structural system, and enclosure), environmental systems, functional systems, and utilities. Discussion of basis of system demands, analytical modeling of physical systems, and role of building codes. Examination of contemporary design solutions in a case study format. Emphasis on engineering design and processes through which design decisions are made in the evolution of a building. (Prerequisites are structured so that the subject can act as an integrator of various discipline areas involved in building design. ***Not offered 1981-82.***)
E. B. Allen, Staff

1.413 The Design-Construction Interface (A)
(Revised Content)

Prereq.: Permission of Instructor
Year: G (1)
3-0-6

The process of transfer from design to construction examined, on a comparative basis, with regard to the nature of the constructed facility, the resources required to construct the facility, and the organization and environment of the construction and its various components. Methods of identifying dominant competitive issues and appropriate strategies for clients and contractors studied, and techniques of planning, scheduling, estimating and pricing the various factors of production applied in a simulated competitive market. The process complementary to the transfer from design to construction, entailing feedback about the constructability of designs, also investigated with reference to the techniques used.
H. G. Irwig

1.421 Learning From Construction Failures (A)
(New)

Prereq.: Permission of Instructor
Year: G (2)
3-0-6

An investigation of the impact of human decision-making processes and communication on the development of constructed facilities, with particular reference to the effectiveness and efficiency of the resultant facilities. Techniques for the identification and analysis of individual and group roles and processes examined and the factors giving rise to these studied in the context of group meetings. Case studies of failures in the design and construction of civil facilities used to demonstrate the relationship between human factors and facility performance.
H. G. Irwig

1.431 Structuring Construction Industry Organizations (A)
(Revised Content and Unit)

Prereq.: Permission of Instructor
Year: G (1)
3-0-6

Examination, from a socio-technical point of view, of the organizations and organizational processes involved in the planning, design, and construction of built facilities. The structure and functioning of firms, sub-units of firms, and conglomerations of firms participating in the development of such facilities studied with regard to variations in technologies used, markets served, and project life cycle stage, and particularly its effect upon productivity and innovation. Techniques for observation, description, analysis, and design of both individual enterprise and project organizations presented and applied to real-world situations.
H. G. Irwig

1.432 Project Control (A)

Prereq.: 1.431
Year: G (2)
3-0-6

Techniques and systems for control of design and construction projects. Requires background in accounting principles, budgeting, cash flow, and financial statements. Relationship of project breakdown to estimating, budgeting, and financial control. Management information systems for building development

projects, from estimating through maintenance and operating cost control. Use of network-based systems for planning and time control of projects, including CPM and PERT. Methods for considering and optimizing for effects of timing and resource constraints on projects' costs. Integrating control of costs and time, with cash flow and manpower projections, with comparison of potential to current practice.
R. D. Logcher

1.441 Modeling of Construction Processes (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-6

Application of analytical modeling techniques to problems of construction management and planning at the single project level. Review of modeling concepts, techniques, and methodologies precedes the development of construction models as informational tools. Models and discussions concentrate on the areas of construction operations and planning. Topics within these areas include selection of major equipment, equipment maintenance policies, resource allocation, crew balancing, cash flow analyses, and probabilistic estimating. Using process interaction simulation techniques and other modeling approaches, the student develops models in above problem areas which are then compared to currently practiced procedures and other analytical approaches.
D. B. Ashley

1.442 Modeling of Project Management Decisions (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Decision making at the construction project, company, and industry levels reviewed and analyzed. Topics include project selection, bidding strategy, construction contract structure and negotiation, joint-venture partnership share allocations, insurance purchase and construction industry regulation. Quantitative risk modeling techniques appropriate for analyzing these decisions introduced in both theoretical and applied contexts. By use of these techniques, students participating in groups address relevant decision problems posed by actual construction industry participants.
D. B. Ashley

1.461 Evaluation and Financing of Development (A) (New)

Prereq.: 1.03
Year: G (1)
3-0-6

Basic financial project criteria and evaluation techniques as applied to a range of projects from private real estate to international public developments. Review and modeling of development decisions as related to project characteristics and parties. Impacts of external influences such as taxation, regulation, and available financial instruments on feasibility and structure. Comparisons of risk assessment methodologies. Assessment and mitigation of the impacts of risks, such as market, construction time and costs, political, and economic risks. Impacts of risks on financial structures and risk allocation. Impacts of financial structures on project characteristics and technology. Work involves problem sets, case studies and a term project. (Permission of instructor required.)
R. D. Logcher, D. B. Ashley

1.471J Legal Problems in Construction (A)

(Same subject as 4.541J)
Prereq.: Permission of Instructor
Year: G (1)
2-0-7

Exploration and analysis of legal concepts and processes applicable to development of constructed facility projects Presents common law, legislation and regulations relevant to: professional registration; forming design organizations and management teams; designer liability for faulty design, cost overruns, and construction supervision; third party rights; analysis of construction contract and contractor's liability; copyright and patent protection for designs; arbitration; implications of systems approach to projects. Emphasis placed upon potential liabilities and risks to the various parties when translating design representation into physical reality. Case material used extensively to illustrate the legal issues being addressed.
C. Sapers

1.481 Seminar in Construction Engineering and Project Management

Prereq.: Permission of Instructor
Year: G (1, 2)
Arr.

Seminar primarily intended for advanced graduate students in Construction Engineering and Project Management. Topics include current and future research issues, as well as material to be presented in future subjects in this area. Students explore topics in depth and make presentations to the seminar group.
D. B. Ashley, H. G. Irwig, R. D. Logcher

1.482 Engineering Risk-Benefit Analysis (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Risk evaluation and cost-benefit analysis techniques for assessment of engineering projects involving risks. Emphasis on public sector. Balancing risks and benefits with concern for financial uncertainties, environmental risks, and especially, issues of human safety. Introduction to decision analysis, value of information, problems with multiple goals and issues related to collective decisions. Issues of public policy and regulation. Case studies with attention to the nature of public discussion. Cases drawn from dam safety, safety of nuclear reactors, transport and storage of liquefied natural gas, seismic risk problems, and offshore oil exploration. Some background in elementary probability is assumed. (This subject is intended mainly for graduate and upperclass students in the School of Engineering, and is an Engineering School-Wide Elective subject.)
M. E. Paté, A. W. Drake

1.491J Current Issues in Engineering

(Same subject as 3.562J, 6.941J, 13.682J, 22.87J)
Prereq.: —
Year: G (S)
3-0-6

Review of a selection of technological developments of great significance to industrialized societies, choosing from current areas such as electronic materials and microprocessers, conventional and new energy technology, and practical aspects of cell manipulation. Key features of the technologies, and their relationships to social, economic and managerial issues that their development implies.
T. H. Lee

1.492J Cases and Projects in Engineering Management (A) (New)

(Same subject as 3.563J, 6.942J, 13.683J, 22.88J)
Prereq.: 1.491J
Year: G (1)
3-1-5

Continuation of 1.491J with a shift from macro-level of technologies toward micro-level of projects. Case studies of and student projects involving several real engineering and scientific programs in industrial firms and government agencies. Cases chosen from new ventures as well as mature firms, in both project and process development. All aspects of projects assessed.
T. H. Lee

1.493J Technology Planning (A) (New)

(Same subject as 3.564J, 13.684J)
Prereq.: —
Year: G (1)
3-0-6

Methods for planning RD&E projects and multi-project programs. Cost and schedule control of technical work. Approaches to technology forecasting and resource allocation among technical areas. Technical planning in companies and government agencies.
J. M. Utterback, R. D. Logcher

Structural Engineering

1.50 Introduction to Structural Engineering

Prereq.: 1.04
Year: U (1)
3-2-7

Basic philosophy of structural design. Loads on structures. Design criteria and factors of safety. Stress-strain relationships. Column theory. Application of statics to analysis of beams, trusses, and frames. Influence lines and moving loads. Deformation of structures. Indeterminate analysis. Design of components in steel and reinforced concrete.
J. M. Biggs

1.502 Structural Analysis and Design

Prereq.: 1.50
Year: U (2)
3-1-8

Design and analysis of structural systems including steel and concrete frame buildings, plate girder bridges, and prestressed concrete beam and slab structures. Contemporary design criteria and practice for steel and concrete examined. Approximate and rigorous analysis techniques studied, with emphasis on their role in design process. Matrix methods of analysis. Use of computers in structural design. Plastic design in steel.
O. Buyukozturk

1.503 Engineering Mechanics

Prereq.: 1.502
Year: U (1)
4-0-8

An introductory treatment of the following: engineering elasticity, torsion, plates and shells, energy methods, and dynamic response of the single degree of freedom oscillator.
J. J. Connor, Jr.

1.541 Behavior and Design of Concrete Structures (A)

Prereq.: 1.503
Year: G (1)
3-0-6

Fundamental behavior and design of concrete structures and their members. Bases for code constraints. Load deformation relationships; bond and anchorage; crack formation; ductility and deflections. Creep and shrinkage problems; cyclic loadings. Flexural behavior; shear and torsion. Design of column-slab systems and shell structures for both serviceability and ultimate limit states. Concepts of prestressing; design of prestressed concrete elements. Introduction to modern analysis and modeling techniques. Applications to nuclear power facilities and offshore gravity structures.
O. Buyukozturk

1.542 Behavior and Design of Steel Structures (A)

Prereq.: 1.503
Year: G (2)
3-0-6

Aspects of the following: member performance including stability, brittle fracture, residual stresses, fatigue and fire protection. Connection details. Plastic design. Differential temperature effects. Introductory concepts in design of frame buildings and bridges.
H. M. Irvine

1.551 Planning and Design of Structural Systems (A)

Prereq.: 1.503
Year: G (2)
3-0-6

Fundamental concepts in planning, design, and construction of complete structures. Design philosophies and criteria. Nature of loads and probabilistic determination of design loads. Selection of structural systems for buildings and bridges. Approximate analysis for preliminary design. Utilization of computers in structural engineering. Special problems in tall building design.
J. M. Biggs

1.552 Structural Loads (A)

Prereq.: —
Year: G (2)
2-0-4

Description, analysis, and specification of common structural loadings. Elementary physical bases and empirical data describing common natural loading phenomena (e.g., seismic, wind, tornadoes, snow, temperature, etc.) and human-induced loads (building occupancy, vehicles, etc.). Procedures for data analysis and probabilistic modeling, both as scalars and as temporal processes (including intensity and duration information). Emphasis is on macro-time and space scale, not on dynamic characteristics of loading functions. Load combination analysis. Bases for modern structural code specifications and for probabilistic design procedures used in more advanced practice. (Elementary probability: e.g., 1.03 or first section of 1.153; or permission of instructor required.)
C. A. Cornell

1.553J Analysis and Design of Offshore Structures (A)

(Same subject as 13.112J)
Prereq.: 1.503 or 13.10J
Year: G (2)
3-0-6

Offshore structural configurations: concrete gravity structures vs. piled steel jackets. Functional requirements; material considerations. Concrete as a structural material; concrete in marine environment. Critical loads for design and analysis. Wave theory; wave action on structures. Stability calculations. Design methods for concrete and steel structures; codes. Static and dynamic analyses. Fatigue considerations. Computer methods. Safety assessment for offshore structures; development of risk-based loading criteria for ambient and extreme conditions. Spectral representation of loads on offshore structures. Geotechnical as-

pects: site investigation; foundation performance. Lectures are given by several members of Civil and Ocean Engineering faculty and by guest lecturers from offshore engineering industry.
O. Buyukozturk, J. J. Connor, Jr., E. Vanmarcke, J. K. Vandiver, P. C. Xirouchakis

1.562 Finite Element Methods (A)

Prereq.: 1.161, 1.503
Year: G (2)
3-0-6

Review of variational principles in solid mechanics. In-depth treatment of finite element displacement method as derived from principle of virtual displacements. Application to beams, plates, shells, and three-dimensional bodies. Solution schemes for geometrically nonlinear and time-dependent behavior. Discussion of mixed, hybrid, and equilibrium finite element formulations. Development of finite element computer systems and problem-solving techniques addressed in home assignments.
J. J. Connor, Jr.

1.565J Structural Mechanics in Nuclear Power Technology (A)

(Same subject as 2.084J, 3.82J, 13.14J, 16.261J, 22.314J)
Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Structural components in nuclear power plant systems, their functional purposes; mechanical, thermal, and nuclear operating conditions; mechanical-structural design requirements. Mechanics of continuous media are combined with models of material behavior to determine adequacy of component design. Effects considered include: mechanical loading, hydraulic forces, elevated temperatures, and neutron irradiation; normal operation, accident situations, and seismic effects. Lectures given by several members of Institute faculty and by guest lecturers from nuclear power industry.
O. Buyukozturk, A. S. Argon, J. E. Meyer, R. M. N. Pelloux, T. H. H. Pian, P. C. Xirouchakis

1.571 Advanced Structural Analysis I (A)

Prereq.: *1.161*, 1.503
Year: G (1)
3-0-6

Basic concepts in formulation and solution of structural problems, with primary application to member systems. (Trusses, frames, curved members.) Matrix formulation of equilibrium problems. Geometrically nonlinear behavior.
D. Veneziano

1.572 Advanced Structural Analysis II (A)

Prereq.: 1.503 or 13.10J
Year: G (2)
3-0-6

Review of stress and strain. Basic equations of linear isotropic elasticity. Two-dimensional problems in rectangular and polar coordinates; stress functions. Unrestrained torsion of open and closed cross-sections. Linear elastic bending of rectangular and circular plates; elastic plate buckling. Theory of thin elastic shells in curvilinear coordinates; membrance and flexural behavior of cylindrical, spherical, and hyperbolic-paraboloidal shells. Applications to nuclear power facilities, slab bridges and roof structures.
M. N. Fardis

1.573 Advanced Structural Analysis III (A)

Prereq.: 1.571
Year: G (2)
3-0-6

Advanced topics in structural analysis and mechanics with varying contents. Offers students the possibility to get acquainted with some current research. May include subjects such as interaction between structures, soils and fluids, stability theory, large deformation theory, nonlinear material behavior, and new computational techniques.
E. A. M. Kausel

1.581 Structural Reliability (A)

Prereq.: 1.153
Year: G (2)
3-0-6

Analysis and design specification of structural performance and safety through probability theory. Description of random occupancy, wind, and earthquake loadings, and of variability in material properties. Structural system reliability. New probabilistically based code specifications. Optimum design accounting for uncertainty and failure consequences. (Permission of instructor required. Alternate years. ***Not offered 1981-82.***)
C. A. Cornell

1.586 Structural Dynamics (A)

Prereq.: 1.161, 1.503
Year: G (1)
3-0-6

Analysis of structures subjected to dynamic loads. Theory developed for single degree of freedom system and generalized to multiple degree of freedom and continuous systems. Analytical and numerical techniques for solution of equations of motion. Transient, steady-state, and modal response. Applications to earthquake design, forced vibrations, and presentation of approximate (practical) methods.
E. A. M. Kausel

1.587 Safety of Structures and Foundations Under Dynamic Loads (A)

Prereq.: 1.586 or 1.331, 1.03
Year: G (2)
3-0-6

Evaluation of safety of buildings, offshore structures and soil-structure systems under earthquake, wave, and wind loads. Description of forcing functions as random processes: intensity versus frequency, duration, and spectral content of earthquake ground motion, atmospheric turbulence, and ocean waves. Multi-degree linear system probabilistic response analysis. Extremes and cumulative performance measures. Modeling of inelastic behavior and of foundation-structure interaction. Uncertainty in dynamic properties and component resistance. Overall risk assessment. Design to resist uncertain dynamic loads.
E. Vanmarcke

1.589 Studies in Structural Engineering (A)

Prereq.: Permission of Instructor
Year: G (1, 2, S)
Arr.

Individual study of advanced subjects under staff supervision. Content arranged to suit the particular requirements of the student and interested members of the staff.
Staff

1.59J Materials of Construction

(Same subject as 3.143J)
Prereq.: 8.01
Year: U (2) SD
3-0-9

Principles underlying the structure-properties interaction in materials important to civil engineers. Topics including atomic arrangements in crystalline and non-crystalline phases; thermodynamics of phase relationships and structural change; elasticity, microplasticity, visco-

elasticity, and fracture; corrosion. Application of principles to structural metals, cementitious materials, structural-ceramics, wood, asphalt, and polymers. Mechanical properties of composite materials, including Portland cement concrete, asphalt-aggregate mixtures, and reinforced plastics.
F. Moavenzadeh, F. J. McGarry

1.591J Fracture of Structural Materials (A)

(Same subject as 3.90J, 13.16J)
Prereq.: 1.59J or 2.30 or 3.141 or 13.15J
Year: G (1)
3-0-6

Analysis of criteria for crack initiation and propagation leading to structural failure. Study of fracture mechanics starting with Griffith theory for ideally brittle materials and through plane strain fracture toughness phenomena. Effects of geometry, rate, environment, fatigue, temperature, composition, and microstructure. Fracture behavior of welded metals, heat affected zone. Relation to dislocation mechanics. Significance of fracture surface morphology. Metals, cementitious materials, rock, polymers, fiber reinforced composites. Emphasis on current research in field.
F. J. McGarry, K. Masubuchi

1.592 Mechanical Behavior of Construction Materials (A)

Prereq.: 1.59J
Year: G (1)
3-0-6

Study of mechanical behavior of major construction materials, such as concrete, structural steel, and wood with emphasis on mathematical modeling. Yield and failure criteria. Uniaxial and multiaxial stress-strain relations describing instantaneous response to monotonic and cyclic loading. Linear and nonlinear time-dependent deformations. Brittle fracture and fatigue. Effects of temperature and humidity. Dependence of properties on composition and microstructure.
M. N. Fardis

1.593J Mechanical Behavior of Plastics (A)

(Same subject as 3.91J)
Prereq.: 1.59J
Year: G (1)
3-2-4

Relation among chemical composition, physical structure, and mechanical behavior of plastics or synthetic high polymers. Study of types of polymers; fundamentals of viscoelastic phenomena such as creep, stress relaxation, stress rupture, mechanical damping, impact; effects of chemical composition and structure on viscoelastic and strength properties; methods of mechanical property evaluation. Influences of plastics fabrication methods. Emphasis on recent research techniques and results. Individual laboratory projects investigating problems related to current research.
F. J. McGarry, D. K. Roylance

1.594J Composite Materials (A)

(Same subject as 3.92J)
Prereq.: 1.59J
Year: G (2)
3-2-4

Concepts underlying formation, characteristics, and behavior of plastics-based composites such as fiberglass laminates, structural sandwiches, plywood, and load-bearing adhesive joints. Typical components such as metals, glass, synthetic and natural adhesives, plastics, foams, wood, paper, fabrics and rubber. Correlation between adhesion principles and physical behavior. Methods of design, analysis, fabrication, and testing. Discussion of failure mechanisms of chemical, electrical, and mechanical types. Individual laboratory projects investigating problems related to current research.
F. J. McGarry

1.598 Research in Constructed Facilities

Prereq.: —
Year: G (1, 2, S)
Arr.

For research assistants in constructed facilities, when assigned research is not used for thesis, but is approved for academic credit. (Credits for this subject may not be used for any degree granted by Course I.)
Staff

1.599 Teaching in Constructed Facilities

Prereq.: —
Year: G (1, 2)
Arr.

For teaching assistants, in recognition of educational value derived from satisfactory performance of assigned duties, and for other qualified students interested in teaching in this area as a career. Laboratory, tutorial, or classroom teaching under supervision of a faculty member. (Credits for this subject may not be used for any degree granted by Course I.)
Staff

Water Resources and Environmental Engineering

1.60 Fluid Dynamics

Prereq.: 1.05, 18.03
Year: U (1)
4-0-8

Fundamental principles and methods of fluid dynamics forming analytical basis for physical processes governing distribution, movement, and quality of water in the environment. Continuation of 1.05. Dynamic similitude, basic theory of models and correlation of experimental data. Laminar and turbulent boundary layers, uniform and nonuniform flow in conduits and open channels. Design of pipeline and fluid transport systems. Dynamic drag and lift forces on immersed objects. Hydraulic machinery. Turbulent diffusion and mass transport process in water quality control. Transient phenomena such as water hammer and simple harmonic surface waves. Lectures supplemented by problem sessions.
W. K. Melville

Hydrodynamics and Coastal Engineering

1.61 Engineering and Management of Water Related Projects

Prereq.: —
Year: U (2)
0-4-8

Overview, integration, and application of technological subjects taken by students completing (or who have completed) their undergraduate primary programs in water resource systems and environmental engineering. Students undertake a broadly based water environment related project, typically working in several teams, under close supervision by one or more faculty members. Projects can include analytical and managerial aspects of hydrodynamic and coastal engineering, hydrology, and water resource systems, water quality control and ecological analysis, and environment management. (Primarily for Course I students in their last term of undergraduate work.)
D. R. F. Harleman

1.62 Free Surface Hydraulics

Prereq.: 1.60, 18.03
Year: U (2)
3-1-8

Derivation of one-dimensional equations of continuity, momentum and energy used in open channel flow analyses. Boundary resistance and computation of uniform steady flow in open channels. Steady, non-uniform flow (backwater curves). Momentum and energy

principles in open channel flow illustrated by hydraulic jump, bores, and energy dissipation in sudden expansions. Significance of the Froude Number in open channel flow. Subcritical and supercritical transitions. Channel controls, weirs, sluice gates, spillways, and stilling basins. Elements of unsteady free surface flows. Flood routing and introduction to theory of oscillatory waves in deep and shallow water.
O. S. Madsen

1.63 Principles of Hydrodynamics (A)

Prereq.: 1.60
Year: G (1)
3-0-6

An advanced account of dynamics of incompressible fluids. Materials are equally divided into four parts: 1) Basic formulation (kinematics, stress-strain, Navier-Stokes equations). 2) Potential flows (vorticity and circulation, analytic functions for two-dimensional problems, conformal mapping, flow through porous media). 3) Viscous flows and boundary layers (exact and approximate solutions). 4) Turbulent shear flows (instability, Reynolds equations, wall shear flows and dispersion; free shear flows and plumes). ***(Not offered 1981-82.)***
C. C. Mei

1.64 Dynamics of Stratified Fluids (A)

Prereq.: 1.63
Year: G (2)
3-0-6

Advanced treatment of stratified-fluid dynamics, with an emphasis on the basic phenomena that influence environmental flows. Linear and nonlinear internal waves in multiple layer and continuously stratified fluids. Boundary layers, stability and breakdown of internal waves, shear and convective flows. Introduction to the modeling of turbulent flows. Diffusion and dispersion of heat and pollutants. Two-phase flows.
W. K. Melville

1.66 Problems in Water Resources and Environmental Engineering (A)

Prereq.: Permission of Instructor
Year: G (1, 2, S)
Arr.

Advanced topics selected by students for individual study with staff approval. Choice of subjects from theoretical, experimental, and practical phases of hydromechanics, hydraulic engineering, water resources, and environmental engineering.
Staff

1.67 Sediment Transport and Coastal Processes (A)

Prereq.: 1.60; 18.03
Year: G (2)
3-0-6

Introduction to mechanics of sediment transport in steady and unsteady flows. Mechanics of entrainment, movement and deposition of granular sedimentary materials by moving fluids. Prediction of sediment transport rates. Onshore-offshore motion of sediment due to wave action. Beach profile changes. Hydrodynamics of wave-induced longshore currents and associated longshore sand transport. Hydrodynamics of tidal inlets and their stability. (Some knowledge of elementary wave theory an advantage. Students without this background should contact instructor in early January. Alternate years. ***Offered 1981-82.***)
O. S. Madsen

1.68 Physics of Natural Water Bodies (A)

Prereq.: 1.63
Year: G (1)
3-0-6

Systematic analytical and descriptive treatment of principal physical processes present in natural water bodies such as rivers, lakes, reservoirs, estuaries, and coastal regions. Emphasis on motion of water masses but also including temperature, surface elevation, salinity, and pollutant transport. Categorization of water bodies in terms of spatial and temporal scales of observed variability. Analytical, experimental, and numerical models corresponding to different levels of resolved variability. Linkages among physical, chemical, and biological processes. Design of sampling programs and instrumentation for field measurements of physical parameters.
K. D. Stolzenbach

1.69 Introduction to Coastal Engineering (A)

Prereq.: 1.60; 18.03
Year: G (1)
3-0-6

Introduction to hydrodynamics of waves in deep and shallow water, including some nonlinear aspects. Emphasis on physical interpretation of results and their engineering application. Progressive and standing waves, dispersion, group velocity, energy transport and energy dissipation through bottom friction. Wave refraction, diffraction by breakwaters. Wave breaking criteria. Storm surges on the open coast. Some statistical aspects of water waves, wave forecasting. Interaction between waves and structures: forces on piles, breakwater stability.
O. S. Madsen

1.691 Wave Dynamics in Coastal Engineering (A)

Prereq.: 1.69
Year: G (2)
3-0-6

Problems in water waves and currents of interest to coastal engineers. Emphasis on mechanical principles and theoretical methods of analysis. Topics chosen from the following areas: Ray theory of refraction, scattering of shallow water waves, tsunamis and transients, linearized theory of harbor oscillations. Effect of entrance losses. Viscous damping and mass transport. General theory of depth averaged conservation laws. Nearshore currents related to breaking. (Alternate years. ***Not offered 1981-82.***)
C. C. Mei

1.692 Wave Dynamics in Oceanographic Engineering (A)

Prereq.: 1.69, 18.075, 18.076
Year: G (2)
3-0-6

Problems in waves and currents of interest to oceanographic engineers. General theory of floating bodies, linearized radiation and diffraction, analytical and numerical aspects. Nonlinear long waves: various approximations including Airy, Boussinesq, Korteweg-de Vries equations, harmonic generation and nonlinear harbor resonance. Nonlinear short waves: slow modulation and instability of Stokes waves. Diffraction of Stokes waves by slender objects. Other current topics such as interaction of water waves with a poro-elastic sea bed. Content not strongly dependent on 1.691. (Alternate years. ***Not offered 1981-82.***)
C. C. Mei

1.697J Oceanographic Systems I

(Same subject as 13.990J)
Prereq.: —
Year: G (S)
2-4-6

Orientation subject for students entering the MIT-Woods Hole Oceanographic Institution program in oceanographic engineering. Oceanographic experiments of research interest in Cape Cod waters carried through experiment design, instrumentation design, construction and test, deployment, data taking and interpretation of results. Research teams

made up of students in 1.697J and 1.698J together. Participation in summer seminars at WHOI. (Given at Woods Hole Oceanographic Institution.)
Woods Hole Staff

1.698J Oceanographic Systems II

(Same subject as 13.991J)
Prereq.: —
Year: G (S)
2-4-6

Continuation of 1.697J during second summer term in the MIT-WHOI joint program in oceanographic engineering. (Given at Woods Hole Oceanographic Institution.)
Woods Hole Staff

1.699J Special Projects in Oceanographic Engineering (A)

(Same subject as 13.999J)
Prereq.: Permission of Instructor
Year: G (1, 2, S)
Arr.

Special problems in oceanographic engineering carried out under the supervision of members of the Woods Hole Oceanographic Institution. (Given at Woods Hole Oceanographic Institution.)
Woods Hole Staff

Hydrology and Water Resource Systems

1.70 Design of Water Resource Systems

Prereq.: 1.60
Year: U (2)
3-0-9

Principles and philosophy of design. Interactive role of planning, design, and operation in management of water resource systems. Design of total system to meet technical, environmental, economic, and institutional constraints. Performance and design of typical system compcnents such as conduits, canals, diffusers, spillways, turbomachinery, etc. Emphasis on role of models in both component and system design. Simulation and search procedures for design optimization. Examples drawn from various applications including flood-damage mitigation, hydroelectric power generation, reservoir and dam design, multipurpose river basin development, waste heat management, municipal-industrial water supply and distribution, and urban drainage.
Staff

1.71 Introduction to Hydrology

Prereq.: 1.05
Year: U (1)
3-1-8

Designed for undergraduates interested in Water Resources and Environmental Engineering. Useful for graduate students with no previous hydrology background. Topics include: types of precipitation and associated meteorological concepts; rainfall data collection and preliminary analysis; losses to precipitation including evaporation, transpiration, infiltration, and depression storage; runoff process and techniques of hydrograph analysis. Routing and runoff models are a main topic and include discussion of unit hydrograph concept, Instantaneous Unit Hydrograph, and numerical solutions of Kinematic Wave Equations. Knowledge of above concepts leads to discussion and use of basin wide deterministic hydrologic models such as the MIT Catchment Model and the National Weather Service River Forecasting Model. Introduction to groundwater hydrology and flow in saturated porous media.
R. L. Bras

1.711 Hydro-climatology (A)

Prereq.: 1.03, 1.60
Year: G (1)
3-0-6

Dynamics and derived statistics of the principal physical processes of interest in the coupled balances of water and heat at a landsurface. Philosophy and techniques of hydrologic modeling. Structure of the hydrothermal coupling in hydrology and its expedient simplification. Emphasis upon the dynamic interaction of climate, soil and vegetation: precipitation and its modeling as a Poisson process; infiltration; atmospheric vapor transfer capacity; evapotranspiration; surface runoff; percolation; capillary rise from the water table, groundwater runoff and their derived distributions. Modeling the one-dimensional annual water and heat balances. Coping with two-dimensionality in macroscale applications. Hydro-thermal climate classification. An introductory subject in hydrology recommended.
P. S. Eagleson

1.712 Hydrologic Analysis and Synthesis (A)

Prereq.: 1.153
Year: G (2)
3-0-6

Study of hydrologic time series. Correlation and spectral analysis of periodic and aperiodic signals. Time and frequency domain analysis of random processes and fields. Signal synthesis. Stochastic models for simulation of random functions like rainfall and runoff. State-space representation of random hydrologic processes. Optimal estimation theory for static and dynamic stochastic systems. Kriging and Kalman filtering techniques. Applications to system identification, design of sampling networks and hydrologic forecasting.
R. L. Bras

1.713 Engineering Hydrology (A) (New)

Prereq.: 1.60, 1.71
Year: G (2)
2-3-4

Topics in surface water hydrology. Physical behavior and engineering decisions through hands-on computer applications of commonly used numerical models. Rainfall-runoff, snowmelt, flood routing, urban hydrology, vegetative water use, forest hydrology and crop-yield.
P. S. Eagleson

1.72 Groundwater Hydrology (A)

Prereq.: 1.60
Year: G (1)
3-0-6

A basic subject analyzing the role of groundwater in the hydrologic system. Mechanics of flow in porous media. Development of the equations of conservation of water mass and dynamics in porous media. Compressible systems and elementary well analysis. Analytical, numerical, and physical distributed parameter models of seepage through earth structures, regional groundwater flow, stream-aquifer interaction, salinity intrusion, and artificial recharge. Groundwater development and economics, conjunctive use and conservation of groundwater.
J. L. Wilson

1.721 Groundwater Resources Evaluation and Modeling (A)

Prereq.: 1.72
Year: G (2)
3-0-6

Analysis of groundwater aquifers through field investigations, hydrogeologic models, and hydroeconomic models. Organization of field investigations and a description of use of borehole, and surface geophysical instruments in developing hydrogeologic data. Advanced well hydraulics applied to determination of aquifer transmissivity and storativity, and evaluation of hydraulic connection between various aquifer units and surface water bodies. Estimation of lateral inflows, and natural and artificial recharge. Mixing cell, finite difference, integrated finite difference and finite element numerical, hydrogeologic aquifer models. Adjustment of model aquifer parameters, and evaluation of parameter and recharge/withdrawal data uncertainty, by sensitivity analysis, solution of inverse problem and by filtering techniques. Simulation and optimization hydroeconomic models for evaluation of conjunctive use and groundwater mining, and design and operation of extraction well fields and artificial recharge. (Alternate years. ***Offered 1981-82.***)
J. L. Wilson

1.723 Subsurface Water Quality (A)

Prereq.: 1.77
Year: G (2)
3-0-6

An examination of subsurface water quality problems, from chemical and physical viewpoints in context of groundwater quality management. Physical transport of quality constituents through zone of aeration and groundwater with emphasis on ion exchange and adsorption chemistry, and the mixing introduced by molecular diffusion, mechanical dispersion, and formation dispersion. Development of a mass transport equation incorporating the above effects; and analytical and numerical solutions. Case studies of quality problems including industrial and radioactive waste disposal, land application of treated sewage, septic tank waste disposal, and irrigation return flows. (Alternate years. ***Not offered 1981-82.***)
J. L. Wilson

1.731 Water Resource Systems I (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-6

Design and analysis of large-scale, complex, water resource systems. System definition and manipulations: coupling, decomposition, resolution, comparison, computation. System simulation: methodology, generators of common variates and processes, Monte Carlo solution of system problems. System design: tricotyledon theory; cost-effectiveness methodology; multicriteria decision making including ordering, dominance, utility, outranking algorithms, metagame theory; treatment of uncertainties. Linear optimization models including chance constrained and multicriteria formulations. Throughout, subject methodologies intertwined with applications: river basic planning; watershed management; design and analysis of reservoirs; design of systems for flood control, water supply, navigation improvement, low flow augmentation, hydropower generation; design of conjunctive surface and groundwater supply systems, irrigation systems, water reuse system. (Some knowledge of economics, probability, and optimization methods assumed. Please see instructor if there are any questions about prerequisites.)
R. Krzysztofowicz

1.732 Water Resource Systems II (A)

Prereq.: 1.731
Year: G (2)
3-0-6

Modeling and solving decision problems in water resources and environmental engineering. *Part I, Design problems:* design of storage reservoirs, levee systems, drainage systems, well fields, data collection networks; analysis of hydrologic uncertainties; model choice; evaluation of performance of complex engineering and social systems. Methodological topics include: types of uncertainties; decision criteria; quantification of subjective preferences and probabilities; Bayes decision analysis: risk, Bayes decision function, opportunity loss, value of information, conjugate prior distributions; decision theoretic measures of system performance; Bayes simulation. *Part II, Multistage decision processes:* real-time reservoir control, timing and sequencing of investments, water quality management and design of regional facilities, irrigation scheduling, sequential sampling, optimal stopping, behavioral processes such as choice process, response of a floodplain dweller to hydrologic forecasts, response of a farmer to changes in water supply and commodity market conditions. Methodological topics include: dynamical systems and decision processes, Markovian process, dynamic programming, computational aspects, cost allocations, forecasts, imperfect state information, suboptimal control. (Some knowledge of economics, stochastic processes, and optimization methods assumed. Please see instructor if there are any questions about prerequisites. Permission of instructor required.)
R. Krzysztofowicz

Water Quality Control and Environmental Management

1.75 Limnology and Wetland Ecology (A)

Prereq.: —
Year: G (1)
3-0-6

Covers dominant physical, chemical, and biological features of lakes and wetlands in the north temperate zone. Topics include: basin geology, water budget, wind-driven hydromechanical phenomena, heat balance, thermal stratification, radiation environment, macro- and microscopic biological communities, and cycles of carbon, oxygen, and inorganic nutrients. Also origin and characterization of wetlands (including salt marshes), wetland biota, and chemical conditions of wetlands. Subject further considers dynamics of system responses to seasonality and human-induced perturbations; methodologies of modern limnology, including field methods and use of models; and current issues in lake and wetland management.
H. F. Hemond

1.76 Aquatic Chemistry (A)

Prereq.: 5.40
Year: G (1)
3-0-6

Quantitative treatment of variables which govern chemical behavior of aquatic systems such as lakes, oceans, rivers, estuaries, groundwaters, and wastewaters. After a brief review of the principles of chemical thermodynamics, such topics as equilibrium between acids and bases, dissolved carbon dioxide, interactions between solid phases and aqueous solutions, coordination and redox chemistry covered. Emphasis on quantitative study of simple and complex model systems. Interactions between physical, chemical, and biological variables in natural waters stressed. (5.60 is a suggested prerequisite.)
F. M. M. Morel

1.77 Water Quality Control (A)

Prereq.: 1.60
Year: G (1)
3-0-6

Analysis of environmental engineering problems in water quality and pollution control technology. Emphasis on predicting distribution and fate of effluents discharged into lakes, reservoirs, rivers, estuaries, and oceans. Development of basic convective-mass transfer equations leading to deterministic models for multidimensional and one-dimensional, steady and unsteady flow, mixing and diffusion processes. Emphasis on formulation and structure of predictive models rather than on details of analytical and numerical solution techniques. The objective: to develop the ability to make initial assessments of analytical tools and judgment to distinguish between predictive models and descriptive or curve-fitting models. Role of element cycles, such as oxygen, nitrogen and phosphorus, as water quality indicators. Offshore outfalls and diffusion in the ocean. Salinity intrusion in estuaries. Thermal stratification in lakes and reservoirs and its effect on water quality.
D. R. F. Harleman

1.78 Water Quality Management (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Systematic approach to management of water quality. Identification of major issues and problem areas. Type, sources, and stochastic nature of waste materials and their effect on water bodies. Identification and implications of control alternatives. Relationship of water use to water quality. Regional water quality management models. Application of optimization techniques to problems of water quality management. Dynamic models of decision processes. Basis and implications of quality standards. Institutional arrangements for planning, implementing, and operating water quality management plans. Legal, regulatory, enforcement, and economic aspects of quality management. Land development — water quality interactions. Storm water quality. Effluent charges and other economic alternatives as a method for quality control. Case studies of large-scale systems. (For graduate students and advanced undergraduates. Some knowledge of economics, statistics, and optimization techniques assumed. Please see instructor if there are any questions about prerequisites.)
D. H. Marks

1.79 Plankton Ecology (A)

Prereq.: —
Year: G (2)
3-0-6

Basic graduate subject dealing with selected aspects of the ecology of marine and freshwater systems. Emphasis on physiological processes of planktonic organisms as they relate to current models of aquatic ecosystems. Topics include primary and secondary productivity; food webs; biologically mediated nutrient cycles; phytoplankton competition and succession; nutrient limitation; phytoplankton/zooplankton interactions. Lecture/seminar format with extensive outside readings. (Permission of instructor required.)
S. W. Chisholm

1.80 Fundamentals of Ecology

Prereq.: —
Year: U (1)
3-1-8

Principles of interrelationships between organisms and their environment. Development of basic concepts of energy flow through ecosystems; productivity; trophic dynamics; community structure and stability; competition and predation; population growth; and physiological ecology. Emphasis on aquatic systems. Field trips: terrestrial and aquatic ecosystems.
S. W. Chisholm, H. F. Hemond

1.811J Environmental Law: Pollution Control (A)

(Same subject as TPP 33J)
Prereq.: Permission of Instructor
Year: G (1)
3-0-6

Review and analysis of common law, legislation, and regulation of air and water pollution. Emphasis on use of legal mechanisms and alternative approaches for controlling environmental pollution. Economic consequences of pollution control discussed. The Clean Air Act, Clean Water Act, and National Environmental Policy Act analyzed regarding the goals of pollution control, economic consequences, and role of the courts. Both classical pollutants and highly toxic industrial chemicals discussed.
N. A. Ashford, G. R. Heaton, Jr.

1.812J Regulation of Health and the Environment: Selected Topics

(Same subject as TPP 34J)
Prereq.: 1.811J, 3.575J or 10.805J
Year: G (2)
3-0-6

Topics related to environmental and safety regulation are selected from the following: Toxic Substances Control Act, occupational safety and health, noise, pesticides, food additives, pharmaceuticals, hazardous and solid waste, land use and control, fish and wildlife, endangered species. Both health and economic consequences of environmental policy discussed. Focuses on policy design and evaluation in environmental and safety area. (Recommended: other law-related subject, or permission of instructor.)
N. A. Ashford, G. R. Heaton, Jr.

1.82 Problems in Aquatic Biology and Chemistry (A)

Prereq.: Permission of Instructor
Year: G (1, 2)
Arr.

Advanced topics in fields of aquatic chemistry and aquatic biology. Choice of seminar, laboratory or field studies. Typical topics include analytical and bioassay methodologies, nutrient and trace metal interactions with aquatic biota, element cycles.
Staff

1.85 Introduction to Wastewater Treatment Engineering

Prereq.: 1.60 or 1.80
Year: U (2)
2-0-4

Designed for advanced undergraduates interested in environmental engineering of wastewater treatment processes. Basic theory of homogeneous transport in reactor vessels. Physical-chemical removal of dissolved materials, aeration processes and suspended solids removal. Elementary microbiology of water and wastewater treatment, biochemical processes related to the carbon, oxygen, nitrogen, and phosphorous cycles. Waste treatment by suspended culture processes and oxidation ponds. It is recommended that students register for both 1.85 and 1.86. (Taught last seven weeks of term.)
D. R. F. Harleman

Special Studies

1.86 Element Cycles in the Environment

Prereq.: Permission of Instructor
Year: U (2) SD
2-0-4

Cycles of major elements such as water, oxygen, nitrogen, carbon, and phosphorous and some key trace elements such as lead and mercury. Energetic aspects of the cycles, interrelated physical, chemical, and biological processes. Approach is quantitative and focuses especially on our interaction with the environment as it affects distribution and processing of elements through agricultural and industrial development. It is recommended that students register for both 1.85 and 1.86. (Taught first seven weeks of term.)
F. M. M. Morel

1.898 Research in Water Resources and the Water Environment

Prereq.: —
Year: G (1, 2, S)
Arr.

For research assistants in water resources and the water environment, when assigned research is not used for thesis, but is approved for academic credit. (Credits for this subject may not be used for any degree granted by Course I.)
Staff

1.899 Teaching in Water Resources and the Water Environment

Prereq.: —
Year: G (1, 2)
Arr.

For teaching assistants, in recognition of the educational value derived from satisfactory performance of assigned duties, and for other qualified students interested in teaching in this area as a career. Laboratory, tutorial, or classroom teaching under supervision of a faculty member. (Credits for this subject may not be used for any degree granted by Course I.)
Staff

1.91 Civil Engineering Internship

Prereq.: —
Year: U (1, 2, S)
0-6-0

Provides academic credit for the first two work assignments of Course I students affiliated with the Engineering Internship Program. Students register for this subject twice and must complete both work assignments in order to receive academic credit for this subject. (Enrollment limited to students registered in the Course I Internship Option.)
Staff

1.92 Advanced Civil Engineering Internship

Prereq.: 1.91
Year: G (1, 2, S)
0-6-0

Provides credit for the third and fourth work assignments for students affiliated with the Engineering Internship Program. Students register for this subject twice. Students must complete both work assignments to receive the academic credit for this subject. (Enrollment limited to students registered in the Course I Internship Option.)
Staff

1.961-1.965 Special Graduate Studies in Civil Engineering (A)

Prereq.: Permission of Instructor
Year G (1, 2)
Arr.

Graduate subjects taught experimentally; special subjects offered by visiting faculty; seminars on topics of current interest.
Staff

1.969 Graduate Studies in Civil Engineering (A)

Prereq.: Permission of Instructor
Year: G (1, 2, S)
Arr.

Individual study, research, or laboratory investigations at the graduate level, under faculty supervision.
Staff

1.980J Engineering Policy Thesis Seminar (A)

(Same subject as 15.783J, TPP 13J)
Prereq.: Thesis Registration
Year: G (1, 2)
2-0-1

A weekly seminar designed to assist students in formulating research topics, designing their investigation, executing the analysis, and writing the thesis itself. Also serves as preparation for general examinations. Students required to present their work for general discussion by faculty, research staff, and their colleagues.
R. de Neufville, A. R. Odoni, Staff

1.991-1.992 Special Undergraduate Studies in Civil Engineering

Prereq.: Permission of Instructor
Year: U (1, 2)
Arr.

Undergraduate subjects taught experimentally; special subjects offered by visiting faculty; seminars on topics of current interest.
Staff

1.999 Undergraduate Studies in Civil Engineering

Prereq.: —
Year: U (1, 2, S)
Arr.

Individual study, research, or laboratory investigations under faculty supervision.
Staff

2 Mechanical Engineering

2.UR Undergraduate Research in Mechanical Engineering

Prereq.: —
Year: U (1, 2, S)
Arr.

Individual study, research, or laboratory investigations under faculty supervision, including individual participation in an ongoing research project. Coordinator:
D. G. Wilson

Mechanics, Dynamics, and Acoustics

2.01 Mechanics of Solids

Prereq.: 8.01, 18.02
Year: U (1, 2) SD
4-0-8

Introduction to mechanics of continuous deformable media emphasizing three-dimensional requirements of force equilibrium, geometric compatibility, and constitutive behavior. Stress and its relation to force and moment. Strain and its relation to displacement. Linear elasticity with thermal expansion. Failure modes. Applications to stress distributions and deformations of rods, shafts, beams, and other simple structures of engineering importance. Emphasis on free body diagrams. Introduction to energy methods and elastic stability.
N. H. Cook, K. J. Bathe

2.015 Mechanics of Solids

Prereq.: —
Year: G (S)
2-0-4

Review of mechanics of solids primarily for incoming graduate students; a shortened version of 2.01
F. A. McClintock

2.02 Introduction to System Dynamics

Prereq.: 8.01, 18.02
Year: U (1, 2) SD
4-0-8

Dynamic modeling by linear and nonlinear lumped multiport elements of physical systems involving transfer and storage of matter and energy. Unified treatment of active and passive mechanical, fluid, electrical, thermal and electronic devices and systems. Concept of state and state variables. Formulation and solution of state equations by direct analysis, and by digital computer methods. Dynamic response and stability of linear systems. Exponential excitation, system functions, pole-zero configurations and their interpretation. Generalized impedance and source equivalents. Causal and acausal graphs. Extensive use of practical examples from the various fields of engineering and applied science.
D. N. Wormley, H. M. Paynter

2.023 Dynamic Systems

Prereq.: —
Year: G (S)
3-0-6

Review of system dynamics primarily for incoming graduate students; a shortened version of 2.02.
D. N. Wormley, H. M. Paynter

2.03J Dynamics

(Same subject as 13.003J)
Prereq.: *2.01* or *13.002*, 2.02 or 13.001, 18.03
Year: U (1, 2)
4-0-8

Dynamics of lumped and continuous models of mechanical, electrical, and electro-mechanical systems. Kinematics and dynamics of rigid bodies in two- and three-dimensional motions. Formulation of equations of motion by momentum principles and Lagrangè's equations. Behavior of linearized models: natural modes and frequency response of lumped systems, wave transmission and reflection in continuous systems.
J. H. Williams, Jr., H. M. Paynter, P. Leehey

2.032 Dynamics (A)

Prereq.: 2.03J
Year: G (2, S)
3-0-9

Review of fundamentals of dynamics. Momentum principles and energy principles. Applications to mechanical systems including gyroscopic effects. Study of steady motions and nature of small deviations therefrom. Natural modes and natural frequencies for continuous and lumped parameter systems. Forced vibrations. Dynamic stability theory. Causes of instability. (See 16.91. Consult advisor.)
S. H. Crandall

2.04 Probability and Statistics in Mechanical Engineering (New)

Prereq.: 18.031 or 18.03
Year: U(1)
4-0-8

Fundamentals of probability and statistics for mechanical engineering applications. Strong emphasis placed on the analysis and solution of real mechanical engineering problems. Material is presented as a further example of modeling and partial description of real phenomena. Topics include: discrete and continuous random variables, common distributions, parameter estimation, sampling, hypothesis testing, confidence intervals. Brief introduction to random processes, autocorrelation functions, spectral densities.
N. J. Hogan

2.06J Mechanical Vibration

(Same subject as 13.80J)
Prereq.: 2.03J or 13.003J
Year: G (1)
3-0-9

Concepts of mechanical vibration, including free and forced vibration of single and multi-degree of freedom systems. Modal analysis and matrix formulation of vibration problems. Approximate solution techniques. Vibration and modal analysis of continuous systems: beams, rods, and strings. Introduction to the response of linear systems to random excitation. Numerous examples and application of vibration measurement and analysis, including vibration isolation and dynamic absorbers, ships, offshore structures, engines, and rotating machinery.
R. H. Lyon, K. J. Bathe, J. K. Vandiver

2.060J Principles of Acoustics (A)

(Same subject as 13.81J, 16.081J)
Prereq.: 2.03J or 16.004 or 13.004, 18.075
Year: G (1)
3-0-9

Combined with subject 2.063, forms a two-term sequence in acoustics at advanced level; subjects may be taken in any order. Emphasizes acoustics of fluids: derivation of basic equations, radiation of sound, diffraction and scattering and acoustics of ducts and rooms. Acoustic, thermal, and vorticity fluctuations as first order perturbation of equations of fluid dynamics; energy density and intensity. Multipole expansions of source fields, spherical harmonics, radiation impedance and directivity. Scattering and diffraction of sound by obstacles.

Natural modes of sound propagation in ducts; excitation and reverberation of sound in rooms.
R. H. Lyon, P. Leehey, S. E. Widnall

2.061 Random Vibration (A)

Prereq.: 2.03J, 18.075
Year: G (1)
3-0-9

Introduction to mathematical description of stochastic processes. Impulse response and frequency response of linear time-invariant dynamic systems. Autocorrelation and spectral density of stationary response. Crossing rates and distributions of peaks and maxima. Pulse processes triggered by Poisson random counters. Application to vibration problems in vehicles subject to wide-band random excitation. Measurement and simulation of random vibration. Analog and digital data processing. Cross-correlations, cross-spectra, and coherence. Failure under random loading due to fatigue and due to first crossing of a threshold. (Alternate years. ***Not offered 1981-82.***)
S. H. Crandall

2.062 Wave Propagation (A)

Prereq.: 2.03J, 18.075
Year: G (1)
3-0-9

Wave concepts in applied mechanics with examples chosen from elasticity, acoustics, geophysics, hydrodynamics, and related subjects. Plane wave theory, dispersion, phase and group velocities, wave impedance, energy density and intensity. Reflection and refraction, wave guides and boundary waves. WKB method, Green's law and wave action. Generation, transmission, and reception of waves. Water-hammer waves, Rayleigh waves, waves in periodic structures. (Alternate years. ***Offered 1981-82.***)
S. H. Crandall

2.063J Sound and Structural Vibration (A)

(Same subject as 13.82J)
Prereq.: 2.03J or 16.004, 13.004, 18.075
Year: G (2)
3-0-9

Combined with subject 2.060J, forms a two-term sequence in acoustics at advanced level; subjects may be taken in any order. Emphasizes interaction of sound in fluids with structural vibration. Review of dynamics of strings, beams, and plates. Normal modes, phase and group velocity, decay of vibrational energy. Radiation impedance of beams and plates, reciprocity, energy equilibrium between sound field and structure. Concepts of statistical energy analysis (SEA). Sound transmission through walls using "classical" and SEA procedures.
R. H. Lyon, P. Leehey

2.065J Flow Noise (A)

(Same subject as 13.84J, 16.082J)
Prereq.: 2.060J, 16.02, or 2.20
Year: G (1)
3-0-9

Elements of aerodynamic and hydrodynamic sound. Subsonic and supersonic jet noise. Jet noise suppression. Vortex sound and feedback resonance effects. Propeller, compressor, and helicopter rotor noise and noise suppression techniques. V/STOL noise. Boundary layer noise: Mach wave radiation, structural response and re-radiation. (Alternate years. ***Offered 1981-82.***)
P. Leehey, S. E. Widnall

2.071J Introduction to Structural Mechanics

(Same subject as 13.10J)
Prereq.: 2.01 or 2.015 or 13.002
Year: U (1)
3-0-9

Selected structural mechanics concepts applicable to marine and mechanical structures; thick-walled spheres, compound cylinders, mooring lines. Beam design and optimization, introduction to ABS rules. Stability and determinacy of structures, methods for computing deflections, principles of virtual forces and displacements, theorem of stationary potential energy with applications to equilibrium and buckling problems, statically indeterminate structures. Matrix analysis of structures using force and displacement methods. Introduction to plastic analysis, stability of equilibrium, and plastic buckling of columns.
J. H. Williams, Jr., P. C. Xirouchakis

2.072 Mechanics of Continuous Media (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Principles and practical application of continuum concept for deformation of solid, fluid, or multiphase bodies. Kinematics and thermomechanical conservation laws through comprehensive (dyadic) tensor notation. Emphasis on physical consistency in formulating constitutive equations and on solution of basic problems for each material considered, as relevant in metallurgy, materials processing, geomechanical and fluid dynamical phenomena, fracture mechanics and structural analysis (e.g., thermoporoelastic, allowably pressure-sensitive plastic materials, local and diffusional solid creep, fluid flow). Analytical and numerical solution methodology for differential and integral equations (e.g., fundamental solutions and finite-element interpolation), variational and bounding criteria. (Alternate years. ***Offered 1981-82.***)
M. P. Cleary

2.073 Solid Mechanics — Plasticity and Inelastic Deformation (A)

Prereq.: 2.01; 2.30 or 2.31, 2.32
Year: G (1)
3-0-9

Focuses on the analysis of inelastic deformations of solids. Concepts in the idealization and generalization of inelastic behavior observed in simple laboratory tests, such as rate-independence, yield criteria and convexity, flow rules and normality, and material stability, introduced, with an emphasis on relations among such concepts when viewed from microscopic, continuum, or discrete structural levels. The bounding theorems of limit analysis applied to problems in continua (e.g. slipline theory), structures (beams, plates) and polycrystalline aggregates (Taylor/Bishop-Hill). Variational formulations of governing equations developed with a brief discussion of finite element implementations. Some plasticity aspects of fracture mechanics noted. Introduction to finite inelastic deformation. (See also, 13.131 and 16.24. Alternate years. ***Not offered 1981-82.***)
D. M. Parks

2.074 Applications of Mechanics for Porous/Geological Materials (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Unified treatment of governing equations for deformation and failure in bodies produced by geological processes (e.g., rocks, soils) or in other porous media (e.g., sponges, biological materials, ice). Extension of continuum mechanics concepts to theories for fluid-infiltrated porous media: coupled heat/fluid flow and solid deformation/frictional yielding/fracture. Basis for adequate constitutive relations, choice of continuum element, micromodeling with internal variables, resulting idiosyncracies of structural analysis, warping and localization instabilities. Useful solution techniques, numerical superposition, finite element methods. Laboratory simulation of in-place conditions. Examples taken from areas of energy and materials resource prospecting and extraction from underground: response around inclusions and cavities, borehole stability, oil/gas well hydraulic fracturing, geothermal energy, forces and power in mechanical indentation/excavation, wave propagation and blasting; from ge-

ology/geophysics: earthquake mechanisms, glacial structures and igneous intrusions; and from biomechanics: consolidation in cartilage and animal/fruit/vegetable flesh.
M. P. Cleary

2.083 Applied Elasticity (A)

Prereq.: 2.01, *18.075*
Year: G (1)
3-0-9

Introduction to basic concepts and special methods in linear elasticity. Review of fundamentals: stress, strain, tensors, etc. Simple problems: tension, flexure, thick pressure vessels. Torsion of noncircular cross sections. Energy theorems and applications. Planar problems with analytic function theory: holes, cracks, point loads, dislocations. Fundamental three-dimensional problems; contact problems. Introduction to elastic stability. Introduction to plate theory.
D. M. Parks

2.084J Structural Mechanics in Nuclear Power Technology (A)

(Same subject as 1.565J, 3.82J, 13.14J, 16.261J, 22.314J)
Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Structural components in nuclear power plant systems: their functional purposes; mechanical, thermal, and nuclear operating conditions; mechanical-structural design requirements. Mechanics of continuous media are combined with models of material behavior to determine adequacy of component design. Effects which are considered include: mechanical loading, hydraulic forces, elevated temperatures, and neutron irradiation; normal operation, accident situations, and seismic effects. Lectures given by several members of Institute faculty and by guest lecturers from nuclear power industry.
A. S. Argon, O. Buyukozturk, P. C. Xirouchakis, J. E. Meyer, R. M. N. Pelloux, T. H. H. Pian

2.092 Methods of Engineering Analysis (A)

Prereq.: 18.075
Year: G (1)
3-0-9

Study of nature of complex problems in engineering analysis and of means of obtaining practical solutions. Formulation of mathematical models for complex physical situations and organization of computational programs for their solution. Examples chosen from mechanics, hydraulics, heat transfer, elasticity, compressible flow, etc. Numerical methods including iteration, variational, finite difference and finite element methods.
S. H. Crandall, K. J. Bathe

2.093 Computer Methods in Dynamics (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Formulation of finite element and finite difference methods for analysis of linear and nonlinear dynamic problems in solid, structural, and fluid mechanics. Computer numerical solution of dynamic equilibrium equations by mode superposition and direct integration. Study of modern effective direct integration methods considering stability and accuracy. Study of modern effective eigensolution techniques for calculation of frequencies and mode shapes. Digital computer coding techniques appropriate to solution of dynamic problems and use of an existing general purpose dynamic analysis program. Interpretation of numerical results. Methods studied are modern computational procedures applicable to wide classes of problems in solid, structural, and fluid mechanics, heat and mass transfer. Some application areas are forced vibration analysis, earthquake engineering, nuclear reactor analysis, offshore technology, energy resource recovery, pollution control. ***(Not offered 1981-82.)***
K. J. Bathe

2.094 Theory and Practice of Continuum Mechanics (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Basic principles of continuum mechanics, modern application to solution of practical problems in solid, structural, and fluid mechanics, heat and mass transfer, other field problems. Kinematics of deformation, strain and stress measures, constitutive relations, conservation laws, virtual work, and variational principles. Discretization of governing equations using finite element methods, and surface integral equation techniques. Solution of central problems using existing computer programs.
K. J. Bathe, M. P. Cleary

System Dynamics and Control

2.10 Elementary Programming and Machine Computation

Prereq.: —
Year: U (1, 2)
2-1-6

Use of digital computers in engineering and scientific problem solving. FORTRAN is taught since it is the most widely used and available scientific programming language. Methods of digital computation, algorithm formulation, elementary numerical techniques, use of plotting and library programs discussed. Problems include examples from mathematics, physics, and engineering. Emphasis placed upon "hands-on" use of the Joint Mechanical/Civil Engineering Computer Facility. Assumes no prior computing experience.
I. Paul

2.101 Computer Models of Physical and Engineering Systems (Revised Unit)

Prereq.: 18.02, 8.01
Year: U (1) SD
3-0-9

Reduction of physical and engineering systems to simplified physical and mathematical models; representation using networks, graphs, and finite element methods. Process simulations using random variables (Monte-Carlo techniques) and Linear and Dynamic Programming. Manipulation of resulting models using algorithms on digital computers. Examples drawn from fields primarily of interest to scientists and engineers, with some attention to styles of problem solving. Extensive "hands-on" computing experience. (Working knowledge of FORTRAN expected.) This subject is an Engineering School-Wide Elective.
B. Schumacker, R. Kaplow, K. J. Bathe

2.120J Transportation Performance and Technology (A)

(Same subject as 1.290J, CTS 140J)
Prereq.: CTS 100J
Year: G (2)
3-0-6

Transportation system performance measures: energy, pollution, safety, noise, ride quality, speed, reliability. Vehicle technology: propulsion systems, vehicle dynamics (ground, ocean, and air vehicle performance), automatic control and guidance. Vehicle flow in channels: traffic flow, scheduled carrier flow. Intersections and terminals: nonsignalized intersections, queueing phenomena, terminal operations. Transportation Networks — the traffic assignment problem. Operation Plans —

scheduled carrier networks. (Subject assumes knowledge of probability and statistical inference at an introductory level.)
J. K. Hedrick, Y. Sheffi

2.131 Ecodynamic Systems I

Prereq.: 18.02
Year: U (1) SD
2-1-6

Introduction to models of ecosystem structure and function. Consideration of three ecosystem modeling paradigms: 1) population dynamics (biodemography), 2) element-cycle dynamics (biogeochemistry), and 3) trophic dynamics (bioenergetics). Use of linear graphs and principles of conservation and causality to formulate mathematical models. Analysis and simulation of steady-state and perturbed behaviors of simple models. Examination of environmental regulatory mechanisms and ways in which human activities may disrupt them. Computer simulation lab.
A. V. Quinlan

2.132 Ecodynamic Systems II

Prereq.: 18.02
Year: U (2) SD
3-0-6

Introduction to dynamics and control of environmental pathologies. Use of linear graphs and principles of conservation and causality to reveal biogeochemical mechanisms and formulate mathematical models. Case studies: bioaccumulation of toxic chemicals, eutrophication, global heat balance.
A. V. Quinlan

2.14 Control System Principles

Prereq.: 2.02
Year: U (1, 2)
3-2-7

Introduction to analysis and synthesis of feedback systems. Functional description of linear and nonlinear systems. Block diagrams and signal flow graphs. State-space representation of dynamical systems. Transient response using convolution integral and computational techniques. Root locus and frequency response methods. Performance indices and error criteria. Controller realization. Examples of pneumatic, hydraulic, electronic, and electromechanical control systems.
D. N. Wormley, P. K. Houpt, H. M. Paynter

2.141 Modeling and Simulation of Dynamic Systems (A)

Prereq.: 2.151
Year: G (2)
3-0-9

Modeling of complex linear and nonlinear energetic dynamic engineering systems. Emphasis on subdivision into simple multiport elements and representation by bond graph language. Field lumping. Analytic and graphical reductions. Analog, digital, and hybrid simulation using the M. E. Department computing facilities. Examples including mechanisms, electromechanical transducers, electric and fluid circuits, thermal systems, chemical and biochemical processes.
H. M. Paynter

2.151 Advanced System Dynamics and Control (A)

Prereq.: 2.02
Year: G (1, 2)
3-0-9

Analytical and graphical descriptions of state-determined dynamic physical systems; time and frequency domain representations; system characteristics: controllability, observability, stability; linear and nonlinear system responses. Modification of system characteristics utilizing control techniques; feedback and compensation techniques; optimal control of linear systems; Pontryagin's Maximum Principle. Emphasis on application of techniques to physical systems.
D. N. Wormley, H. M. Paynter

2.152 Modern Control Theory and Applications (A)

Prereq.: 2.151 or 6.231 or 16.31
Year: G (2)
3-0-9

Application of linear-quadratic-Gaussian (L-Q-G) method to design multiple input-multiple output control systems. Response of linear dynamic systems to Gaussian inputs presented including propagation of mean and covariance as well as frequency domain description of stationary processes. Classical control methods including consideration of random disturbances. Deterministic linear-quadratic design including optimal integrators, full and reduced order observers, and state-of-the-art numerical methods. Kalman filtering and stochastic optimal control. Emphasis throughout the course is on practical application of modern control principles to engineering design.
J. K. Hedrick

2.153 Nonlinear Analysis and Control Methods (A)

Prereq.: 2.151 or 6.231 or 16.31
Year: G (1)
3-0-9

Introduction to typical nonlinearities encountered in physical systems. Fundamental properties of nonlinear systems such as multiple equilibrium points, limit cycles and jump resonance. Phase plane analysis of second order systems. Analysis of system stability using Lyapunov methods. Time scaling and transformation methods. Frequency domain stability criteria including the Popov and circle criteria. Sinusoidal describing function methods for limit cycle and forced response prediction. Design of control systems using Popov and describing function methods. Application of statistical linearization methods to predict forced response of nonlinear systems to random inputs.
J. K. Hedrick

2.154 Dynamics and Control of Rotating Machine Systems (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Unified study of dynamic behavior and control of systems of interconnected rotating machines, as typically used for power and propulsion, and for instrumentation and control. Modeling and simulation of electromachines (AC and DC motors and generators), turbomachines (pumps, compressors, fans, blowers, screws and steam, gas and hydraulic turbines) and recipromachines (i.c. engines, p.d. pumps, steam engines), together with their energy sources, power modulators and control equipment. Detailed investigations and case studies of a number of particular machine systems. Subject intended for qualified students concerned with plant utilities and services, test facilities, power and propulsion systems, as well as for those interested in automatic control applications. (Alternate years. ***Not offered 1981-82.***)
H. M. Paynter

2.155 Dynamics and Control of Thermofluid Processes and Systems (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Unified study of dynamic behavior and control of complex systems of interconnected thermal and fluid elements, as typically encountered in industrial processes, power and propulsion systems, and systems for environmental control. Discussion of representative examples in-

cluding heat pumps, drying ovens, steam generators, fossil and nuclear power plants, and distillation columns. Review of fundamental physical principles with emphasis on mass, momentum, and energy balances in lumped and distributed representations. Introduction of a primitive set of thermofluid elements as unit operations. Modeling and dynamic simulation of system components, together with design and performance of complete systems. Detailed case studies of actual plants and processes. (Alternate years. ***Offered 1981-82.***)
H. M. Paynter

2.157 Computer-Aided Design (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Use of computers to aid design and manufacturing functions. Geometry: representation of three-dimensional objects, reticular surfaces, Coons' patches, splines. Interactive graphics system components: storage and refresh CRT displays, data tablets, and software. Three-dimensional rotation, translation and perspective transformations, hidden-line removal. Review and discussion of state-of-the-art CAD systems. Emphasis on development and usage of systems for computer-aided design. FORTRAN proficiency required.
D. C. Gossard

2.158 Vehicle Dynamics (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Application of dynamic and system analysis techniques to ground transportation vehicles. Equations of motion including rigid body and flexible modes are formulated via Newtonian and LaGrangian methods. Guideway and aerodynamic inputs to vehicle are described both statistically and deterministically. Digital simulation methods for random and deterministic, linear and nonlinear systems. Linear frequency domain transfer function/spectral density methods. Performance criteria such as ride quality, stability, tracking and handling. Suspension design of both active and passive systems. Rubber tire and steel wheel/steel rail dynamics. Dynamic model validation and parameter identification methods.
J. K. Hedrick

2.161 Computer-Controlled Experimentation (A)

Prereq.: 2.14 or 2.151
Year: G (2)
3-0-9

State-of-the-art techniques involving use of digital and analog computers to monitor and control physical processes. Specific topics include introductions to analog and digital hardware at the computing module level, programming techniques for digital minicomputers in real-time on-line applications and fundamental topics in signal conditioning and data reduction. Students should be able to program in FORTRAN and to set up elementary simulations on an analog computer.
D. Rowell, P. K. Houpt

2.171 Analysis and Design of Computer Control Systems

Prereq.: 2.151
Year: G (1)
3-3-6

A comprehensive introduction to control system synthesis in which the digital computer plays a major role, reinforced with hands-on laboratory experience. Topics include: elements of real-time computer architecture; I/0 operations and interrupts; A/D and D/A conversion methods; number systems and their relevance in real time control. Analysis of systems described by linear difference equations; z-transforms; continuous-discrete sampled data systems from both state space and transfer function viewpoint. Review of classical control synthesis and its extension to discrete time case; discrete linear quadratic control; pole-zero placement and observer-based compensators. Emphasis on design with practical control actuators, including electro-hydraulic and electro-pneumatic devices, with analysis of inherent and parasitic nonlinear effects. (Permission of instructor required for other than 2.151 background.)
P. K. Houpt

2.173 Instrumentation for Measurement, Analysis and Control (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Case studies of instrumentation for measurement, analysis and control selected from research and industrial examples. Measurement of primary quantities (temperature, pressure, flow, composition, force, motion, position). Resolution, accuracy, and statistical evaluation of measurements. Analog and digital techniques for data acquisition, processing, transmission, storage, and display. Dynamic measurements and control of industrial processes. Economics, reliability and failure analysis in instrument design.
C. F. Dewey, Jr.

2.18J Man-Machine Systems (A)

(Same subject as 16.355J)
Prereq.: Permission of Instructor
Year: G (2)
3-3-6

Introduction to modeling, design, and evaluation of human-operated systems. Relevant theories of communication, decision, and control. Readings from the human factors engineering literature. Design of displays and controls, as applied to aircraft and space vehicles, undersea and industrial robotics, nuclear power plants and various person-computer interactions. Illustrative laboratory experiments and demonstrations using human subjects. An understanding of elementary dynamics assumed. Text: Sheridan and Ferrell, *Man-Machine Systems.*
T. B. Sheridan, Y. Y. Zeevi

2.192 Engineering Systems Analysis (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-6

Synthesis of analytic procedures for the identification and selection of optimal systems. Review of economic framework for analysis. Systematic survey of theory and applications of mathematical optimization to engineering problems. Evaluation procedures for single and multiattributed problems covering utility theory and decision analysis in addition to standard procedures. Application of this material to real problems in planning and design stressed throughout term. (Open to qualified undergraduates. Knowledge of probability, microeconomics, and computer systems at an undergraduate level required.) This subject is an Engineering School-Wide Elective.
R. de Neufville, J. P. Clark

Fluid Mechanics and Combustion

2.20 Fluid Mechanics

Prereq.: 8.02, *18.03*
Year: U (1, 2) SD
4-0-8

An introduction to incompressible flows. Hydrostatics. Mass conservation equation. Differential equation of motion for inviscid flows. Bernoulli's equation. Linear and angular momentum theorems and applications to engineering problems. Vorticity and potential flows.

Equations governing viscous fluid flow, and some special solutions. Dimensional analysis and modeling, with application to flow problems. Flows with head losses and gains in ducts and pipes. Boundary layers and separation. Drag and lift.
A. A. Sonin, H. M. Paynter

2.21 Applications in Fluid Mechanics

Prereq.: 2.20, *2.40*
Year: U (2)
3-0-9

Application of fluid mechanics to specific problem areas such as lift and drag, flow in open and closed conduits, boundary layers, separation. Includes a review of fundamentals, with emphasis on order-of-magnitude estimates, similarity laws, and modeling. Introduction to steady compressible flow. One- and two-dimensional subsonic and supersonic flows, shock waves, friction. Applications in propulsion. Wave phenomena and their solution by the method of characteristics. Introduction to turbulence: length scales, momentum diffusivity, Reynolds stresses. Applications in turbulent shear flows.
P. W. Huber, H. M. Paynter

2.25 Advanced Fluid Mechanics (A)

Prereq.: 2.20, *18.075*
Year: G (1)
3-0-9

Survey of principal concepts and methods of fluid dynamics. Statics. Fluid kinematics. Continuity, momentum, and energy relations for continuous fluids. Vorticity dynamics. Circulation. Kelvin's and Helmholtz' theorems. Dynamical similarity in fluid flows. Navier-Stokes equations for viscous fluids and applications. Lubrication theory. Boundary layer theory, including separation and other examples of shear flow phenomena. Introduction to turbulence. Drag. Lift.
A. H. Shapiro, A. A. Sonin

2.271 Compressible Fluid Mechanics (A)

Prereq.: 2.20, 2.40
Year: G (2)
3-0-9

Fundamental survey of compressibility effects in transient and steady flows, with examples drawn from engineering practice. Review of governing principles and equations. Steady one-dimensional flows with area change, stationary shock waves, friction and heat transfer. Unsteady one-dimensional flows: wave phenomena and their solution by the method of characteristics. Compressible flow transients in ducts, including water hammer effect, flows with shock and rarefaction waves, and some compressibility effects in two-phase flows. Steady, two-dimensional flows: subsonic high-speed flow and application of the method of characteristics to supersonic flows.
A. H. Shapiro, T. Y. Toong

2.272 Laminar Flows and Stability (A)

Prereq.: 2.20
Year: G (1)
3-0-9

Viscosity and dissipative phenomena. Navier-Stokes and energy equations, their formulation, properties, and some exact solutions. Low Reynolds number flows including lubrication, two-phase, and porous media flows. High Reynolds number flows and laminar boundary layers. Integral methods and singular perturbation methods. Separated flows, wakes, and jets. Stratified flows and wave motions. Hydrodynamic instabilities and transition. Linear stability theory for Couette and boundary layer flows.
R. F. Probstein

2.273 Turbulent Flow and Transport (A)

Prereq.: 2.25 or 2.272
Year: G (2)
3-0-9

Turbulent flows, with emphasis on engineering methods. Governing equations for momentum, energy and species transfer. Turbulence: its production, dissipation, and scaling laws. Averaged (Reynolds) equations for momentum, energy, and species transfer. Simple approaches (mixing length, effective viscosity) for free and bounded turbulent shear flows: jets, pipe and channel flows, boundary layers, plumes, dispersion problems, etc., including heat and species transport as well as flow fields. Introduction to more complex closure schemes and statistical methods in turbulence; examples of applications.
A. A. Sonin

2.275 Turbomachinery Design (A)

Prereq.: 2.20 or 2.25; 2.40 or 2.41J
Year: G (1)
3-0-9

Momentum transfer in turbomachines. Axial compressors and turbines: design considerations, cascade aerodynamics including effects of viscosity and compressibility, three-dimensional flow, performance limitations; radial machines; hydraulic pumps and turbines; cavitation. (Alternate years. ***Offered 1981-82.***)
D. G. Wilson

2.277 Biomedical Fluid Mechanics (A)

Prereq.: 2.20
Year: G (2)
3-0-9

Engineering approach to the function of circulatory, respiratory, reproductive, and urinary systems. Review of relevant anatomy and physiology with particular emphasis on quantitative considerations. Mathematical or engineering models presented and discussed in relation to physiological phenomena they intend to simulate. Comparative descriptions of artificial organs (heart assist devices, blood oxygenators, artificial kidneys). Medical instrumentation related to fluid flow. Directed to graduate students in Engineering and Science, but open to medical students and undergraduates with the permission of the instructor.
R. D. Kamm

2.281 Reacting Gas Dynamics (A)

Prereq.: 2.20 or 16.02
Year: G (1)
3-0-9

Fundamental treatment of problems in non-equilibrium gas dynamics involving simultaneous occurrence of chemical reaction and transport of mass, momentum, and energy. Applied chemical kinetics. Conservation equations considering chemical reaction and multispecies diffusion. Relaxation phenomena. Method of characteristics for non-equilibrium flows. Acoustic waves, shocks, flames, detonations; their propagation and structure. High-temperature gas flow in jets, nozzles, hypersonic boundary layers. Chemical effects on turbulence. Engineering applications. (Alternate years. ***Not offered 1981-82.***)
T. Y. Toong

2.282 Combustion (A)

Prereq.: 2.20 or 16.02
Year: G (1)
3-0-9

Comprehensive treatment of combustion principles and their applications. Topics emphasized varying from year to year. Fire research. Engine combustion. Combustion instability, linear and nonlinear mechanisms, interactions of acoustic waves with nonuniform and fluctuating reacting flows. Laminar and turbulent flames. Exothermic hypersonic flows. Supersonic combustion. Reacting boundary layers with ablation. (Alternate years. ***Offered 1981-82.***)
T. Y. Toong

2.284 Water Purification (A)

Prereq.: 2.20, 2.40
Year: G (1)
3-0-9

Introduction to water resources, water quality parameters and pollutants. Outline of various water purification processes and economic considerations for water supply and wastewater treatment. The physics and chemistry, fluid and thermodynamics of biological and chemical treatment; coagulation, flocculation and sedimentation; filtration, adsorption and ion exchange; ultrafiltration and reverse osmosis; electrodialysis; distillation and freezing. Process dynamics and economics included as an integral part of each major topic. (Alternate years. ***Not offered 1981-82.***)
R. F. Probstein

2.285 Mixing and Reaction in Turbulent Flows (A)

Prereq.: 2.20, *2.25*
Year: G (1)
3-0-9

A fundamental treatment (leading to practical models of mixing and reaction in turbulent flows. Behavior of turbulent shear flows with and without mixing and reaction. Size and scale of turbulent fluctuations; gross features of premixed and diffusion flames. Fundamental processes and governing equations. Averaged equations and closure problems. Turbulence models: effective viscosity; mixing length; kinetic energy and dissipation equation; model equations for transported scalars. Solutions of model equations: comparison with experiment. Probability density function (pdf) and its use in reactive flows. Assumed pdf's for mixing-limited reaction. Stochastic model of reaction in homogeneous turbulence. (Alternate years. ***Not offered 1981-82.***)
S. B. Pope

Materials

(See also listing under Polymers and Fibers)

2.301 Advanced Mechanical Behavior of Materials (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Dependence of stress on strain, time, temperature, and material, including an introduction to its physical basis: elasticity, viscosity, rubber elasticity, plasticity, and creep. Shift factor and superposition for viscoelasticity. Linear elastic and plastic fracture mechanics. Statistics and size effect in brittle fracture. Fatigue crack initiation and growth. Hardness, erosion, damping, friction, and wear. High strength materials and composites. Materials selection and failure analysis. Background of introductory subjects in mechanics and materials required. 2.333J recommended for students who have had 2.30. Text: F. A. McClintock, A. S. Argon, *Mechanical Behavior of Materials.*
F. A. McClintock

2.31 Mechanical Behavior of Materials I

Prereq.: 2.01
Year: U (1)
3-1-5

Introduction to mechanical behavior of engineering materials emphasizing a combined materials science and continuum mechanics approach. Basic concepts of structure of metals, ceramics, polymers and composites, phase equilibria, microstructure and heat-treatment. Rate-independent constitutive behavior of materials. Microscopic and continuum analysis of elastic and plastic deformation with applications to selection of materials for engineering applications. Survey of materials in engineering use. Laboratory experiments involving a variety of materials, testing methods, and analyses, and a preliminary study of a special project. (Requires competency in 2.01. Recommended that it be taken in term following 2.01.)
A. S. Argon, F. A. McClintock, K. J. Bathe

2.32 Mechanical Behavior of Materials II

Prereq.: 2.31, *2.86*
Year: U (2)
3-1-5

Combined materials science and continuum mechanics treatment of rate-dependent deformation and failure in engineering materials. Analysis of viscoelastic and creeping deformation with applications to metals, ceramics, polymer and composites. Simple concepts of linear elastic fracture mechanics applied to monotonic and fatigue failure. Topics include time-dependent plastic deformation, viscoelasticity, electrochemistry and corrosion, fracture, fatigue, friction and wear. Diagnosis and cure of material failures; case studies. Project laboratory provides opportunity for independent research into mechanical behavior. (Competency required in 2.31 and taken in term following.)
A. S. Argon, F. A. McClintock, K. J. Bathe

2.332J Physics of Deformation and Fracture of Solids I (A)

(Same subject as 3.25J)
Prereq.: 2.01, 2.30 or 2.31, 2.32
Year: G (1)
3-0-9

Derivation from the theory of elasticity of the properties of dislocations in isotropic and anisotropic crystals. Line properties of dislocations. Dislocations in particular crystal structures. Interaction of dislocations with point defects, and climb. Hardening by localized obstacles — yield stress of solution, precipitation, and dispersion hardened alloys. Work hardening in pure metals and particle hardened alloys.
A. S. Argon, W. S. Owen

2.333J Physics of Deformation and Fracture of Solids II (A)

(Same subject as 3.26J)
Prereq.: 2.01, 2.30 or 2.31, 2.32
Year: G (2)
3-0-9

Rate mechanisms in crystal plasticity, kinetics and dynamics of slip, superposition of mechanisms controlling the yield stress. Mechanisms of non-elastic deformation in non-metals, viscoelasticity and plasticity of metallic inorganic and polymeric glasses, plasticity of crystalline polymers. Macroscopic plasticity in metals and polymers, flow stress of polycrystals. macroscopic yield conditions and associated flow rule with application to localization of deformation in rate and pressure sensitive materials. Criteria of fracture in metals and polymers, nucleation and localization of fracture. ***(Not offered 1981-82.)***
A. S. Argon, W. S. Owen

2.34J Deformation and Fracture Mechanics of Engineering Alloys

(Same subject as 3.144J)
Prereq.: 2.01, 2.30 or 2.31, 2.32
Year: U (2)
4-0-8

Understanding and prevention of fracture of engineering alloys in service depends upon integration of basic concepts in materials science and solid mechanics. Fundamentals of these disciplines applied to selected subjects in fracture. Major topics include linear elastic, elastic-plastic, and fully plastic fracture mechanics, fatigue, creep rupture and creep crack growth, and environmentally assisted fracture. In each case, emphasis placed on connecting the microscopic fracture mechanisms with appropriate macroscopic (continuum) characterizations. ***(Not offered 1981-82.)***
D. M. Parks, R. M. N. Pelloux

Thermodynamics and Statistical Mechanics

2.40 Thermodynamics

Prereq.: 8.02, *18.03*
Year: U (1, 2) SD
4-0-8

Classical thermodynamics with emphasis on relation of abstract concepts to physical situations. Work and energy for pure conservative and pure dissipative systems. Heat, temperature, first law of thermodynamics. Pure thermal systems. Equilibrium and reversibility. Thermodynamically coupled systems, second law of thermodynamics, thermodynamic temperature, entropy. Bulk flow and open systems. The pure substance, solid, liquid, and gaseous phases. Applications to engineering systems.
J. L. Smith, Jr., J. B. Heywood, H. M. Paynter

2.41J Thermodynamics of Power Systems

(Same subject as 13.25J)
Prereq.: 2.40
Year: U (2)
3-0-9

Application of thermodynamics to power-generating systems. Thermodynamics of combustion and mixtures of gases. Analysis of Carnot, Rankine, Brayton, Otto, and Diesel cycles. Availability. Performance of modern steam plants, gas turbines, internal combustion engines, refrigeration plants, marine power plants. Economic and pollution aspects. New power generation concepts, such as fuel cells, MHD, vapor engines, solar, wind, tidal.
J. B. Heywood, J. L. Smith, Jr., A. D. Carmichael, H. M. Paynter

2.451J General Thermodynamics I (A)

(Same subject as 22.571J)
Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Presentation of foundations of thermodynamics in a general way, followed by application of thermodynamic principles to energy conversion systems and industrial processes. First part: the first and second laws are introduced together with definitions of work, energy, stable equilibrium, available work, entropy, thermodynamic potentials, and interactions (work, nonwork, heat, mass transfer). Second part: thermodynamic analyses of stable equilibrium properties of materials, bulk flow, energy conversion processes, chemical equilibria, combustion, and industrial manufacturing processes.
E. P. Gyftopoulos

2.452J General Thermodynamics II (A)

(Same subject as 22.572J)
Prereq.: 2.451J or 22.571J
Year: G (2)
3-0-9

Continuation of application of thermodynamic principles to practical problems, followed by a presentation of quantum statistical foundations of thermodynamics. First part: thermodynamic analyses of ideal and nonideal solutions, electrolytes, surface phenomena, and gas-solid interfaces; linear rate processes and phenomenological equations. Second part: Gibbsian and quantum probabilities, and corresponding definitions of states. Derivations of canonical distributions, and Bose-Einstein, Fermi-Dirac, and Boltzmann statistics, and quantum-statistics of semiperfect and perfect gases, including one-particle systems, and Einstein and Debye theories of crystals.
E. P. Gyftopoulos

2.454J Thermoeconomics (A) (Revised Unit)

(Same subject as 10.808J)
Prereq.: Permission of Instructor
Year: G (1)
3-0-6

Thermoeconomics is a new method for the optimum design of a thermodynamic system. According to the method, a plant (power, chemical process, etc.) is divided into separate zones and a miniature economy is erected which governs the buying and selling of generalized availability from one zone to another. Proper transfer prices for interzonal trading are found from the Lagrangian of the system which guarantees that local optima coincide with plant optimum. Lectures cover generalized availability analysis, Lagrangian prices and their determination, methods of calculation for real systems, and computational techniques in thermodynamic analysis. ***Not offered 1981-82.)***
W. M. Rohsenow, J. B. Howard, M. Tribus

2.46 Thermodynamics and Statistical Mechanics of Rate Processes (A)

Prereq.: 2.452J or 6.018 or 8.08 or 2.404J or 5.62
Year: G (1)
3-0-9

Survey of rate processes important in combustion, energy conversion, materials processing, lasers, aerodynamics, and atmospheric physics. Topics included: atomic and molecular interactions; mechanics of collisions. Kinetic theory. Phase space representation of many particle systems; Liouville and Boltzmann equations. Transport properties of gases, and plasmas; diffusion, viscosity, thermal and electrical conduction. Internal excitation: rotational and vibrational relaxation; master and diffusion equations. Chemical reactions: dissociation and recombination, exchange reactions, unimolecular decay; rate controlled constrained equilibrium; phase space, transition state, and statistical theories; surprisal analysis; Monte Carlo methods. Gas-surface interactions: scattering, accommodation, and chemical reaction. Radiation processes: emission and absorption; transport; line broading. ***Not offered 1981-82.)***
J. C. Keck

Heat and Mass Transfer

2.51 Heat and Mass Transfer

Prereq.: 2.20, 2.40
Year: U (1, 2)
3-0-9

Heat conduction in solids; steady and transient states; finned surfaces. Heat and momentum transfer associated with laminar and turbulent flow of fluids in forced and free convection; fully developed flows and boundary layer development in ducts over flat plates and blunt bodies, through tube bundles and packed beds. Condensation. Boiling. Heat exchanger design; heat transfer in nuclear reactors. Radiative heat transfer. Mass transfer in stationary systems; mass transfer associated with laminar and turbulent flows.
B. B. Mikić, H. M. Paynter

2.54 Heat Transfer

Prereq.: —
Year: G (2)
3-0-3

Fundamentals of conduction, radiation of heat, and effects of convection, with applications to problems arising in practice. (Primarily for selected officers of US Navy and Coast Guard.)
W. M. Rohsenow

2.55 Advanced Heat Transfer (A)

Prereq.: 2.20, 2.40, 18.075
Year: G (1, S)
3-0-9

Review of analogies among heat, mass, and momentum transfer. Free and forced convection from theoretical and experimental viewpoint for laminar and turbulent flows in ducts and over flat plates and blunt bodies. Heat transfer coefficients at high velocities. Heat transfer-friction relationship in heat exchangers. Film and dropwise condensation. Boiling with forced and natural convection. Radiative heat transfer; heat transfer between surfaces, in absorbing media.
W. M. Rohsenow

2.56 Conduction Heat Transfer (A)

Prereq.: 2.40, *18.075*
Year: G (2)
3-0-9

Steady and transient-state heat conduction and mass diffusion for various boundary conditions. Solution of differential equations in rectangular, cylindrical, and spherical coordinate systems. Approximate methods: finite difference technique, analogies, fixed and floating random walk. Moving boundaries: problems in freezing and melting. Thermal stress resulting from nonuniform temperature distribution. Thermal contact resistance.
B. B. Mikić

2.57J Two-Phase Flow and Boiling Heat Transfer (A)

(Same subject as 22.36J)
Prereq.: 2.20 or 2.25 or 10.52; 2.51 or 2.55 or 10.50; or 22.312
Year: G (2)
3-0-9

Phase change in bulk stagnant systems. Kinematics and dynamics of adiabatic two-phase flow. Dynamics and thermodynamics of forced-convection two-phase flow with boiling and/or evaporation. Thermal and hydrodynamic stability of two-phase flows. Associated topics, such as condensation and atomization. Both water and liquid metal applications considered under each topic where data exists.
W. M. Rohsenow, P. Griffith, J. E. Meyer

2.58 Radiation Heat Transfer (A)

Prereq.: 2.40, *18.075*
Year: G (1)
3-0-9

Basic laws of thermal radiation. Radiation properties of solids; electromagnetic theory, dispersion, experimental results. Radiant interchange among surfaces separated by a transparent medium; non-gray surfaces specularly reflecting surfaces. Radiation properties of gases. Radiant interchange through absorbing, emitting, and scattering media; radiative equilibrium, combined radiation and conduction; combined radiation and convection; approximate methods of solution. ***(Not offered 1981-82.)***
E. G. Cravalho, M. G. O'Callaghan

Power Systems

2.601J Thermal Power Systems (A)

(Same subject as 13.26J)
Prereq.: 2.20; 2.40 or 2.402, 2.51
Year: G (2)
3-0-9

Design of thermal power system components and system optimization. Review of thermodynamics, gas dynamics, and heat transfer. Design of axial and centrifugal compressors and pumps, axial and radial inflow turbines, heat exchangers, evaporators, boilers and condensers. Problems and examples taken from the fields of space, electrical utility and marine power systems. Knowledge of elementary heat transfer and simple thermal power cycles assumed.
W. M. Rohsenow, A. D. Carmichael

2.615 Internal Combustion Engines (A)

Prereq.: 2.20, 2.40
Year: G (2)
3-0-9

Analytical approach to the engineering problems and performance analysis of internal combustion engines. Study of fluid flow, thermodynamics, combustion, friction, heat transfer and other factors affecting power, efficiency, and emissions. Design and operating characteristics of conventional, Wankel, and stratified charge spark-ignition engines, diesel and mixed cycle engines. Engine laboratory project. For graduate and selected undergraduate students.
J. B. Heywood

2.621 Gas-Turbine Design (A)

Prereq.: 2.20; 2.40 or 2.41J or 2.51
Year: G (1)
3-0-9

Application of engineering science to design and development of gas turbines. Thermodynamics and fluid mechanics of flow phenomena in turbines and compressors. Design of turbines, compressors, heat exchangers and combustion chambers. Operating characteristics of gas-turbine power plants in various applications. (Alternate years. ***Not offered 1981-82.***)
D. G. Wilson

2.63 Energy Production from Renewable Resources (A)

Prereq.: 2.20, 2.51
Year: G (2)
3-0-9

Basic elements of energy production from wind, solar light, ocean waves, tides and thermal gradients, geothermal gradients, and biomass. Significant physical properties of solar radiation, the atmosphere and the ocean which affect design and operation of energy-gathering machines and systems. System dynamics of production, storage, and demand. Elements of component design, including economic factors.
J. A. Fay

2.64 Synthetic Fuel Production (A)

Prereq.: 2.40 or 5.60
Year: G (2)
3-0-9

Methods and technologies for producing clean liquid, gaseous, and solid fuels from coal, oil shale, and tar sands. Topics included are: Resources. Properties and chemistry of raw and product fuels. Conversion fundamentals. State-of-the-art and developing processes including *in situ* conversions and integrated plant designs. Environmental considerations. Plant and production economics. Future requirements and developments. (Open to undergraduates by permission of instructor.)
R. F. Probstein

2.649 Low Temperature Refrigeration (A)

Prereq.: 2.40
Year: G (1)
3-3-6

Thermodynamic processes for producing low-temperature refrigeration. Problems of heat exchangers, insulation and rectification. Applications of low-level refrigeration to liquefaction of helium and to application of superconduc-

tors. Laboratory projects on related topics according to individual interests. (***Not offered 1981-82.***)
J. L. Smith, Jr.

2.65J Fluidization (A)

(Same subject as 10.651J)
Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Regimes of fluidization, slugging, spouted and particulately fluidized beds. Motion of a single bubble in fluidized beds. Bubble behavior and growth in a multi-bubble bed. Properties of emulsion phase in dense bubbling beds. Heat and mass transfer in fluidized beds. Gas-solid reactions. Treatment of particle ensembles. Conversion of gas in bubbling systems. Analysis of non-catalytic gas-solid reactions. Applications to heat exchangers and fluidized-bed combustors. (Alternate years. ***Offered 1981-82.***)
L. R. Glicksman, A. F. Sarofim

Experimental Engineering

2.671 Measurement and Instrumentation

Prereq.: 2.02
Year: U (1, 2) LAB
2-3-4

Experimental techniques for observation and measurement of fundamental system variables such as: displacement, force, pressure, temperature, flow, and acceleration. Emphasis on electrical measurement of these quantities, the associated instrumentation, and understanding of statistical and dynamic implications. Typical laboratory experiments involve: oscilloscopes, strain gages, accelerometers, chart recorders, lasers, hi-fi equipment, thermocouples, etc. Required background for lab projects developed in lectures with grading based primarily on lab reports. Six units may be applied to the General Institute Laboratory Requirement.
C. F. Dewey, Jr., N. H. Cook

2.672 Project Laboratory

Prereq.: *2.20, 2.40,* 2.671
Year: U (1, 2) LAB
1-3-2

Engineering laboratory subject for mechanical engineering juniors. Major emphasis on interplay between analytical and experimental methods in solution of research and development problems. Groups of three students work together on three problems during the term.
W. C. Unkel, N. H. Cook

Design

2.70 Introduction to Design

Prereq.: —
Year: U (1)
2-3-4

Introduction to design process in engineering, stressing creative approach. Problem definition and concept generation, visual thinking and graphical communication, design analysis and optimization. Familiarization with standard machine elements, design specifications, production techniques, and economic considerations. Instruction via case, project, and independent resource methods to simulate professional engineering practice.
W. C. Flowers, N. H. Cook

2.701 Drafting for Engineers

Prereq.: —
Year: U (1, 2)
1-2-1

Lectures and workshop sessions on basics of drafting as used to delineate engineering design information and data. Introduction to orthographic projection, sectional and auxiliary views, and techniques of dimensioning and tolerancing. Use of drafting tools explained and practiced in addition to orthographic and pictorial sketching techniques.
W. C. Flowers

2.72 Elements of Mechanical Design (New)

Prereq.: 2.01, 2.70
Year: U (1)
3-3-6

For students interested in additional background in mechanical design and practice. Examination and practice in the application of many mechanical design elements, including control components. Typically two or more individual design projects selected to employ a variety of machine elements, demanding integration into a functional and practical device. Topics include typical machine elements, power transmission elements, motors and prime movers, control elements, material selection, and assembly techniques. Emphasis on innovative as well as practical applications. Taken prior to 2.73, this subject enhances the design experience in the latter.
C. R. Peterson

2.73 Design Projects

Prereq.: *2.03J,* 2.20, 2.30 or 2.31, 2.40, 2.70
Year: U (2)
2-3-4

Practice in engineering design through projects specifically chosen to integrate significant portions of material covered in prerequisites. Typically, one group project and two individual projects. Emphasis on pursuing creative solutions to current, real, engineering design problems. Guest lecturers are invited to provide problem backgrounds and insights. Other lecturers address the breadth of topics involved in engineering design from analytical techniques to human-machine interactions, economics and patent laws.
C. R. Peterson, N. H. Cook

2.731 Advanced Engineering Design (A)

Prereq.: 2.73
Year: G (1)
3-3-6

Two distinct but symbiotic sections. First, involves the study of advanced topics in engineering design such as, optimization, reliability theory, kinematics and mechanisms, and human factors engineering. Also studied are design morphology, idea generation and creative problem solving, and development of sketching and presentation skills. Second, which runs concurrently, students design, build and test pieces of mechanical hardware for industrial clients. These projects serve as ongoing case studies of the design process. Two semesters required for design, assembly, and "debugging" of the mechanical devices. Interested students enroll in 2.731 for the fall semester and 2.732 for the following spring semester. During the fall, problems defined, solutions created and evaluated, and a detailed design generated. (Requires background of 2.73 or equivalent.)
W. P. Seering

2.732 Advanced Design Projects (A) (New)

Prereq.: 2.731
Year: G (2)
2-0-7

Continuation of 2.731. Class meetings include discussions of such topics as product liability and product safety, entrepreneurship, marketing of a product, patent applications, and methods of redesign. From parts built for them by the participating industrial clients, students assemble and "debug" the devices which they designed during the fall in 2.731. By the end of the semester, the devices are brought to

specification and are presented to the respective sponsors. (Permission of instructor required.)
W. P. Seering

2.741 Fundamentals of Mining Technology (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Essential features of mining operations, beginning with the nature and origins of orebodies, properties of materials, and a study of the geometry of mining in general. Mining methods and equipment now in use, in coal and other materials, with primary emphasis on underground operations. Safety and environmental considerations, including regulations for gassy mines. Study of force and energy requirements of basic excavation and fragmentation elements. Application of basic information to design and/or evaluation of innovative mining concepts. Study of potential for interplay between mining geometry and equipment design in development of new methods. This is a design- and applications-oriented subject which may be advantageously combined with analytical treatment offered in 2.074.
C. R. Peterson

2.742J Introduction to Mining and Mineral Technology (Revised Unit)

(Same subject as 1.384J, 3.095J, 12.043J)
Prereq.: —
Year: U (1)
3-0-6

A basic introduction to mining and the minerals industry with emphasis on state-of-the-art technology. Includes mineral exploration, surface and underground mining, extractive metallurgy, health and safety, and environmental considerations. Integration of diverse subject matter stressed. Guest lectures by a variety of faculty members, classroom discussions based on assigned reading.
R. G. Lundquist, C. R. Peterson, G. B. Baecher, R. G. Burns, J. F. Elliott

2.745J Interdisciplinary Design of Wave-Power Conversion Devices (New)

(Same subject as 13.442J)
Prereq.: Permission of Instructor
Year: G (2)
3-4-5

Analysis and design of devices for converting ocean wave power to electricity. Topics include a survey of previous work and inventions, a description of the wave environment, hydrodynamic performance, structural loading, turbines and other power conversion devices, and power storage. Lectures in these areas, followed by preparation of designs for each element, laboratory testing to validate the design elements and simulate the performance of a wave-power conversion device, and preparation of a final report. The subject is structured to examine the design of a wave-power conversion device for a particular site and application, e.g., a US Coast Guard light tower. (Alternate years. ***Not offered 1981-82.***)
D. G. Wilson, H. M. Paynter, A. D. Carmichael, J. N. Newman

Biomedical Engineering

(See also 2.277, 2.900J and 2.907)

2.75 Physiology and Biomechanics of Human Movement (A)

Prereq.: Permission of Instructor
Year: G (1)
3-3-6

Cybernetic study of anatomy-physiology and biomechanics of human manipulation and mobility. Components and integration of the human sensory, nervous, muscular, and skeletal systems as they relate to posture, gait, and manipulation. Biomechanics of muscle, bone, and skeletal joints. Description of normal human system leads to examples of pathophysiological conditions and of appropriate technological responses, i.e. amputation prosthesis, arthroidial joint deterioration and replacement, etc. Human performance measurement and sports medicine. Laboratory includes current research in Laboratory for Human Mechanics and Rehabilitation.
R. W. Mann

2.76J Ultrasound: Physics, Biophysics, and Technology (A)

(Same subject as 6.562J, HST 530J)
Prereq.: Permission of Instructor
Year: G (1)
4-1-7

Physics and technology of generation and detection of ultrasound. Transducers and arrays. Propagation and fields. Diagnostic, therapeutic, and processing applications in medicine and industry. State of the art of imaging and Doppler systems. Biophysics, biological effects, linear and nonlinear phenomena. Hazards and safety levels. (Alternate years. ***Not offered 1981-82.***)
P. P. Lele, F. R. Morgenthaler

2.761J Principles of Medical Imaging (A)

(Same subject as 22.56J, HST 561J)
Prereq.: Permission of Instructor
Year: G (2)
4-0-8

Principles of medical imaging including X-ray, nuclear medicine, ultrasound, NMR, emission and transmission computed tomography, and other modalities. Two-dimensional and three-dimensional imaging techniques and displays. Fundamentals of image formation, physiology of image perception, physics of radiation and ultrasound interaction and detection, and physics of NMR. Quantitation of images and reconstruction algorithms. Medical applications, biological hazards, and cost-benefit analysis of imaging modalities. A comprehensive term paper required.
P. P. Lele, G. L. Brownell, Staff

2.762J Non-Ionizing Radiations in Biomedical Sciences (A) (New)

(Same subject as HST 531J)
Prereq.: Permission of Instructor
Year: G (1)
4-1-7

Fundamental physics and biophysics, biological effects and mechanisms, hazards and safety levels of Laser, Microwaves, Ultrasound and Ultraviolet. Special emphasis on current techniques and applications in medicine and biomedical research. (Alternate years. ***Offered 1981-82.***)
P. P. Lele, Staff

2.77 Research in Biological Effects and Applications of Ultrasound and Other Non-Ionizing Radiations (A)

Prereq.: 2.76J
Year: G (1, 2)
Arr.

Opportunity for graduate students and advanced undergraduates desiring to pursue substantial theoretical or practical projects of their own choice or to conduct critical analysis of literature in this area. Details arranged on an individual basis.
P. P. Lele

2.78 Seminar on Rehabilitation Engineering Research and Practice

Prereq.: Permission of Instructor
Year: G (1, 2)
2-0-4

Seminar providing a broad contemporary overview of current research, professional roles, and conceptual framework in application of engineering to problems in rehabilitation medicine and their underlying pathophysiology. A critical review paper and an oral presentation related to a seminar topic required. Lecturers include authorities from the Boston area, including MIT and Harvard Medical School faculty, from the national and international research communities, and from students conducting research and participants in the seminar series.
M. J. Rosen, R. W. Mann

2.791J Quantitative Physiology: Cells and Tissues (Revised Unit)

(Same subject as 6.021J, HST 541J)
Prereq.: 2.02 or 6.002 or 6.071; 8.02; 18.03
Year: U (1)
4-2-6

Principles of mass transport, energy transduction, and electrical and mechanical signal generation in animal cells. Structure of biological membranes. Transport through biological membranes: diffusion, osmosis, solute flow, ion flow, active transport. Mechanics of connective tisssues (tendon, cartilage, blood vessels, and skin) and their analysis as fiber-reinforced composite materials. Electric properties of cells: equilibrium, resting, action, and junctional potentials. Electrical and chemical intercellular interactions. Mechanical properties of muscle. Conversion of electrical, chemical, and mechanical energy. Molecular basis of contraction. (Intended for juniors and seniors in engineering; others admitted by permission of instructor.)
I. V. Yannas, T. F. Weiss

2.792J Quantitative Physiology: Organ Transport Systems

(Same subject as 6.022J, HST 542J)
Prereq.: *2.791J*; 2.20 or 6.013
Year: U (1)
3-2-7

Application of principles of energy and mass flow to major organ systems of humans and other animals. Mechanisms of regulation and homeostasis. Anatomical, physiological, and pathophysiological features of cardiovascular, respiratory, and renal systems. Clinical instrumentation and prosthetic devices. Emphasis on those systems, features, and devices that are most illuminated by the methods of physical sciences. (Intended for juniors and seniors in engineering; others admitted by permission of instructor. May be taken concurrently with 2.791J.)
B. B. Mikić, R. D. Kamm, R. G. Mark

2.793J Quantitative Physiology: Sensory and Motor Systems

(Same subject as 6.023J, 16.351J, HST 543J)
Prereq.: 2.02 or 6.003 or 16.30
Year: U (2)
3-2-7

Studies of sensory and motor physiology with objectives of establishing quantitative models. Peripheral signal processing in eye, ear, and vestibular system. Physiology and psychophysics of audition, vision, orientation, and body stabilization. Organization of neuromuscular and proprioceptive systems at level of spinal cord reflex. Postural control and kinetics of movement. Supplemented by laboratory exercises. (2.791J Recommended background.)
R. W. Mann, L. S. Frishkopf, L. R. Young

Manufacturing

(See also 2.922)

2.800 Tribology (A) (New)

Prereq.. Permission of Instructor
Year: G (1)
3-0-9

Geometric, chemical, and physical characterization of surfaces. Various theories of friction and wear of metals, polymers, and ceramics. Brief survey of hydrodynamic, elastohydrodynamic, and boundary lubrication. Boundary and solid film lubrication. Rolling contact problems. Tribological problems in metal processing. Monitoring and diagnosis of friction and wear. Case studies.
E. Rabinowicz, N. P. Suh

2.810 Advanced Manufacturing Processes of Metals

(2.865)
Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Fundamentals of metal cutting, metal forming and non-traditional manufacturing processes. Reliability and accuracy of manufacturing processes and machine tools. Manufacturing economics. ***(Not offered 1981-82.)***
N. H. Cook, B. M. Kramer

2.820J Polymer Processing (A)

(2.867J)
(Same subject as 10.57J)
Prereq.: 10.301
Year: G (2)
3-0-9

Review of physicochemical properties, and mechanical and rheological behavior of polymers. Uses of polymers as adhesives, foams, coatings, engineered rigid plastics, and elastomers. Survey of processing techniques. Modeling, analysis and scale-up of extrusion, molding, thermoforming, calendering and mixing. Chemical aspects of polymer processing, e.g., degradative reactions, synthesis for separations, methods for cross-linking. Case studies in process syntheses. Relationship between selected processing techniques and properties of end products. Limitations of the present state of art. Assigned projects. (Alternate years. ***Not offered 1981-82.***)
N. P. Suh, L. Erwin, R. C. Armstrong, E. W. Merrill

2.830 Control for Manufacturing Automation (A) (New)

Prereq.: 2.14
Year: G (2)
3-0-9

Provides a background for the application of computer-based control system techniques to batch manufacturing automation problems. Centered around three groups of manufacturing devices or processes: 1) metal cutting, where complex machine-material interaction dynamics occur, 2) robotics for manufacturing, where multi-degree of freedom linkages must be controlled while interacting with a changing environment, and 3) metal forming, where intrinsic material properties strongly influence the control requirements. A brief review of

classical control concepts and the use of computers in control systems is followed by in-depth study of the modeling and control problems associated with each of these intrinsically different processes. In each case a "new-look" is taken rather than concentrating on current practice.
D. E. Hardt

2.840 Productivity Analysis and Improvement (New)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

The elements of productivity analysis at the level of a distinct organization; an office, a laboratory, a division, or a firm. Preparation, manipulation, and interpretation of economic productivity data. Techniques for evaluating the productivity of white-collar ("knowledge") workers. The role of automation, including its social effects. Productivity improvement strategies.
M. B. Packer

2.841 Elements of Manufacturing

(2.863)
Prereq.: —
Year: G (2)
3-0-9

An introduction to operating concepts and functions present in manufacturing. Intended for engineering and science students interested in careers related to manufacturing, but who do not intend to pursue management courses at the undergraduate level. Topics include industrial organization, types of productive systems, workforce management, capacity planning, scheduling, use and control of inventories, product quality control, plant layout and technological innovation. Case method of instruction, which emphasizes student participation in class discussion, used. Supplementary readings and field visits to manufacturing plants. (Intended for juniors, seniors and graduate students.)
R. T. Lund

2.66 Manufacturing Processes

Prereq.: —
Year: U (1, 2) LAB
3-3-3

Introduction to modern manufacturing techniques for metals and polymers. Lectures and laboratory projects illustrate capabilities and limitations of manufacturing methods, emphasize importance of cost in manufacturing, and point out interaction with other engineering disciplines such as design, stress analysis, material properties, and heat transfer. Topics include metal cutting, forming, casting, welding, powder metallurgy, heat treatment, polymer processing, and process analysis. (Six units may be applied to the General Institute Laboratory Requirement.)
B. M. Kramer, N. H. Cook, K. J. Bathe

Polymers and Fibers

2.900J Biomedical Materials

(Same subject as 3.101J)
Prereq.: 2.901J or 3.091 or 7.01
Year: U (2)
2-0-4

Introduction to science and engineering of materials used in a variety of medical applications such as sutures, orthopedic implants, artificial joints, blood vessel replacements, and artificial organs. Elements of structure and properties of polymers, ceramics and metals with emphasis on interaction with the human body. Histological analysis of connective tissue with emphasis on aspects related to materials science and engineering. Fracture, structure, and healing of normal and abnormal bone. Implantation problems: inflammation, thrombogenesis, rejection, resorption, corrosion, structural failure. Case histories. (Basic background in descriptive biology desirable. ***Not offered 1981-82.***)
I. V. Yannas, R. M. Rose

2.901J Introduction to Polymer Science and Engineering

(Same subject as 3.061J)
Prereq.: 3.091 or 5.41
Year: U (2) SD
3-0-9

Introduces principles of macromolecular synthesis and structure, their relation to properties of bulk polymers, and their application to polymer processing and design of engineering materials. Molecular weight and configurations of macromolecules. Polymer synthesis. Polymer processing. Elastic and viscoelastic deformation. Yielding and fracture. Electrical and optical properties. Polymeric composites.
I. V. Yannas, D. R. Uhlmann

2.907 Science and Engineering of Biological Membranes and Structural Tissue (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Covers biophysical design and function of the cellular membrane and of skin considered as a membrane. First part: an introduction to basic molecular components of the cellular membrane, models of membrane structure and experimental models of membrane proteins (valinomycin and gramicidin), Eisenman theory of ionic selectivity, allosteric control of proteins, and the molecular basis for active transport and vision. Second part: molecular biology of components of skin (collagen, elastin, mucopolysaccharides, protein polysaccharides), interaction of fibrous components with the protein polysaccharide matrix, physiological and pathological aspects of structural tissue, and an analysis of skin as an engineering composite material. Active and passive mass transfer properties of skin, role of skin in thermoregulation and medical problems caused by loss of cutaneous cover. ***(Not offered 1981-82.)***
I. V. Yannas

2.915 Clothing Comfort and Utility

Prereq.: —
Year: U (2)
2-0-4

Material and design of clothing as they affect functionality. Textiles used in construction of clothing and their mechanical, aesthetic, and thermal properties. Manufacturing technologies of textile and apparel industries. Physiology and human comfort. Thermal analysis of comfort for indoor and outdoor environments. (Alternate years. ***Not offered 1981-82.***)
S. Backer

2.921 Polymer Deformation and Fracture (A)

Prereq.: 2.30 or 2.31, 2.32
Year: G (2)
3-0-9

Chain structure of polymeric materials, free volume, and supramolecular structure. Crystallization by chain folded lamellae, spherulites, and the melting point. Molecular packing in glassy state, and glass transition (T_g). Rubbery behavior above T_g, and theory of rubber elasticity. Linear and nonlinear viscoelasticity below and above T_g; phenomenological and experimental approaches, recovery of deformation, and molecular theories. Phenomenology of plastic deformation in crystalline, and glassy polymers, molecular theories for yield-

ing, post yield extensions for intermediate and large strains, development of deformation textures, anisotropic yield conditions. Fracture in polymers, statistical damage accumulation. Crazing as a precursor to fracture, kinetics of nucleation of crazes, mechanics of craze extension, development and propagation of cracks. Fatigue in polymers under both static and cyclic loading.
I. V. Yannas

2.922 Fiber Processing Mechanics (A)

Prereq.: 2.01 or 3.11
Year: G (1)
3-0-9

Analysis of mechanical processes used to convert natural or synthetic fibers into useable forms such as bonded, twisted, woven, knitted, stitched, or tufted materials. Review of mechanical principles of textile technological processes used in fiber producing, textile, and apparel industries. Focus on mechanics of selected processes such as drafting, twisting, texturing, weaving, and knitting. Treatment of material-process interactions in steady state and during transient operation. Effect of process variables on product quality and performance. (Alternate years. ***Offered 1981-82.***)
S. Backer

2.924 Structural Mechanics of Fiber Assemblies (A)

Prereq.: 2.01 or 3.11
Year: G (1)
3-0-9

Interaction between the mechanical properties of polymeric fibers and their statistical variation, and the geometric configurations of fiber assemblies. Differential geometric models of twisted structures and of woven, knitted, and stitched materials. Consideration of influence of textile manufacturing process on local deviations from ideal geometry and their significance in product performance. Analysis of mechanical behavior as in tensile load-deformation, fabric tearing, abrasion, drape, pucker, curl, shear, yarn slippage, buckling, bending, and seam failure. (Alternate years. ***Offered 1981-82.***)
S. Backer

2.925 Textile Fibers: Structure and Chemical Modification (A)

Prereq.: 2.901J
Year: G (2)
3-0-9

Essential molecular properties of fiber-forming polymers. Properties related to development of fibrous structure, to processability in fiber manufacturing and in conversion of fibers to textile products (yarns and fabrics). Properties related to performance in application. Approaches to synthesis of fiber forming polymers and to change in fiber properties by chemical modification. Chemical modification in fiber manufacturing, and in textile products (finishing).
G. C. Tesoro

2.926J Materials Science of Polymers (A)

(Same subject as 3.93J)
Prereq.: 3.061J, 10.691
Year: G (1)
3-0-9

Consideration of structure and properties of polymers from viewpoint of materials science. Specific attention to polymerization processes, melt and crystal structures, crystallization from the melt and dilute solutions, rheology and relaxation behavior, rubber elasticity, mechanical properties, and effects of orientation and fillers on various properties. Strong emphasis on student participation in class discussion. (Alternate years. ***Not offered 1981-82.***)
G. C. Tesoro, D. R. Uhlmann

2.927J Materials Engineering of Polymers (A)

(Same subject as 3.97J)
Prereq.: 3.601J, 10.691
Year: G (1)
3-0-9

Consideration of engineering of polymers, tailoring molecular structure and process parameters to produce materials with desired end-use properties. Specific attention given to cellulosic polymers, thermosetting resins, thermally stable polymers, engineering thermoplastics, adhesives, formation of fibers, films, foams, and coatings, and flammability of polymers. Strong emphasis on student participation in class discussion. (Alternate years. ***Not offered 1981-82.***)
G. C. Tesoro, D. R. Uhlmann

Special Studies

2.941J Invention

(Same subject as 6.935J, 10.802J, 13.77J, 16.671J)
Prereq.: —
Year: G (1)
3-0-6

Process of invention is analyzed with intention of enhancing the skill of the student inventor. Instructions include the following phases of the process: a) technology observation to increase technology background of potential inventor; b) need analysis to define clearly requirements and limitations of needed inventions; c) parameter analysis, to focus attention of inventor on the important parameters of the problem and on potential solutions; d) creative step, to develop techniques for providing innovative solutions. Students encouraged to provide innovative solutions to invention needs of their own choice.
W. C. Flowers, A. D. Carmichael, D. G. Jansson, J. B. Howard

2.942 Entrepreneurship

Prereq.: —
Year: G (2)
4-0-5

Introduction to the various issues faced by technical innovators interested in becoming entrepreneurs. Lectures and discussions held on concept evaluation, patents, licensing, contract negotiation, marketing, business planning, financing, accounting and small business management. Students encouraged to use their own innovative ideas as object of study topics. This subject is an Engineering School-Wide Elective (open to undergraduates).
D. G. Jansson

2.943 Engineering Risk-Benefit Analysis (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Risk evaluation and cost-benefit analysis techniques for assessment of engineering projects involving risks. Emphasis on public sector. Balancing risks and benefits with concern for financial uncertainties, environmental risks, and, especially, issues of human safety. Introduction to decision analysis, value of information, problems with multiple goals, and issues related to collective decisions. Issues of public policy and regulation. Case studies with attention to the nature of public discussion. Cases drawn from dam safety, safety of nuclear reactors, transport and storage of liquefied natural gas, seismic risk problems, and offshore oil exploration. Some background in elementary

probability assumed. (This subject is intended mainly for graduate and upperclass students in the School of Engineering, and is an Engineering School-Wide Elective subject.)
M. E. Patè, A. W. Drake

2.95 Innovation and Industrial Development

Prereq.: —
Year: U (1)
3-0-6

Recognition of regularities in the pattern of product and process change, types of change required and likely sources of change in different industry and national settings (for example, continuous processes, consumer durables, mass produced consumer goods, assembled industry products; in US, Japan, and Brazil). Familiarity with evolution of design criteria and product planning requirements as technical market uncertainties change. Practice with basic management and design process change. Participants discuss current research findings and case materials. Designed to help the graduate who must develop a new product or process or who must manage and implement a change in either an existing or a new business. (Intended for seniors and graduate students.)
T. B. Sheridan, J. M. Utterback

2.951 Engineering Internship

Prereq.: —
Year: U (1, 2, S)
0-6-0

Approximately six months over two summers of practical work carried out by the students in manufacturing, engineering, research, and development at industrial plants. Credit awarded after evaluation and approval of the actual work performed.
I. Paul

2.952 Advanced Engineering Internship (A) (New)

Prereq.: 2.951
Year: G (1, 2, S)
0-6-0

Continuation of 2.951 by students admitted to the department's graduate program. Credit awarded after evaluation and approval of the actual work performed during approximately seven months of practical work at an industrial plant.
I. Paul

2.96 Management in Engineering

Prereq.: —
Year: U (1)
3-0-9

Introduction to the concepts of management of the engineering function, as found in a variety of industrial and non-industrial settings. Aim is to help the student acquire: 1) recognition of role of engineering and its relationship to other functions in getting a job done. 2) familiarity with some managerial tools and concepts employed in engineering organizations, 3) practice in dealing with both short- and long-term managerial problems in a range of real-life circumstances, and 4) incentive to develop a career strategy relevant to engineering training. Topics: financial principles; management of innovation; engineering project planning, scheduling, and control; human factors; career planning; contracts; patents; and technical strategy for firms. Taught, in part, by case method, which emphasizes student participation in discussion. (Intended for juniors, seniors, or graduate students; others should consult the instructor in charge.) This subject is an Engineering School-Wide Elective.
R. T. Lund, D. P. Hoult, H. S. Marcus

2.97 Independent Activities

Prereq.: —
Year: U (J)
Arr.

For undergraduates desiring to carry on independent studies during the (January) period between terms. Each student will carry on a program of his or her own choosing, either as an independent worker, or as a member of a team, or class. Special lectures, seminars, and laboratory projects arranged when appropriate. Programs arranged on an individual basis in consultation with the instructor. Credit arranged with the coordinator:
D. G. Wilson

2.981J Project Proseminar in Technology and Policy I (A)

(Same subject as TPP 11J)
Prereq.: Permission of Instructor
Year: G (1)
4-0-8

2.982J Project Proseminar in Technology and Policy II (A)

(Same subject as TPP 12J)
Prereq.: TPP 11J
Year: G (2)
4-0-8

Designed to develop the students' ability to analyze problems involving interaction of technology with economic and social considerations. Exercises in problem formulation, design, analysis and evaluation of alternative policies, and hardware configurations. Problems of institutional change. Case studies, individual and group projects drawn from fields such as: energy, transportation, communications, health care, automation. Emphasis on written, oral, and graphic communication of results. Integral to the projects is directed reading and written or oral critique with respect to value implications and historical context. This effort, consisting of approximately one-third of the total proseminar, is guided by associated faculty in the School of Humanities and Social Science, and explicitly designed to ensure that the student experiences a perspective outside that of technology itself. (Restricted to graduate students in Technology and Policy; others admitted by permission of instructor.)
M. A. Sirbu, T. B. Sheridan, D. F. Noble

2.995 Special Topics in Mechanical Engineering

Prereq.: —
Year: U (1, 2, S)
Arr.

For undergraduates desiring to carry on substantial projects of own choosing in Mechanical Engineering. Work may be of experimental, theoretical, or design nature. Projects may be arranged individually in most fields of department interest, i.e., in Mechanics and Materials, Thermal and Fluid Sciences, Systems and Design, and Biomedical Engineering. Coordinator:
D. G. Wilson

2.996 Advanced Topics in Mechanical Engineering (A)

Prereq.: —
Year: G (1, 2, S)
Arr.

Assigned reading and special problems or research in special areas, either theoretical or experimental, or design. Arranged on individual basis with instructor in the following areas: Mechanics and Materials, Thermal and Fluid Sciences, Systems and Design, and Biomedical Engineering. Coordinator:
W. M. Rohsenow

2.998 Introduction to Technology and Law

Prereq.: —
Year: U (1)
3-0-9

An introduction to basic principles and functions of law, using legal cases and materials arising from scientific and technical issues. Provides an understanding of law and legal processes as they impact upon the work of engineers and scientists. Study of judicial lawmaking focuses on elementary civil procedure and how change in legal doctrine takes place. Examination of statutory lawmaking shows how Federal and state power to govern grows as technology grows. Administrative lawmaking focuses on the regulatory agencies' role in controlling and supporting technology as well as the extent and curbs on their power. Study of law cases, using so-called "Socratic method," and of legal processes and doctrines provides insight into the lawyer's working methods. Law's task of resolving conflicts found in scientific and engineering alternatives sensitizes students to choice of values questions. This subject is an Engineering School-Wide Elective. ***(Not offered 1981-82.)***
J. D. Nyhart

2.999 Engineer's Degree Thesis Proposal Preparation (A)

Prereq.: —
Year: G (1, 2, S)
Arr.

For students who must do additional work to connect an S.M. Thesis to an M.E. Thesis, or for students who do an M.E. Thesis after having received an S.M. degree.
W. M. Rohsenow

3 Materials Science and Engineering

3.UR Undergraduate Research

Prereq.: —
Year: U (1, 2)
Arr.

Extended participation in work of a research group, which includes such activities as independent study of the literature, direct involvement in group's research commensurate with the student skills and preparation, or project work under an individual faculty member extending over more than one term. (Admission by arrangement with individual faculty member.)
T. B. King

3.00 Thermodynamics of Materials

Prereq.: 3.091 or 5.41, 18.02
Year: U (1) SD
4-0-8

Essential concepts of thermodynamics and other aspects of physical chemistry and their application to the behavior of metals and ceramics. First law of thermodynamics; thermochemistry; enthalpies of reaction, transformation, and solution. Introduction to the second law, entropy, the third law, work functions, chemical potential, kinetic theory of gases and statistical thermodynamics.
G. J. Yurek

3.01 Physical Chemistry of Materials

Prereq.: 3.00 or 5.60 or 2.40 or 10.13
Year: U (2)
4-0-8

Phase equilibria in a one-component system, reactions involving gases, reactions involving pure condensed phases and a gaseous phase, behavior of solutions, free energy-composition and phase diagrams of binary systems, reaction equilibria in systems containing components in condensed solution, Gibbs phase rule, chemical kinetics, elementary mechanisms, reaction rate constant, atomistics, activation energy, diffusion in liquids and solids.
T. W. Eagar

3.02 Phase Transformations and Structure Development

Prereq.: 3.01 or 10.14
Year: U (1)
3-0-5

Movement of crystal defects. General treatment of nucleation and growth. Examples of phase transformations in materials: condensation of vapors, solidification, precipitation of a second phase in solids, recovery, recrystallization and grain growth, martensitic transformations, spinodal decomposition, second-order transformations. Importance of phase transformations in the development and control of structure emphasized.
K. C. Russell

3.03 Chemical Metallurgy

Prereq.: 3.01 or 10.14
Year: U (1)
3-0-5

Application of chemical and thermodynamic principles to treatment of important metallurgical processes. Classifications of extractive metallurgy processes. Gas-solid reactions and oxide reduction. Slag-metal reactions in smelting. Refining processes, including precipitation, segregation, distillation, vacuum degassing. Examples taken from metallurgy of common metals.
T. B. King

3.04 Special Problems in Materials Science and Engineering

Prereq.: —
Year: U (1, 2, S)
Arr.

For undergraduates desiring to carry on projects of their own choosing which may be experimental, theoretical, analytical, or of a design nature. Also for ad hoc undergraduate studies arranged by students or staff which may consist of seminars, assigned reading, or laboratory projects.
J. B. Vander Sande, Staff

3.041 Thesis Seminar

Prereq.: —
Year: U (2)
2-0-1

Lectures on basic skills necessary for conducting thesis planning, research, analysis, and preparation of the final written document given. Topics include library resources, computer aided literature searches, how to plan experiments, departmental central facilities, laboratory safety, data analysis, technical writing, and specifications for the format of the thesis. The seminar also serves as a forum for each student to present orally a brief initial research proposal, and a more formal presentation of the completed thesis.
S. M. Allen

3.05 Computer Models of Physical and Engineering Systems (Revised Unit)

Prereq.: 18.02, 8.01
Year: U (1) SD
3-0-9

Reduction of physical and engineering systems to simplified physical and mathematical models; representation using networks; graphs, and finite element methods. Process simulations using random variables (Monte-Carlo techniques) and Linear and Dynamic Programming. Manipulation of the resulting models using algorithms on digital computers. Examples drawn from fields primarily of interest to scientists and engineers, with some attention to styles of problem solving. Extensive "hands-on" computing experience. (Working knowledge of FORTRAN expected.) This subject is an Engineering School-Wide Elective.
B. Schumacker, R. Kaplow, K. J. Bathe

3.06 Engineering of Glasses and Polymers

Prereq.: 3.11, 3.01 or 10.14
Year: U (1)
3-0-5

Consideration of structure and micro-structure of polymers and glasses and their relation to processing and properties. Specific attention directed to glass formation, viscous flow and relaxation phenomena, glass melting, glass forming processes, fabrication and properties of glass-ceramic materials. Also discussed: crystallization of polymers, forming processes for polymers, rubber elasticity, viscoelasticity, yield and fracture behavior of polymers, and polymer-based composite materials. Emphasis on recent developments, and on present state of the particular industries.
D. K. Roylance, D. R. Uhlmann

3.061J Introduction to Polymer Science and Engineering

(Same subject as 2.901J)
Prereq.: 3.091 or 5.41
Year: U (2) SD
3-0-9

Introduces principles of macromolecular synthesis and structure, their relation to properties of bulk polymers and their application to polymer processing and design of engineering materials. Molecular weight and configurations of macromolecules. Polymer synthesis. Polymer processing. Elastic and viscoelastic deformation. Yielding and fracture. Electrical and optical properties. Polymeric composites.
D. R. Uhlmann, I. V. Yannas

3.069 Introduction to Ceramics Processing (New)

Prereq.: 3.12, 3.01 or 10.14
Year: U (2)
3-0-5

Principles for processing technical ceramics based on an understanding of and application of fundamental principles for reliable and reproducible manufacturing. Case studies: ferrite magnets, alumina chip carriers, oxide varistors, and heat engine components. Topics covered: powder formation and conditioning, powder packing, densification and microstructure development, melt and vapor processing. Description of industrial manufacturing processes and how these relate to the fundamental concepts.
H. K. Bowen

3.07 Introduction to Ceramics

Prereq.: 3.12, 3.01 or 10.14
Year: U (1) SD
4-0-8

Characteristics of the crystal structures, including crystal defects, of oxide materials and local atomic arrangements in silicate glasses discussed with regard to relative stability of alternate possible arrangements and influence of structure on properties. Application of phase equilibria, interface properties, atomic mobility, and phase transformations to development of structure discussed together with relationship of structure to certain physical properties: Individual study of a particular ceramic, ceramic property, or ceramic process selected by the student required.
W. D. Kingery

3.070J Materials for Nuclear Applications (New)

(Same subject as 22.070J)
Prereq.: 3.091 or 3.14 or 3.071J
Year: U (2)
3-0-9

Introductory subject for students who are not specializing in nuclear materials. Applications and selection of materials for use in nuclear applications. Radiation damage, radiation effects and their effects on performance of materials in fission and fusion environments.
Staff

3.071J Physical Metallurgy Principles for Engineers (New)

(Same subject as 22.071J)
Prereq.: 3.091
Year: U (1)
3-0-9

Crystallography and microstructure of engineering materials. Thermodynamics of alloys, structural theory of metallic phases. Rate processes in metals; solidification, solid state diffusion, oxidation, and phase transformations. Defect properties; point defects, dislocations and radiation damage. Mechanical properties; plastic deformation, work hardening, strengthening mechanisms and fracture. Recovery and recrystallization. Emphasis on structure-properties relationships, their physical interpretation and quantification.
I-W Chen

3.075 Ceramics and Glass Laboratory (New)

Prereq.: 3.091
Year: U (1, 2)
1-3-2

The practice of ceramic fabrication and glass forming is illustrated by means of laboratory exercises and student projects which result in the application of appropriate techniques to actually form objects and evaluate their properties. (Limited enrollment. Permission of instructor required.)
W. D. Kingery, D. R. Uhlmann, P. B. Vandiver

3.08 Economics of Engineering Materials

Prereq.: —
Year: U (2)
3-0-6

Economic aspects of production and utilization of engineering materials considered on levels of the national economy, the materials industries, and individual firms. Primary resources for production of materials. Reclamation of secondary materials. Relation between economic and technical features of production processes, including energy requirements and pollution effects. Consideration of public policy affecting materials production and consumption. Economic factors in selection of materials for engineering applications. Competition between materials. Estimation of future supply and demand. Lectures, discussion, reading, and quantitative problems.
M. B. Bever, J. P. Clark

3.081 Materials Laboratory I

Prereq.: 3.091
Year: U (2) LAB
1-6-5

Introduction to study of materials by light, X-ray, and electron microscopy. Examination of structures and relationship of structure to mode of fabrication. Both classical techniques and recently developed methods in transmission and scanning electron microscopy applied. In special project part of laboratory students employ many of these modern analytical tools. (Permission of instructor required.)
R. E. Ogilvie

3.082 Materials Laboratory II

Prereq.: 3.081
Year: U (1)
1-6-5

Laboratory in which materials properties including effects of processing are investigated by means of a series of laboratory experiments plus an extensive project. Laboratory experiments cover a range of physical properties in metallic, ceramic, and polymeric materials. Project undertaken with faculty supervision in one of the following areas: ceramics, materials engineering, materials science, metallurgy, and polymerics.
R. M. Cannon, C. S. P. Sung, Staff

3.083J Introduction to Microelectronic Technology (Revised Content and Unit)

(Same Subject as 6.150J)
Prereq.: 3.15 or 6.012
Year: U (1, 2)
1-3-2

Introduction to some of the basic techniques and processes used in the fabrication of silicon monolithic integrated circuits. Lectures and laboratory sessions on the theory and technology of device fabrication and integrated circuit processing, including wafer cleaning, oxidation, photoengraving, chemical etching, diffusion, thin film deposition, and device testing. (This subject is a suitable introduction for students wishing to do project lab work in 3.084 or thesis work in the microelectronics field.)
H. L. Tuller, L. R. Reif, C. G. Fonstad

3.084 Semiconductor Devices Project Laboratory (New)

Prereq.: 3.083J
Year: U (1, 2)
0-6-0

Student use of facilities of the Microelectronics Laboratory at CMSE for individual or team projects in the area of design, fabrication, modeling and characterization of individual MOS or bipolar devices and of integrated circuits using these devices. Each term, the project topics are selected to fit the general areas of development in the Laboratory. When taken in conjunction with 3.083J it may be used to satisfy Institute Lab requirement. May be taken in same term as 3.083J. (Permission of instructor required.)
H. L. Tuller

3.091 Introduction to Solid-State Chemistry

Prereq.: —
Year: U (1, 2) SD
5-0-7

Development of relationships between electronic structure of elements, bonding characteristics and crystal structure. Characterization of atomic and molecular arrangements in crystalline solids. Mechanisms and energy changes in chemical reactions and phase transformations. Chemical and physical properties of solids — metals, semiconductors, insulators, glasses, and polymers — as they relate to basic atomic parameters and processing technology.
R. M. Rose, A. F. Witt

3.092 Perspectives in Materials Science

Prereq.: —
Year: U (2)
2-0-4

Survey, in some depth, of materials science and its applications at levels suitable for those with no prior experience in the field. Lectures by MIT staff and guests to form series of integrated seminars on important aspects of field.
A. F. Witt

3.093 Magnetic Materials

Prereq.: 3.091 or equivalent, 8.02
Year: U (1) SD
3-0-9

Magnetic materials and circuits used in loudspeakers, tapes, discs, information storage, and switching mechanisms. Origin of magnetic moments, theories of ferromagnetism, magnetic domains. Piezomagnetic and piezoelectric devices, special motors and generators.
B. L. Averbach

3.094 Materials Technology

Prereq.: —
Year: U (2)
3-0-9

Mechanical behavior, phase diagrams, microstructures and phase transformations in steels, aluminum alloys, and titanium alloys used in aerospace, automotive and ocean vehicles. Influence of microstructure and environment on fatigue and fracture behavior. Concepts and applications of fracture mechanics. Overview of polymers, composites, and ceramics used in vehicles.
B. L. Averbach

3.095J Introduction to Mining and Mineral Technology (Revised Unit)

(Same subject as 1.384J, 2.742J, 12.043J)
Prereq.: —
Year: U (1)
3-0-6

A basic introduction to mining and the minerals industry with emphasis on state-of-the-art technology. Includes mineral exploration, surface and underground mining, extractive metallurgy, health and safety, and environmental considerations. Integration of diverse subject matter stressed. Guest lectures by a variety of faculty members, classroom discussions based on assigned reading.
J. F. Elliott, R. G. Lundquist, G. B. Baecher, C. R. Peterson, R. G. Burns

3.10 Chemical Physics of Materials

Prereq.: 3.01 or 10.14, 18.03
Year: U (1) SD
3-0-5

Introduction to quantum physics of electronic structure and chemical bonding of atoms, molecules, and solids. Emphasis on those concepts which are basic to an understanding of the chemical and physical properties of materials. Topics: wave mechanics and Shrodinger's equation; atomic and molecular orbitals; the nature of the chemical bond; electronic structure of semiconductors and insulators; electronic structure of metals and alloys.
K. H. Johnson

3.101J Biomedical Materials

(Same subject as 2.900J)
Prereq.: 2.901J; 3.091 or 7.01
Year: U (2)
2-0-4

Introduction to science and engineering of materials used in a variety of medical applications such as sutures, orthopedic implants, artificial joints, blood vessel replacements, and artificial organs. Elements of structure and properties of polymers, ceramics, and metals with emphasis on interaction with the human body. Histological analysis of connective tissue with emphasis on aspects related to materials science and engineering. Fracture, structure, and healing of normal and abnormal bone. Implantation problems: inflammation, thrombogenesis, rejection, resorption, corrosion, structural failure. Case histories. (Basic background in descriptive biology desirable. ***Not offered 1981-82.***)
R. M. Rose, I. V. Yannas

3.11 Mechanics of Materials I

Prereq.: 8.01, 18.02
Year: U (1) SD
4-0-8

Aspects of solid mechanics necessary for understanding the response of polymers, metals, and ceramics to applied loads; static equilibrium, states of stress and strain, material stress-strain-temperature relations, response to torsion and bending, stability.
D. K. Roylance

3.12 Mechanics of Materials II

Prereq.: 2.01 or 3.11
Year: U (2)
3-0-5

Application of 3.11 to study of mechanics of plastic deformation of materials. Introduction to dislocation theory, stress fields around dislocations, dislocation interactions. Deformation of single crystals and polycrystals. Point defects, recovery processes, mechanical twinning. Application to work hardening, solid-solution strengthening, and two-phase hardening.
S. M. Allen

3.13 Crystallography

Prereq.: 8.02, 18.02
Year: U (2)
3-0-5

Crystal geometry and its effect on crystal properties. Lattices and symmetry, point groups, crystal systems, and plane groups. Principles of space group derivation, equivalent positions. Applications of symmetry theory to the chemical content and atomic arrangement in unit cells of crystals. Experimental methods for determination of symmetry. Effect of crystal symmetry on properties: anisotropy and the physical basis and formalism of tensor representation of properties. Transformation of tensors and constraints imposed by symmetry. Representation quadric. Selected examples of anisotropy in properties of actual materials.
B. J. Wuensch

3.14 Physical Metallurgy

Prereq.: 3.02, 3.12
Year: U (2)
3-0-5

Relationship between structure and properties of engineering alloys presented and discussed in detail. Alloy systems covered include steels, stainless steels, aluminum and titanium alloys, and superalloys. Processing history, microstructure, and properties of each alloy system illustrated by case studies. Fracture analysis of alloys widely used in engineering applications emphasized.
N. J. Grant, R. M. N. Pelloux

3.141 Engineering Materials

Prereq.: 3.03, 3.12
Year: U (2) SD
3-3-6

Same subject as 3.14, but including a laboratory involving SEM microscopy, mechanical testing, foundry, welding, and corrosion.
N. J. Grant, R. M. N. Pelloux

3.142 Introduction to Electron Microscopy

Prereq.: —
Year: U (1)
1-5-3

Lectures give general introduction to microscopy, and cover principles and limitations of conventional light microscopy, principles of electron optics, including electron guns, acceleration of electrons, electron lens theory, image formation in transmission and scanning electron microscopes, and interaction of electrons with matter, as well as signal generation and interpretation. Laboratory gives concentrated introduction to use of light and electron microscopes for quantitative study of structure of matter. Individual laboratory projects chosen by the student emphasize application of microscopy in quantitative study of microstructure for purpose of elucidating structure-behavior relationships of a wide variety of solid materials such as: metals, ceramics, composites, wood, concrete, polymers, and biological materials. Such studies of microstructure often necessitate other supporting laboratory experiments to clarify their relationship to the particular macro behavior. ***(Not offered 1981-82.)***
J. B. Vander Sande

3.143J Materials of Construction

(Same subject as 1.59J)
Prereq.: 8.01
Year: U (2) SD
3-0-9

Principles underlying the structure-properties interaction in materials important to civil engineers. Topics including atomic arrangements in crystalline and non-crystalline phases; thermodynamics of phase relationships and structural change; elasticity, microplasticity, viscoelasticity, and fracture; corrosion. Application of principles to structural metals, cementitious materials, structural-ceramics, wood, asphalt, and polymers. Mechanical properties of composite materials, including Portland cement concrete, asphalt-aggregate mixtures, and reinforced plastics.
F. J. McGarry, F. Moavenzadeh

3.144J Deformation and Fracture Mechanics of Engineering Alloys

(Same subject as 2.34J)
Prereq.: 2.01, 2.30 or 2.31, 2.32
Year: U (2)
4-0-8

Understanding and prevention of fracture of engineering alloys in service depends upon integration of basic concepts in materials science and solid mechanics. Fundamentals of these disciplines applied to selected subjects in fracture. Major topics include linear elastic, elastic-plastic, and fully plastic fracture mechanics, fatigue, creep rupture and creep crack growth, and environmentally assisted fracture. In each case, emphasis is placed on connecting the microscopic fracture mechanisms with appropriate macroscopic (continuum) characterizations. ***(Not offered 1981-82.)***
R. M. N. Pelloux, D. M. Parks

3.145 Introduction to Systems Analysis

Prereq.: 18.01
Year: U (2) SD
3-0-9

Introduction to major concepts and techniques of systems analysis as an approach to engineering problem solving. First half defines the use of optimization procedures to maximize efficiency and other objectives, with a systematic survey of theory and applications of mathematical optimization to engineering problems. Second half presents evaluation procedures for single and multiattributed problems, covering utility theory and decision analysis in addition to standard procedures. Application of this material to real problems in planning and design stressed throughout the term. ***(Not offered 1981-82.)***
J. P. Clark, N. H. Cook, R. de Neufville, D. H. Marks, A. R. Odoni, T. B. Sheridan

3.15 Electrical, Optical, and Magnetic Materials and Devices

Prereq.: 3.10 or 6.017J
Year: U (2)
3-0-5

Introduction to electronic, optical, and magnetic properties of materials in terms of their electronic structure, chemical composition, and bonding. Properties of metals, semiconductors, and insulators including electrical conduction, thermoelectric power, Hall effect, optical absorption and reflection, luminescence, para- and ferromagnetism analyzed with respect to fabrication dependent variables such as microstructure (e.g., grain boundaries, heterojunctions), impurities and degree of disorder in addition to intrinsic constraints. Manipulation of these properties for incorporation into devices of timely technological import (e.g., light emitting diodes, lasers, field effect transistors, memory units) discussed. No prior knowledge of device theory assumed.
H. L. Tuller

3.16 Applied Surface Chemistry

Prereq.: 3.01, 10.14
Year: U (2)
3-0-6

Introduction to structural, chemical, and electronic properties of crystalline surfaces. Thermodynamics and kinetics of surface processes. Colloid chemistry. Application of principles of surface chemistry to corrosion and oxidation of metals, Rebinder phenomena, degradation of ceramics in severe environments, adsorption and catalysis, fuel cells and

batteries, colloid stability, adhesion, lubrication, electrometallurgy. (Alternate years. ***Offered 1981-82.***)
R. M. Latanision

3.171 Ceramic Artifact Interpretation (New)

Prereq.: —
Year: U (2)
1-3-5

Ceramic artifact examination and interpretation form the basis for failure analysis, product development, and many inferences in archaeology, art history, and the history of technology. In combination with laboratory investigations of actual artifact samples, seminar discussions focus on the nature of the induction process applied to artifact data. In particular, the use of statistical hypotheses and the nature of plausible reasoning examined as applied to materials technology.
W. D. Kingery

3.172 Inventions and Patents (New)

Prereq.: 14.02
Year: U (1)
3-0-6

History of private and public rights in scientific discoveries and applied engineering leading to the development of worldwide patent systems. The classes of invention protectable under the patent laws of the US, including the procedures in protecting inventions in the Patent Office and in the courts. Reviews of past cases involving inventions and patents in a) the chemical process industry and medical field, b) devices in the mechanical, ocean exploration, civil, and/or aeronautical fields, c) the electrical and electronic areas including key radio, solid-state, and computer inventions. This subject is an Engineering School-Wide Elective.
R. H. Rines

3.18 Materials Processing

Prereq.: 3.02, 18.03
Year: U (2)
3-0-5

Fundamentals of control of shape, structure, and properties of materials through processing. Fundamentals of heat flow, fluid flow, and mass transport applied to processing. Economic and environmental aspects of processing. Examples of processes considered: thermal treatments, solidification, vapor deposition, electro-deposition, powder processing, fiber processing, and recycling of materials.
M. C. Flemings

3.185 Fluid Flow, Heat and Mass Transfer in Materials Processing

Prereq.: 3.02, 18.03
Year: U (2)
3-0-5

Definition of viscosity, simple overall mechanical energy balances, elements of laminar flow and turbulent flow. Thermal conductivity, steady and unsteady conduction problems, forced and natural convection, heat transfer coefficient and radiative heat transfer. Definition of binary diffusivity, convection mass transfer, and mass transfer coefficient. Illustrative examples given throughout, chosen from the materials processing field.
J. Szekely

3.19 Techniques of Metal Sculpture

Prereq.: —
Year: U (1, 2)
0-4-2

Workshop devoted to learning techniques for translation of design to modern metal sculpture: brazing, welding, forming, cutting; mechanical and chemical finishing, and patinas. Basic materials involved: steels, aluminum, brass, copper, and stainless steel, in the simple forms: tubing, rod, sheet, strip, and bar. Complex industrial shapes will also be utilized, as well as junk sculpture. (Limited enrollment.)
T. W. Eagar, A. J. Zona

3.20 Thermodynamics of Materials (A)

Prereq.: 3.01
Year: G (1)
4-0-8

Advanced treatment of thermodynamic properties of inorganic materials. Introductory statistical thermodynamics and surface thermodynamics. Application of laws of thermodynamics to chemical behavior of elements, compounds, and solutions. Discussion of heterogeneous equilibria, chemical reactions, and thermodynamics of interfaces and structural defects.
J. F. Elliott

3.21 Kinetic Processes in Materials (A)

Prereq.: 3.01, 3.02
Year: G (2)
4-0-8

Unified treatment of kinetics from phenomenological and atomistic viewpoints. Diffusion in metals and non-metals, including boundary value problems in growth, coarsening, and homogenization; mechanisms, high diffusivity paths, scaling, and oxidation. Rate laws, consecutive and competing reactions, absolute rate theory. Phase changes, including film deposition, spinodal decomposition, precipitation, and athermal transformations. Frequent introduction of examples to illustrate principles discussed.
D. R. Sadoway

3.22J Solid-State Surface Science (A)

(Same subject as 10.613J)
Prereq.: 3.20 or 10.40
Year: G (2)
3-0-6

Structural, chemical, and electronic properties of solid surfaces in ionic crystals, metals, and ceramics. Surface analytical tools for characterizing structure and composition of solid surfaces in ultra-high vacuum, with emphasis on Auger and photoelectron spectroscopies and electron diffraction techniques. Surface thermodynamics and kinetics. Phase transitions at surfaces. Effects of interactions of surfaces with crystalline defects. Applications, including heterogeneous catalysis, oxidation, crystal growth, and tribology. (Alternate years. ***Not offered 1981-82.***)
R. M. Latanision, F. A. Putnam

3.23 Physics and Chemistry of Materials

Prereq.: 8.03, 18.03
Year: G (2)
4-0-8

Introduction to physics and chemistry of materials, based on electronic structures and chemical bonding of atoms, molecules, and solids. A broad, interdisciplinary range of topics, including: wave mechanics and atomic structure; molecular structure and nature of the chemical bond; electronic band structures of insulators, semiconductors, ceramics, metals, and alloys; dielectric, magnetic, and optical properties of materials; effects of impurities and disorder on electronic structures and properties; bonding in amorphous materials, electronic structure of polymers; surface electronic structure, chemisorption, and corrosion; catalytic materials. (Alternate years. ***Not offered 1981-82.***)
K. H. Johnson

3.24J Surface and Colloid Chemistry (A) (New)

(Same subject as 10.61J)
Prereq.: 3.20 or 5.62
Year: G (1)
3-0-6

Thermodynamic, kinetic, and chemical factors underlying surface and interfacial phenomena. Intermolecular forces and origins of surface tension. Capillarity and effects of surface curvature on bulk phase properties. Thermodynamics of adsorption at interfaces; the Gibbs

adsorption isotherm. Electrical phenomena at interfaces: origins of surface potential, structure of the diffuse double layer. Surface active agents and orientation at interfaces. Contact angles, spreading and wetting phenomena. Properties of colloidal electrolytes, micelle formation, solubilization phenomena. Classical theory of charge stabilization in colloidal systems, macromolecular stabilization, stability in emulsions and nonaqueous media, flocculation. Electrokinetic phenomena. Applications of these fundamentals in understanding: emulsification, foaming, flotation, detergency, adhesion, lubrication, ceramics, polymers, metallurgy.
A. Bleier, F. A. Putnam

3.241 Surface and Colloid Chemistry in Materials Science (A) (New)

Prereq.: 3.20
Year: G (1)
3-0-6

Fundamentals of interfacial phenomena. Adsorption at interfaces. Wetting, electrical double layer, and dispersion forces, stability of dispersed systems: sols, emulsions, foams. Surface active agents and soluble polymers. Grain boundaries. Experimental techniques. Applications: ceramics processing, mineral processing, polymerics, metallurgy. (Permission of instructor required. ***Not offered 1981-82.***)
A. Bleier

3.25J Physics of Deformation and Fracture of Solids I (A)

(Same subject as 2.332J)
Prereq.: 2.01, 2.30 or 2.31, 2.32
Year: G (1)
3-0-9

Derivation from the theory of elasticity of the properties of dislocations in isotropic and anisotropic crystals. Line properties of dislocations. Dislocations in particular crystal structures. Interaction of dislocations with point defects, and climb. Hardening by localized obstacles — yield stress of solution, precipitation, and dispersion hardened alloys. Work hardening in pure metals and particle hardened alloys.
W. S. Owen, A. S. Argon

3.26J Physics of Deformation and Fracture of Solids II (A)

(Same subject as 2.333J)
Prereq.: 2.01, 2.30 or 2.31, 2.32
Year: G (2)
3-0-9

Rate mechanisms in crystal plasticity, kinetics and dynamics of slip, superposition of mechanisms controlling yield stress. Mechanisms of non-elastic deformation in non-metals, viscoelasticity and plasticity of inorganic and polymeric glasses, plasticity of crystalline polymers. Macroscopic plasticity in metals and polymers, flow stress of polycrystals, macroscopic yield conditions and associated flow rule with application to localization of deformation in rate and pressure sensitive materials. Criteria of fracture in metals and polymers, nucleation and localization of fracture. ***(Not offered 1981-82.)***
W. S. Owen, A. S. Argon

3.27 Diffraction and Structure (A)

Prereq.: 8.04, 18.03
Year: G (1)
4-0-8

X-ray production, absorption, and scattering. Overview of symmetry theory, point groups, and space groups. Physics of diffraction, and interpretation through the Ewald construction, reciprocal lattice and Fourier transforms. Instrumentation and interpretation of diffraction patterns: the Laue, Debye-Scherrer, Weissenberg, and precession techniques. Diffractometer geometrics. Determination of particle size, pole figures, and texture. Determination of structure through diffraction effects: the phase problem, Patterson function and direct methods of phase determination. Analysis of noncrystalline materials. ***(Not offered 1981-82.)***
B. J. Wuensch

3.271 Structure of Materials (A)

Prereq.: 18.02, 3.10
Year: G (1)
4-0-8

Quantitative descriptions of structure of crystalline, glassy, polymeric, and liquid materials. Atomic arrangements in technologically important ionic, metallic, and covalent types. Structural imperfections and atomic vibrations. Experimental methods related to structure analysis, such as diffraction (using Fourier transform techniques), Mossbauer spectroscopy, and optical methods. ***(Not offered 1981-82.)***
R. Kaplow, B. J. Wuensch

3.28 Statistical Mechanics of Materials (A) (New)

Prereq.: 3.01, 3.02, 3.20
Year: G (2)
4-0-8

Brief reviews of classical thermodynamics and analytical mechanics. Ensembles and phase space. Elementary mathematical statistics. Density in phase space and Liouville's theorem. Statistical equilibrium. Microcanonical, canonical, and grand canonical ensembles. Classical (Maxwell-Boltzmann) statistics. Equipartition theorem. Quantum (Fermi-Dirac and Bose-Einstein) statistics. Applications of quantum statistics to occupation of electron states in semiconductors and metals, photon gas, lattice vibrations and phonons, Einstein and Debye theories of lattice heat capacities. Boltzmann transport theory of electrical and thermal conductivities of metals. Statistical thermodynamics of small atomic clusters. Lattice statistics and Ising model; applications to alloy order-disorder transformations, ferromagnetism-paramagnetism, vacancies, interstitials, grain boundary segregation of impurities, statistical thermodynamics of surfaces, and polymer statistics. Equilibrium between phases. Chemical equilibrium. Elementary theories of melting. Structural and electronic phase transformations. Symmetry and phase transformations. Landau theory of second-order phase transformations. Critical phenomena. "Soft-mode" transformations. Superconductivity. Theory of chemical reaction rates. Statistical basis of diffusion in solids. (Permission of instructor required. Alternate years. ***Offered 1981-82.***)
K. H. Johnson

3.29 Structure-Properties Relationships in Materials (A)

Prereq.: 3.23, 3.271, 3.281, 3.282
Year: G (2)
4-0-8

A systematic treatment of the relationships among atomic arrangements, electronic structure, and physical properties of materials, with emphasis on electrical, magnetic, optical, and thermal properties. Illustrative examples among crystalline and noncrystalline materials discussed. Effects of phase morphologies and structural imperfections on observed properties included.
R. Kaplow

3.30 Electron Microscopy: Image Interpretation (A)

Prereq.: 3.081, 3.12, 3.13
Year: G (2)
3-2-7

Emphasis on determination of relation between detail in image observed in transmission electron microscope and internal structure of object. Kinematical and dynamical theories of electron diffraction developed and applied to observation and quantitative analysis of point defects and their agglomerates, dislocations, stacking faults, second phase particles, and grain boundaries. High resolution techniques and X-ray topography. Laboratory sessions provide for experimental applications of concepts described in lectures.
J. B. Vander Sande

3.31 Phase Transformations (A)

Prereq.: 3.20, 3.21
Year: G (1)
3-0-9

Advanced treatment of phase transformations in solids. Homogeneous and heterogeneous nucleation, theories of growth and transformation kinetics. Precipitation, eutectoidal, massive and martensitic transformations. Thermodynamics and kinetics of spinodal decomposition and continuous ordering.
S. M. Allen

3.32 Introduction to Electron Optics and Electron Microscopy (A)

Prereq.: 3.13, 3.14
Year: G (1)
2-4-6

Interaction of electrons with materials treated in detail. Employing results of these interactions, materials examined to obtain information about their structure and chemistry on a micro-scale as used in modern scientific tools. These include Electron Microanalyzer, Auger Spectrometer, Scanning and Transmission Electron Microscope, Leed (low energy electron diffraction), and Field Ion Microscope.
R. E. Ogilvie

3.33 Defects in Crystals (A)

Prereq.: 3.02, 3.12
Year: G (2)
3-0-9

Unified treatment of point, line, and planar defects in crystals. Point defects include vacancies, self-interstitials, and solute atoms. Line defects correspond to dislocations, while planar defects include stacking faults, small and large angle grain boundaries, and interphase boundaries. Discussion of geometrical structure and various physical properties such as stress fields, energies, and mobilities. Interactions between defects including, for example, point defect clustering, point defect-dislocation pinning, dislocation climb and grain boundaries as point defect sources/sinks.
R. W. Balluffi

3.34 Advanced Physical Metallurgy (A)

Prereq.: 3.14, 3.20, 3.21, 3.33
Year: G (1)
3-0-9

Development and stability of metallurgical microstructure and its effect on mechanical properties such as strength and hardness. Structures produced by plastic deformation and annealing. Recovery, recrystallization, grain growth. Deformation and annealing textures. Coarsening and thermal stability. Deformation and strengthening mechanisms. Deformation maps. Typical alloy systems.
R. W. Balluffi

3.35 Solidification Processing (A)

Prereq.: 3.02 or 3.141
Year: G (1)
2-0-4

Principles of control of structure, properties, and shape in processes involving liquid-solid and vapor-solid transformations. Heat flow, solute redistribution, nucleation, growth kinetics, Resultant structures and properties. Examples drawn from commercial processes, including metal casting, zone refining, electrodeposition, and crystal growth from the melt, vapor, and solution.
M. C. Flemings

3.36J Welding Engineering (A)

(Same subject as 13.17J)
Prereq.: 3.02 or 3.141
Year: G (1)
3-0-6

Detailed study of processing variables involved in joining materials by welding, brazing, and adhesive bonding. Synthesis of elementary physical phenomena such as transient heat flow, phase transformations, and dimensional changes into the complex overall reactions associated with joining. Testing, inspection, and properties of finished joints. Laboratory demonstrations of arc, electron beam, resistance, and other electric welding processes.
K. Masubuchi

3.37 Deformation Processing (A)

Prereq.: 3.11, 3.14 or 3.141
Year: G (2)
2-0-4

Processing for shape change and property control by plastic deformation. Yield behavior in isotropic and anisotropic material, continuum plasticity, use of constitutive relations, structural basis of anisotropy, upper bound forces, friction and friction control, flow instability, drawability, and superplasticity. (Alternate years. ***Offered 1981-82.***)
Staff

3.38 Behavior of Metals at Elevated Temperatures (A)

Prereq.: 3.14 or 3.141
Year: G (1)
3-0-6

Study of mechanical behavior of pure metals and alloys above the minimum recrystallization temperature. Mechanisms of deformation and fracture at elevated temperatures. Creep theories. Applications of stress rupture and thermal fatigue testing. Strengthening principles of superalloys and refractory metals.
N. J. Grant

3.39 Mechanical Behavior of Materials (A)

Prereq.: 2.30 or 3.11
Year: G (1)
3-0-9

Review of elasticity theory. Elements of plasticity theory. Strengthening mechanisms in metals. Mechanical behavior of polymers. Application of principles of linear elastic fracture mechanics to brittle fracture and to fatigue crack propagation. Micromechanisms of fracture (cleavage, ductile fracture, fatigue, creep, stress corrosion cracking). Principles of failure analysis. Discussion of case studies and review of current research in fracture.
R. M. N. Pelloux

3.40J Advances in Fracture Research (A)

(Same subject as 16.253J)
Prereq.: 2.30 or 2.31, 2.32, or 2.301 or 3.39
Year: G (1)
2-0-4

Discussion of recent advances in the understanding of phenomena, mechanics and mechanisms of fracture in structural alloys under service conditions. An integrated selection of topics including nucleation and growth of cracks under fully plastic conditions, in both rate insensitive as well as in creeping alloys, under both steady loading as well as cyclic

loading, discussed by experts in the field from points of view ranging from phenomenological to detailed and mechanistic.
R. M. N. Pelloux, A. S. Argon, T. H. H. Pian

3.50 Physical Chemistry of Metallurgical Processes (A)

Prereq.: 3.20
Year: G (2)
3-0-6

Study of physiocochemical nature of pyrometallurgical processes and systems. Nature and behavior of principal phases of interest: liquid metals, slags, fused salts, mattes, gas, and refractory materials. Nature of heterogeneous reactions among constituents of these phases. Application of physicochemical principles to analysis of behavior of pyrometallurgical processes.
J. F. Elliott

3.51 Process Metallurgy (A)

Prereq.: 3.03
Year: G (2)
3-0-6

Applications of fundamental treatment of 3.03 to integrated metallurgical processes such as the iron blast furnace; basic oxygen steelmaking; direct reduction and electric furnace steelmaking; stainless steelmaking by the AOD process; copper smelting; manganese nodule processing by liquid ion exchange separation; halide processes; ferroalloy production. Term report on topics of current interest required.
T. B. King

3.52 Dynamic Behavior of Metallurgical Systems (A)

Prereq.: 3.01, 18.03
Year: G (2)
3-0-6

Interpretation of behavior of metallurgical systems by application of methods of process analysis and control theory. Modeling of systems and exploration of their characteristics.
J. F. Elliott, T. A. Ring

3.53 Electrochemical Processing of Materials (A)

Prereq.: 3.20 or 3.54
Year: G (2)
3-0-6

Discussion of principles of electrochemistry: thermodynamics and kinetics of electrode processes, polarization, electrical charge double-layers, electrokinetic phenomena, nature of ionic media. Application and use of electrochemical principles in fuel cells and batteries, electroslag remelting, electroplating, electrorefining, electrowinning, fused-salt electrolysis of metals, electrolytic production of gases and chemicals, solid-state electrolytes. (Alternate years. ***Offered 1981-82.***)
J. F. Elliott, R. M. Latanision

3.54 Corrosion—The Environmental Degradation of Materials (A)

Prereq.: 3.00
Year: G (1)
3-0-6

Initial emphasis on the thermodynamics and kinetics of electrochemical corrosion of metals and alloys. Description of metallurgical factors, effect of applied stress (stress corrosion cracking and corrosion fatigue) and passivity. Discussions of methods of corrosion control and prevention including alloy selection, environmental control (inhibitors), design rules, anodic and cathodic protection, and protective coatings. Treatment of environmental degradation of non-metals (ceramics, silicate glasses, and concrete) and polymers. Discussion of current materials degradation problems in marine environments, the petroleum industry, energy conversion and generation systems, and other areas.
R. M. Latanision

3.541 Oxidation and Corrosion of Materials at Elevated Temperatures (A)

Prereq.: 3.20, 3.21
Year: G (2)
3-0-6

Application of fundamental principles of thermodynamics and kinetics to determination of the mechanisms of the oxidation and corrosion of materials at elevated temperatures. Relationship of oxidation theory to design of alloys and of coating materials for protection against oxidation. Discussions of high-temperature oxidation and corrosion problems that occur in systems for the conversion and utilization of energy, and in petrochemical and metallurgical industries. Experimental techniques for studying oxidation and corrosion of materials at elevated temperatures. (Alternate years. ***Offered 1981-82.***)
G. J. Yurek

3.55 Macroscopic Transport in Materials Processing (A)

Prereq.: 18.03
Year: G (1)
3-0-9

Elements of laminar and turbulent flow, heat transfer by conduction, convection, and radiation, mass transfer in laminar and in turbulent flow. Modeling of transport phenomena in industrial systems, including steelmaking, continuous casting, and vacuum degassing.
J. Szekely

3.551J Gas-Solid Reactions (A)

(Same subject as 10.48J)
Prereq.: 3.55, 10.50
Year: G (2)
3-0-6

Elements of Gas-Solid Reactions, involving single particles, including chemical kinetics, heat and mass transfer pore diffusion effects, and structural changes. Reaction of porous and non-porous particles, reactions between solids, proceeding through gaseous intermediates. Review of experimental techniques used for study of gas-solid reactions, including physical characterization of solid specimens. Behavior of multi-particle systems, such as packed beds, fluidized beds, and rotary kilns. Gas-solid reactions of industrial importance, including coal gasification, iron oxide reduction, roasting of sulfide ores, reaction of SO^2 with limestone, and incineration of urban wastes. Text: J. Szekely, J. W. Evans, and H. Y. Sohn, *Gas-Solid Reactions*, Academic Press, 1976. (Alternate years. ***Offered 1981-82.***)
J. Szekely, C. Georgakis

3.56 Engineering Systems Analysis (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-6

Synthesis of analytic procedures for the identification and selection of optimal systems. Review of economic framework for analysis. Systematic survey of theory and applications of mathematical optimization to engineering problems. Evaluation procedures for single and multiattributed problems covering utility theory and decision analysis in addition to standard procedures. Application of this material to real problems in planning and design stressed throughout term. (Open to qualified undergraduates. Knowledge of probability, microeconomics, and computer systems at an undergraduate level required.) This subject is an Engineering School-Wide Elective.
R. de Neufville, J. P. Clark

3.561 Materials Systems Analysis (A)

Prereq.: 3.56
Year: G (2)
3-0-6

Systems Analysis as applied to materials engineering problems, presented at a level beyond 3.56J. The two main components are: 1) Optimization methods, including hill climbing methods, constrained optimization problems, optimization of decomposable structured systems, trajectory optimization of lumped and distributed systems. Practical examples include optimization of an electric furnace shop, calculation of optimal trajectory in an oxygen-argon steelmaking process and optimization of a grinding circuit. 2) Systems modeling, including regression analysis, simulation modeling, time series analysis, multiobjective analysis. Practical examples include estimation of production functions, supply and demand relationships in the materials industries, analysis of dynamics of intermaterial competition. (Alternate years. ***Not offered 1981-82.***)
J. P. Clark, J. Szekely

3.562J Current Issues in Engineering

(Same subject as 1.491J, 6.941J, 13.682J, 22.87J
Prereq.: —
Year: G (S)
3-0-6

Review of a selection of technological developments of great significance to industrialized societies, choosing from current areas such as electronic materials and microprocessors, conventional and new energy technology, and practical aspects of cell manipulation. Key features of the technologies and their relationships to social, economic, and managerial issues that their development implies.
T. H. Lee

3.563J Cases and Projects in Engineering Management (A) (New)

(Same subject as 1.492J, 6.942J, 13.683J, 22.88J)
Prereq.: 3.562J
Year: G (1)
3-1-5

Continuation of 3.562J with a shift from macro-level of technologies toward micro-level of projects. Case studies of and student projects involving several real engineering and scientific programs in industrial firms and government agencies. Cases chosen from new ventures as well as mature firms, in both product and process development. All aspects of projects assessed.
T. H. Lee

3.564J Technology Planning (A) (New)

(Same subject as 1.493J, 13.684J)
Prereq.: —
Year: G (1)
3-0-6

Methods for planning RD&E projects and multi-project programs. Cost and schedule control of technical work. Approaches to technology forecasting and resource allocation among technical areas. Technical planning in companies and government agencies.
J. M. Utterback, R. D. Logcher

3.565J Manufacturing/Technology Interface (A) (New)

(Same subject as 13.685J, 15.365J)
Prereq.: 15.311 or 15.515 or 15.361
Year: G (1)
3-0-6

Focus on the management of process innovation. Economic and other influences on manufacturing process change. Interactions between research, development and engineering activities and manufacturing operations. Transfer of new product developments into manufacturing.
J. M. Utterback

3.57 Particulate Technology (New)

Prereq.: 3.21
Year: G (2)
3-0-6

Methods of particle size analysis are presented in detail to set the stage for a discussion of the following processes in particulate technology — communication, crystallization, dispersion, agglomeration, filtration, sedimentation and froth flotation. Analysis of these topics provides familiarity with population balance theory of particulate processes.
T. A. Ring

3.576J Law, Technology and Public Policy

(Same subject as TPP 32J)
Prereq.: Permission of Instructor
Year: G (2)
3-0-6

In-depth examination of relationship between technology and the legal system. Five major areas discussed: 1) responses of legal system to new social problems created by new or existing technology (including regulation); 2) responses of technology to legal action; 3) changes in legal theory and practice (including the burden and standards of proof with regard to technological issues, and ways in which technology has changed the treatment of evidence in court); 4) responses of political system to increasing technology (including forums for interaction of legal and technological issues such as the science court); and 5) equity/market changes brought about by law/technology interaction (including discussion of differences between processes involved in "market" or "economic" regulation from those designed to ameliorate adverse consequences of technology, and law as a resolver of equity and distributional problems raised by changing technology).
J. P. Clark, N. A. Ashford, G. R. Heaton, Jr.

3.577 Engineering Risk-Benefit Analysis (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Risk evaluation and cost-benefit analysis techniques for assessment of engineering projects involving risks. Emphasis on public sector. Balancing risks and benefits with concern for financial uncertainties, environmental risks, and especially issues of human safety. Introduction to decision and analysis, value of information, problems with multiple goals and issues related to collective decisions. Issues of public policy and regulation. Case studies with attention to the nature of public discussion. Cases drawn from dam safety, safety of nuclear reactors, transport and storage of liquefied natural gas, seismic risk problems, and offshore oil exploration. Some background in elementary probability assumed. (This subject is intended mainly for graduate and upperclass students in the School of Engineering, and is an Engineering School-Wide Elective subject.)
M. E. Paté, A. W. Drake

3.58 Seminar on Problems in Materials Policy

Prereq.: —
Year: G (2)
2-0-4

Discussion of materials scarcity, production capacity, position of Socialist block and third-world countries, financial factors affecting capacity expansion, costs and prices, history and prospects of producer cartels, stockpiles and international buffer stocks, competition of materials for markets. Emphasis on metals or other materials, depending on choice of instructor in charge.
M. B. Bever, S. D. Strauss

3.581J Resources Management (A)

(Same subject as 13.961J)
Prereq.: 14.04, 15.012
Year: G (2)
3-0-6

Contemporary global perspectives on nature of natural resources, their utilization and management. General topics include: changing perceptions of the importance of natural resources; including concerns over their availability and costs; results of the pressures of increasing demand; effects of new technologies on patterns of development and distributions; compelling factors for new management systems; evolving role of resources in international economic and political affairs; and result and institutional and process changes in public and private sectors. Cases of several resources which are undergoing marked changes in their management systems used as basis for much of the analysis and discussion. Marine ferromanganese deposits, fisheries, and outer continental shelf oil and gas development are principal resource cases, although other resources are discussed as need and interest arises. (Open to qualified undergraduates. Knowledge of microeconomics at the level of 14.04 required.)
J. P. Clark, J. T. Kildow, L. Smith (Woods Hole Staff)

3.59 Research Proposals — Planning for Discovery (A) (Revised Unit)

Prereq.: —
Year: G (2)
2-0-4

Individual research proposals aimed at new discoveries analyzed in relationship to concepts such as market for discovery, importance of paradigms, importance of anomalies, influence of communities, distinction between discovery and proof of discovery, and nature of plausible reasoning. Requires preparation of several research proposals and includes individual counseling and evaluation by a faculty member other than advisor or thesis supervisor. Readings from T. S. Kuhn, Derek de S. Price, M. Polanyi, N. Hanson, P. Medewar, G. Polya, class notes.
W. D. Kingery, Staff

3.60 Material and Tensor Properties of Ceramics (A) (Revised Unit)

Prereq.: 3.06 or 3.07
Year: G (1)
3-0-6

Tensor representation of properties of crystalline ceramics. Anisotropy, representation surfaces and effects of crystal symmetry. Application to piezoelectric and elastic properties. Propagation of elastic waves in crystals. Discussion of thermal properties: heat capacity, thermal expansion, and thermal conductivity, with emphasis on real materials and influences of microstructure. ***(Not offered 1981-82.)***
B. J. Wuensch

3.601 Electrical, Optical, and Magnetic Properties of Ceramics (A) (Revised Unit)

Prereq.: 3.07
Year: G (1)
3-0-6

Analysis of electrical, optical, and magnetic properties of ceramics in terms of defect chemistry, band theory, and transport theory. Emphasis on effects of materials processing, composition, and microstructure on properties of real materials. Applications of theory in design of new materials discussed.
H. L. Tuller

3.603 Advanced Topics in Mechanical Properties of Ceramics (A)

Prereq.: Permission of Instructor
Year: G (2)
2-0-4

Fundamentals and current models for brittle fracture including time dependent crack growth, fatigue and impact failures, thermal stress failure, plastic deformation, creep and creep rupture of ceramics considered, including effects of microstructure, composition, and environment. Emphasis on crystalline and polyphase ceramics, particularly advanced or new ceramic materials. (Alternate years. ***Offered 1981-82.***)
R. M. Cannon

3.604 Problems in Nonstoichiometry (A)

Prereq.: 3.601
Year: G (1)
2-0-4

Derivation of thermodynamics of nonstoichiometric phases and analysis of inherent limitations of this approach. Study of attempts to extend theory to highly defective systems. Real systems, including oxides, hydrides, and chalcogenides, subjected to critical analyses to aid in identifying dominant defects (including impurities), their states of ionization and existence ranges of the nonstoichiometric phases. Applications of theory to crystal growth, solid electrolytes, reaction rates, etc. Review of experimental methods, including electrical, optical, and thermodynamic techniques. Each student expected to critically analyze literature on a system of interest. ***(Not offered 1981-82.)***
H. L. Tuller

3.61 Glass Structure and Properties (A) (Revised Unit)

Prereq.: 3.06 or 3.07
Year: G (2)
3-0-6

Consideration of topics of interest in the science and technology of amorphous solids, including glass formation, crystallization of glass-forming liquids, flow and relaxation phenomena, structure of glasses, phase separation in glasses, mechanical, electrical, and thermal properties of glasses, etc. Information from recent publications emphasized.
D. R. Uhlmann

3.611 Polyphase Ceramics (A)

Prereq.: 3.06, 3.07
Year: G (2)
2-0-4

Application of phase transformation kinetics and multi-component phase equilibria to structure and properties of polyphase ceramics such as glass-ceramic compositions, triaxial porcelains, glazes, clay products and refractories. (Alternate years. ***Not offered 1981-82.***)
W. D. Kingery, D. R. Uhlmann

3.63 Ceramic Processes (A) (Revised Unit)

Prereq.: 3.06 or 3.07, 3.20
Year: G (2)
3-0-6

Quantitative treatment of unit operations in powder processing-powder preparation, fabrication and firing. Glass processing-homogenization during melting; relationship to mixing theory-glass forming. Growth of crystals, ther-

modynamics, transport processes and kinetics in relation to structures developed. ***(Not offered 1981-82.)***
R. L. Coble

3.64 Special Problems in Ceramics (A)

Prereq.: —
Year: G (1, 2, S)
Arr.

Advanced work in this field. Lectures, conferences, assigned readings, and laboratory work.
W. D. Kingery

3.65 Ceramics Seminar (A)

Prereq.: 3.06 or 3.07
Year: G (2)
1-0-2

Individual talks followed by group discussion on current research and developments in ceramics by staff, students, and invited speakers.
R. L. Coble

3.691-3.699 Teaching Materials Science and Engineering

Prereq.: —
Year: G (1, 2)
Arr.

Laboratory, tutorial, or classroom teaching under the supervision of a faculty member. Students selected by interview. (Enrollment limited by availability of suitable teaching assignments.)
J. B. Vander Sande

3.70 Special Problems in Metallurgy (A)

Prereq.: —
Year: G (1, 2)
Arr.

Minor investigation in one of the special branches of metallurgy. (Open only to students properly qualified in the special field.)
Staff

3.71J Physical Metallurgy Principles for Engineers (A)

(Same subject as 22.71J)
Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Crystallography and microstructure of engineering materials. Thermodynamics of alloys, structural theory of metallic phases. Rate processes in metals; solidification, solid state diffusion, oxidation, and phase transformations. Defect properties; point defects, dislocations and radiation damage. Mechanical properties; plastic deformation, work hardening, strengthening mechanisms and fracture. Recovery and recrystallization. Emphasis on structure-properties relationships, their physical interpretation and quantification.
I-W. Chen

3.711J Materials for Nuclear Applications (A) (New)

(Same subject as 22.70J)
Prereq.: 3.14 or 3.71J
Year: G (2)
3-0-9

Introductory subject for students who are not specializing in nuclear materials. Applications and selection of materials for use in nuclear applications. Radiation damage, radiation effects and their effects on performance of materials in fission and fusion environments.
Staff

3.72J Nuclear Fuels (A)

(Same subject as 22.72J)
Prereq.: 3.14 or 22.71J
Year: G (1)
3-0-9

Behavior of nuclear fuels and fuel element cladding materials in reactor cores. Experimental observations, phenomenological and theoretical modeling of radiation and thermal induced effects such as fuel and cladding swelling, fission gas release and radiation induced creep. Fuel design, performance modeling and reliability analysis using state-of-the-art computer codes. Recent developments in advanced nuclear and fusion related core materials.
Staff

3.721J Radiation Effects in Crystalline Solids (A)

(Same subject as 22.73J)
Prereq.: 3.02 or 3.71J or 22.071J or 22.71J
Year: G (2)
3-0-9

Unified treatment based on governing principles for radiation effects in crystalline solids with the focus on metals. Collision theory of displacement damage; displacement processes, energy dissipation, and crystallographic effects. Evolution of damage state; primary damage state, recovery of damage related to mobility and structure of crystalline imperfections, defect configurations. Rate processes enhanced by radiation; solute redistribution, phase transformations, gas bubbles, void swelling and phase stability. Mechanical properties; deformation resistance, irradiation creep, irradiation growth and fracture.
I-W. Chen

3.73 Special Problems in Advanced Computer Applications (A)

Prereq.: —
Year: G (1)
1-0-8

An individual, graduate-level project focusing on computer-based analysis by modeling, simulation, optimization, or other numerical analyses. Problem of the student's own choosing. Design of approach by student (with guidance) and program design, coding, implementation, debugging, and testing by student. Working knowledge of necessary basic mathematics and of suitable programming language required.
R. Kaplow

3.74J Materials for Advanced Energy Systems

(Same subject as 6.780J)
Prereq.: 2.40 or 3.00 or 5.60 or 6.018; 3.15 or 6.012
Year: G (2)
3-0-6

Development of new energy technologies and improvement of more conventional systems requires development of new materials and an understanding of materials failures. An overview given of relationship between properties of materials, fabricability of materials, and their use in specific energy systems (nuclear, solar, storage batteries, coal gasification, fuel cells, turbines, MHD). Emphasis on failures in current technologies and needs for new systems and specifically research problems faced by practicing engineers and scientists.
H. K. Bowen, D. Adler, M. S. Dresselhaus

3.75J Radiation Effects in Reactor Structural Materials (A)

(Same subject as 22.75J)
Prereq.: 3.71J or 22.71J, 22.73J
Year: G (2)
3-0-9

Classes and characteristics of structural materials used in the core and primary circuits of fission and fusion reactor systems. Effects of radiation on strength, brittle fracture, high-temperature embrittlement, creep and growth, and void swelling on engineering properties. Materials specifications, design principles, and

quality assurance. Materials problems in reactor safeguards analysis. Case studies of reactor materials failures.
K. C. Russell

3.76J Electronic Materials (A)

(Same subject as 6.761J)
Prereq.: 3.15; or 6.012, 6.301
Year: G (1)
2-0-6

Various aspects of electronic materials such as preparation, purification, crystal growth, crystal structure, characterization, electronic properties, band structure and device applications. Special emphasis on relationships between structural characteristics, atomic bonding and physical properties in classes of materials such as elemental and compound semiconductors, thermoelectrics, and superconductors. Extensive rather than intensive coverage.
H. C. Gatos

3.77 Laboratory Measurement and Control

Prereq.: —
Year: G (2)
2-1-3

Discussion of laboratory techniques. Instrument characteristics. Basic electrical circuits. Transducers for force, stress, pressure, displacement, flow, and temperature input. Vacuum techniques. Special methods such as radio tracers, ultrasonic, laser. Control and recording systems. Analysis of experimental data.
J. T. Blucher

3.78J Advanced Gas Turbines Utilizing Ceramics

(Same subject as 16.544J)
Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Utilization of low cost gas turbines in automobiles and other ground vehicles offers promise of improved efficiencies but requires improved designs and higher temperature materials to obtain satisfactory performance over a range of output power. Issues involved in designing and fabricating advanced engines utilizing ceramic materials addressed; these include cycle efficiencies, component design considerations, design philosophy for using brittle materials, and effects of materials properties and fabrication limitations. The subject is interdisciplinary and involves lecturers from industry or government.
R. M. Cannon, A. Epstein

3.82J Structural Mechanics in Nuclear Power Technology (A)

(Same subject as 1.565J, 2.084J, 13.14J, 16.261J, 22.314J)
Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Structural components in nuclear power plant systems: their functional purposes; mechanical, thermal, and nuclear operating conditions; mechanical-structural design requirements. Mechanics of continuous media are combined with models of material behavior to determine adequacy of component design. Effects which are considered include: mechanical loading, hydraulic forces, elevated temperatures, and neutron irradiation; normal operation, accident situations, and seismic effects. Lectures are given by several members of Institute faculty and by guest lecturers from the nuclear power industry.
R. M. N. Pelloux, A. S. Argon, O. Buyukozturk, J. E. Meyer, T. H. H. Pian, P. C. Xirouchakis

3.90J Fracture of Structural Materials (A)

(Same subject as 1.591J, 13.16J)
Prereq.: 1.59J or 2.30 or 3.141 or 13.15J
Year: G (1)
3-0-6

Analysis of criteria for crack initiation and propagation leading to structural failure. Study of fracture mechanics starting with Griffith theory for ideally brittle materials and through plane strain fracture toughness phenomena. Effects of geometry, rate, environment, fatigue, temperature, composition, and microstructure. Fracture behavior of welded metals, heat affected zone. Relation to dislocation mechanics. Significance of fracture surface morphology. Metals, cementitious materials, rock, polymers, fiber reinforced composites. Emphasis on current research in field.
F. J. McGarry, K. Masubuchi

3.91J Mechanical Behavior of Plastics (A)

(Same subject as 1.593J)
Prereq.: 1.59J
Year: G (1)
3-2-4

Relation among chemical composition, physical structure, and mechanical behavior of plastics or synthetic high polymers. Study of types of polymers; fundamentals of viscoelastic phenomena such as creep, stress relaxation, stress rupture, mechanical damping, impact; effects of chemical composition and structure on viscoelastic and strength properties; methods of mechanical property evaluation. Influences of plastics fabrication methods. Emphasis on recent research techniques and results. Individual laboratory projects investigating problems related to current research.
F. J. McGarry, D. K. Roylance

3.92J Composite Materials (A)

(Same subject as 1.594J)
Prereq.: 1.02J
Year: G (2)
3-2-4

Concepts underlying formation, characteristics, and behavior of plastics-based composites such as fiberglass laminates, structural sandwiches, plywood, and load-bearing adhesive joints. Typical components such as metals, glass, synthetic and natural adhesives, plastics, foams, wood, paper, fabrics, and rubber. Correlation between adhesion principles and physical behavior. Methods of design, analysis, fabrication, and testing. Discussion of failure mechanisms of chemical, electrical, and mechanical types. Individual laboratory projects investigating problems related to current research.
F. J. McGarry

3.93J Materials Science of Polymers (A)

(Same subject as 2.926J)
Prereq.: 3.061J, 10.691
Year: G (1)
3-0-9

Consideration of structure and properties of polymers from viewpoint of materials science. Specific attention to polymerization processes, melt and crystal structures, crystallization from the melt and dilute solutions, rheology and relaxation behavior, rubber elasticity, mechanical properties, and effects of orientation and fillers on various properties. Strong emphasis on student participation in class discussion. (Alternate years. ***Not offered 1981-82.***)
D. R. Uhlmann, G. C. Tesoro

3.930 Industrial Practice

Prereq.: —
Year: U (S)
0-12-0

Enrollment restricted to students in Course III-B. Provides academic credit for the first approved work assignment at a company.
T. B. King

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3.931 Industrial Practice

Prereq.: —
Year: U (S)
0-12-0

Enrollment restricted to students in Course III-B. Provides academic credit for the second approved work assignment at a company.
T. B. King

3.932 Industrial Practice (A)

Prereq.: —
Year: G (1, 2, S)
0-6-0

Provides academic credit for graduate students in Course III-B for approved work assignments at companies. May be repeated.
T. B. King

3.94 Polymer Processing (A)

Prereq.: 18.03
Year: G (2)
3-0-9

Aspects of applied fluid mechanics relevant to analysis of polymer melt processing operations, including both closed-form and numerical techniques. Seeks to introduce the student to the literature of polymer processing research, and to provide the analytical tools used in the conduct of such research.
D. K. Roylance

3.95 Environmental Properties of Polymers (A)

Prereq.: 3.061J
Year: G (2)
3-0-9

Discussion of the many ways in which polymers influence and are influenced by environmental and societal factors, to include polymer weatherability and stabilization effects of solvents, thermal degradation, flammability, recycling and disposal, toxicity, response of polymer industry to current economic and societal trends. Illustrated by case studies. Projects.
D. K. Roylance

3.96 Electrical and Optical Properties of Polymers (A)

Prereq.: 3.06, 10.07 or 10.641
Year: G (2)
3-0-9

Strong emphasis on relationship of structure-electrical, structure-dielectric, and structure-optical properties. Structure in terms of polar, non-polar nature, molecular weight, its distribution, impurities, crystallinity, orientation, and morphology. Electrical properties cover electronic conduction, ionic conduction, photoconductivity, piezo- and pyroelectricity, contact electrification and electrets, on polymers; polymethylenes, polymers containing conjugated double bonds or metal atoms, charge-transfer polymers, polymeric salts of TCNQ radical anion, inorganic polysulfur-nitride. Optical properties cover refractive index, reflection, birefringence, light scattering, Kerr effect, photoelasticity, dichroism, photochromism, optical activity such as ORD and CD, spectroscopic methods, IR, UV, Visible Laser Raman, ESR and Fluorescence, and optical applications of polymers. Dielectric properties cover polarization of polymers in comparison to small molecules, frequency and temperature dependence, dielectric strength, dielectric heating, molecular theories of dielectric relaxation and polymeric insulators.
C. S. P. Sung

3.961 Polymer Synthesis and Properties (A)

Prereq.: 10.691
Year: G (2)
3-1-5

Fundamental chemistry of polymerization reactions. Step growth and chain growth processes; ring-opening polymerization; coordination catalysts. Reaction mechanisms, polymerization techniques and applicable processing methods. Strong emphasis on the relationships among polymer preparation, structure and physical properties; determinants for glass and melting transitions, thermal and oxidative stability, mechanical properties, etc. Topics: post-polymerization reactions such as vulcanization, preparation of fibers and foams, adhesives, polyurethanes, silicones, high-temperature polymers, liquid crystalline polymers and organometallics. Laboratory experiments.
G. E. Wnek

3.97J Materials Engineering of Polymers (A)

(Same subject as 2.927J)
Prereq.: 3.601J, 10.691
Year: G (1)
3-0-9

Consideration of engineering of polymers, tailoring molecular structure and process parameters to produce materials with desired end-use properties. Specific attention given to cellulosic polymers, thermosetting resins, thermally stable polymers, engineering thermoplastics, adhesives, formation of fibers, films, foams and coatings, and flammability of polymers. Strong emphasis on student participation in class discussion. (Alternate years. ***Offered 1981-82.***)
D. R. Uhlmann, G. C. Tesoro

3.99 Special Problems in Polymer Science and Engineering (A)

Prereq.: —
Year: G (1, 2)
Arr.

Advanced work in the field. Lecture, conferences, assigned readings, and laboratory work.
D. R. Uhlmann

4 Architecture

4.UR Undergraduate Research in Architecture

Prereq.: —
Year: U (1, 2)
Arr.

Research and project activities which cover the range represented by the various research interests and projects in the Department.
Staff

4.01 Issues in Architecture

Prereq.: —
Year: U (1)
2-2-8

Introductory architectural design studio subject about seeing and understanding the built world in a way that provides a framework of places for people. Subject structured in a series of cumulative exercises involving designing places for oneself, for a few people, for many people. Lectures, individual and group design projects. (Intended for freshmen and sophomores.)
J. Wampler

4.071J Design with Microclimate

(Same subject as 11.185J)
Prereq.: 8.01, 18.01
Year: U (1) LAB
3-6-3

Introduction to microclimate design that deals with natural phenomena and technical principles, user needs, and policy issues. Study of effects of wind, noise, solar and nocturnal radiation, vegetation and built form on microclimate through lectures, experiments, case studies, and site visits. Modeling methods for testing design alternatives experimentally and measurement techniques for adequate site reconnaissance. Work includes a comprehensive environmental design problem.
T. E. Johnson

4.125 Architectural Design[1]

Prereq.: 4.26
Year: U (1)
0-12-8

4.126 Architectural Design[1]

Prereq.: 4.26
Year: U (2)
0-12-8

Establishment of basic attitudes to architectural organization and its reflection in form. Projects whose imposed conditions of site, program, and building system emphasize the interrelationship of fundamental elements in the pattern of decision making that constitutes architectural design. Subject given as a series of coordinated separate studios. Presentations developed through drawings and models. (Intended for juniors, seniors, and entering graduate students.)
Staff

4.131 Architectural Design[1]

Prereq.: 4.125, 4.126
Year: U (1)
0-12-8

4.132 Architectural Design[1]

Prereq.: 4.125, 4.126
Year: U (2)
0-12-8

Projects selected to develop awareness of the principal issues facing the contemporary architectural designer and the range of possibilities available for effective satisfaction of common environmental needs. Design for intensive, extensive, and multiple space uses. Buildings of multi-story construction. Consideration of natural and artificial environmental controls as they influence the design concepts and the installations associated with them.
Staff

4.143 Architectural Design (A)[1]

Prereq.: 4.125, 4.126
Year: G (1)
0-12-8

4.144 Architectural Design (A)[1]

Prereq.: 4.125, 4.126
Year: G (2)
0-12-8

Projects selected to develop awareness of the principal issues facing the contemporary architectural designer and the range of possibilities available for effective satisfaction of common environmental needs. Design for intensive, extensive, and multiple space uses. Buildings of multi-story construction. Consideration of natural and artificial environmental controls as they influence the design concepts and the installations associated with them.
Staff

4.155 Architectural Design (A)[1]

Prereq.: 4.144
Year: G (1)
0-12-8

4.156 Architectural Design (A)[1]

Prereq.: 4.144
Year: G (2)
0-12-8

Emphasis on the setting of architectural work as part of an organized community in projects having to do with built-up areas as well as those on new sites. Study of plans for long-range development giving students increasing experience in the analysis of real-life situations requiring program research.
Staff

4.160 Urban Settlement Design in Developing Countries I (A)

Prereq.: Permission of Instructor
Year: G (2)
0-12-8

4.161 Urban Settlement Design in Developing Countries II (A)

Prereq.: 4.160
Year: G (1)
0-12-8

Advanced projects on urban settlement environments for low income groups in developing countries. Aims: to prepare designers to participate effectively in the process of shaping the environment; to develop tools to define and evaluate design determinants; and to make these tools available to those concerned and responsible for action at the policy-making level.
H. Caminos, R. Goethert

4.162J Environmental Design III (Total Studio) (A)

(Same subject as 11.316J)
Prereq.: Permission of Instructor
Year: G (1)
Arr.

Concentrates on process and skills in planning and designing for a definable area undergoing major spatial/physical changes. Major emphasis on synthesis in the face of complexity, incomplete data, multiple owners, users and values, diverse implementation agencies. Studio based on a real world problem for a client

[1]Note about the subjects in Architectural Design: The sequences in Architectural Design is a cumulative program. Its successful completion by the student is subject to the evaluation of the staff independently of formal grades accumulated.

with a program for land and building development in conjunction with social change. Focuses on problem statement, synthesis, evaluation, and implementation. A professional report produced for the client. Emphasis on interdisciplinary work and all work done in teams.
T. F. Lee

4.163 Advanced Environmental Design (A)

Prereq.: Permission of Instructor
Year: G (2)
Arr.

Design of a large-scale project with particular attention to its social and cultural context. Explores design of public environments and the structure of public experiences of urban places.
G. A. Hack

4.164 Housing Design and Methods (A)

Prereq.: 4.211, *4.224*
Year: G (1 or 2)
0-12-8

The understanding of problems related to design of residential environments and development of skills to deal with these problems. Emphasis on application of methods which deal with issues of change, evaluation of the capacity of a given environment to accommodate to changing uses and lifestyles, assessment of the impact of changing normative criteria on the physical environment, and development of alternative solutions within a given set of constraints. Projects in the design of buildings and of urban (residential) issues.
E. Dluhosch

4.17, 4.171 Special Problems in Architectural Design

Prereq.: —
Year: U (1, 2)
Arr.

Supplementary work on individual or group basis. Registration subject to prior arrangement for subject matter and supervision by staff.
Staff

4.19, 4.191 Special Problems in Architectural Design (A)

Prereq.: —
Year: G (1, 2)
Arr.

Supplementary design work for graduate students. Registration subject to prior arrangement for subject matter and supervision by staff.
Staff

4.201 Introduction to Computers and Graphics

Prereq.: —
Year: U (1)
4-0-8

Basic principles of computer programming, hardware organization, and intensive interaction with machines in general. Includes extensive hands-on laboratory work with vector and raster scan graphics. PL/1 is the programming language employed. Students without prior programming experience introduced to PL/1 in parallel with the first sessions. Extensive treatment of the topics — graphical input and color displays.
Staff

4.202 Advanced Computer Graphics and Animation

Prereq.: 4.201
Year: U (2)
4-0-8

Real-time 2D and 3D graphics inclusive of additional media: voice, sound, force feedback. Students expected to develop specific projects within ongoing research topics. The general theme of graphical conversation theory includes: spatial data management systems, touch sensitive displays, sound-sync animation, color theory and perception.
Staff

4.211 Intervention and Urban Habitats (A)

Prereq.: 4.125 or 4.126
Year: G (2)
3-0-6

Planning, building, and living processes which shape urban physical form. Evolution and change of these processes in time presented in various cultural and historical contexts. Professional, governmental, and industrial intervention in these processes; types, tools, models, and implications. Case studies illustrating approaches to the analysis of existing habitats. Related design information and regulatory processes at dwelling and neighborhood levels.
Staff

4.224 Design and the Everyday Environment (A)

Prereq.: 4.143
Year: G (1 or 2)
4-2-3

Physical environment as a combination of different morphological systems, the nature of these systems, their behavior under control of powers, their transformation in time, relations of systems on different levels, and concepts of value, function, and privacy as related to morphological systems in the environment. SAR methods as tools to design systems on different levels, formal description of systems by means of zones and their analysis, location of systems in space; positional coordination, communication of values and norms, testing of capacity of spaces and space combinations.
N. J. Habraken

4.227 The Design Process in Architecture (A)

Prereq.: 4.224
Year: G (1 or 2)
Arr.

Various issues related to architectural design analyzed to understand design as a decision-making process in which value judgments are expressed in built forms. Specific issues may include formulation of norms and standards, coordination of design decisions, and evaluations of design decisions. Specific environments, buildings, and urban issues analyzed as the result of design decisions. (Permission of instructor required.)
N. J. Habraken

4.23 Analysis of Urban Design (A)

Prereq.: 4.143, 4.236J
Year: G (2)
3-0-6

Analysis of processes and products of urban design. Discussion of descriptions of environments and of transformations and tests of the descriptions. Examination of techniques, especially computer-based, which can be used to aid the designer. Development of criteria by which to evaluate the adequacy of computer languages to represent design ideas, to accommodate design processes, and to aid designer. An independent project required.
W. L. Porter

4.242 3D Computer Graphics (A)

Prereq.: 4.201
Year: G (2)
2-0-7

Programming workshop in 3D computer graphics techniques. Geometric modeling, homogeneous coordinates, 3D transformations, clipping algorithms, hidden-surface algorithms, smooth shading techniques.
Staff

4.251 Applications of Digital Video (A)

Prereq.: 4.201
Year: G (1)
2-0-7

Aspects of digital video including computer generation of pictures, interaction with live analogue television images, treatment of special raster scan display characteristics such as surface and edge representations and creations of color and gray tone. Methods of synthesizing images, representing high resolution data on standard television systems, and interaction with video mass storage devices such as optical videodisks and digital media. Applications to such research problems as map making and movie making.
A. Lippman

4.26 Built Form Observations

Prereq.: 4.01
Year: U (2)
2-3-7

Introduction to disciplined observation of the built environment. Projects indicating the various ways in which buildings, landscape, and urban form can be described and interpreted. Exploration of relationships among modes of description, environmental content, and design methods. Lectures, field studies, and drawing laboratory.
B. Zevin

4.262 Building Design Techniques

Prereq.: —
Year: U (2)
2-3-7

Introduction to techniques used in design of buildings. Emphasis on consideration of the relationships between fundamental working methods and various ways of drawing and modeling buildings, their context and their use. Design problems, drawing and modeling exercises with lecture and discussion of the process and value implications of design techniques. ***(Not offered 1981-82.)***
Staff

4.27 Analysis of Precedent

Prereq.: 4.01
Year: U (1 or 2)
2-2-5

Critical analysis of some selected concepts, precedents, and cases in the recent history of architecture and environmental design. A major aim to relate current activity, both within the studio and the profession, to intellectual constructs of the near past. Emphasis towards providing an introductory perspective to students prior to (or at the very beginning of) the design studio sequence. Themes include urban structure, formal archetypes, movements and roles.
Staff

4.271 Advanced Topics in Environmental Precedent (A)

Prereq.: 4.27
Year: G (2)
2-2-5

Advanced material developing themes of introductory subject. Major objective to bridge the gap between the action and craft of the studio and the traditional critical historical perspective. Topics including relation between political theory and environmental form; anarchism and expropriation of space; formal expressions of concepts such as flexibility, density, linearity, and nodality; a critical history of recent styles and movements, e.g., the formal image and the politics of the United States embassy building program; and an examination of various professional and non-professional roles and strategies.
J. Beinart

4.273 Methods of Inquiry in Architecture Studies (A)
(Revised Unit)

Prereq.: Permission of Instructor
Year: G (1)
3-2-7

Introduction to ways of acquiring systematic knowledge about the built environment. Examines the problem of what constitutes valid knowledge in architecture and then analyzes and compares various approaches to the understanding of the built environment and its impact on people, including traditions of architecture design, design methods, humanistic inquiry, science and social science. Special emphasis placed on the building of theory and testing and verification of hypotheses as appropriate to the special nature of architecture studies. Requirements include a series of exercises aimed at improving skills in conceptualizing problems; developing concepts; collecting, analyzing, and interpreting information; and communicating results. (Required of all first-year S.M.Arch.S. students.)
E. Robbins

4.281 Preparation for M.Arch. Thesis (A)

4.282 Preparation for S.M.Arch.S. Thesis (A)

4.283 Preparation for S.M.Vis.S. Thesis (A)

Prereq.: Permission of Instructor
Year: G (1, 2)
Arr.

Selection of thesis topic, definition of method of approach, and preparation of thesis proposal. Independent study supplemented by individual conference with faculty.
Staff

4.291 Special Topics in Design Information

Prereq.: —
Year: U (1, 2)
Arr.

Supplementary work on individual or group basis. Registration subject to prior arrangement for subject matter and supervision by staff.
Staff

4.295-4.299 Special Topics in Design Information (A)

Prereq.: Permission of Instructor
Year: G (1, 2)
Arr.

Supplementary work on individual or group basis. Registration subject to prior arrangement for subject matter and supervision by staff.
Staff

4.30 Basic Structural Theory

Prereq.: 8.02, 18.02
Year: U (2) SD
3-3-6

Introduction to the static behavior of structures. Determination of loads, deformations of determinate structures. Definitions of stress and strain at a point. Applications to stress distributions and deflections of slender elements in bending. Considerations of stability of structures. Laboratory work giving students opportunity to produce creative designs for solving structural problems, with execution of these designs by building models and testing them.
L. B. Groisser

4.315J Structural Engineering Laboratory

(Same subject as 1.105J)
Prereq.: —
Year: U (1) LAB
0-3-3

Introduces student to properties of structural materials and behavior of simple structural elements and systems through a series of experiments. Several laboratory sessions involve the student as both the designer and fabricator of a structure.
W. P. Zalewski

4.331 Synthesis of the Behavior of Structural Systems I (A)

Prereq.: —
Year: G (1)
4-0-4

4.332 Synthesis of the Behavior of Structural Systems II (A)

Prereq.: 4.331
Year: G (2)
4-0-4

Classification of the most characteristic patterns of the behavior of basic structural materials, structural systems, and their components. Catenary, arch, and shell structures. Flow of internal forces in deep walls and beams; trusses; frames and plates. Study of relationship between shape of structure and its technological and mechanical efficiency as a way to general optimization. Study of methods of quantitative estimation of structural behavior for typical cases. Mastery of simplified procedures — graphical and numerical — applied to the design of structural systems.
W. P. Zalewski

4.341 Framing Systems for Small Structures (A)

Prereq.: 4.30 or 4.331
Year: G (1)
4-0-4

Approximate methods for the initial selection of framing systems for vertical loading. Loading conditions and building codes. Design of beams for shear, bending moment, and deflection criteria; design of beams, columns. Application to a wood house including alternative wood floor framing, walls, columns, and rafters. Optimum truss depth.
L. B. Groisser

4.342 Structural Design and Application (A)

Prereq.: 4.30 or 4.331
Year: G (2)
4-0-4

Integrated architectural-mechanical-structural design. Nature and range of functional requirements for structures. Study of interrelationship between structures and building methods and architectural and mechanical design. Emphasis on procedure for the conception and initial selection of the structural system.
Staff

4.343 Industrialization of Structural Systems (A)

Prereq.: 4.30 or 4.331
Year: G (2)
4-0-4

Examinations of the application of industrialized processes to building construction. Industrialized building components and systems; design, fabrication, and erection. Implications of industrialized construction for architecture and engineering design.
W. P. Zalewski

4.348 Structural Design Workshop (A)

Prereq.: 4.126, 4.30 or 4.331, 4.402J
Year: G (2)
4-4-4

Phenomenological approach to relationship between structural and general design requirements. Projects dealing with steel and concrete in the conventional and industrialized versions. Major steps of structural design from initial conceptual considerations through design development and detailing towards understanding the influence of details on initial design stages. Studio format: lectures, design, and critiques.
W. P. Zalewski

4.39 Special Problems in Structural Design (A)

Prereq.: 4.30 or 4.331
Year: G (1, 2)
Arr.

Supplementary structural design on individual or group basis. Registration subject to prior arrangement for subject matter and supervision by staff.
Staff

4.402J Basic Building Construction

(Same subject as 1.411J)
Prereq.: —
Year: U (1)
3-3-6

Basic methods of building construction in wood, masonry, steel, and concrete. Materials, foundations, framing systems, systems of roofing and cladding, insulation, vapor control, interior finish materials, stairs, fireplaces. Building trades and assembly processes. Problems, laboratory projects, and field trips to illustrate principles.
E. B. Allen, Staff

4.403J Design of Building Systems

(Same subject as 1.412J)
Prereq.: 1.02, 1.04, 1.06; or 4.402J, 4.30
Year: U (2)
3-2-7

Exploration of problems found in design of the major physical systems associated with buildings, including structure (foundation, structural system, and enclosure), environmental systems, functional systems, and utilities. Discussion of basis of system demands, analytical modeling of the physical systems, and role of building codes. Examination of contemporary design solutions in a case study format. Emphasis on engineering design and processes through which design decisions are made in the evolution of a building. (The prerequisites are structured so that the subject can act as an integrator of the various discipline areas involved in building design. Permission of instructor required.)
E. B. Allen, Staff

4.404 Practical Workshop in the Technology of Construction

Prereq.: 4.402J
Year: U (2)
0-6-3

Workshop exploration of special design projects in systems of construction using actual materials and tools. Each student to select a project and design and build a trial solution by mid-term. The remainder of the term spent in cycles of testing, re-design, and re-fabrication, aiming toward a built, problem-free solution.
I. H. Garabieta-Orueta

4.407 Elements of Buildings (A)

Prereq.: 4.125, 4.126, 4.402J
Year: G (1 or 2)
2-0-4

In-depth consideration of one or two selected physical elements of buildings, such as windows, entrances, circulation systems, roofs, or site with reference to technical aspects, patterns of human use, and integration of each element into overall building design. Lectures, group discussions, student presentations, and design exercises.
E. B. Allen

4.408 Integrated Design of Buildings (A)

Prereq.: 4.126, 4.30 or 4.331, 4.402J
Year: G (2)
3-9-8

The simultaneous design of the space, form, and structure of a simple building, including engineering computations and detailing. Lectures cover both means of architectural expression and techniques of structural analysis for a selected structural material. Each student carries out a design project for a building in the given material.
E. B. Allen

4.409 Special Problems in Building Technology (A)

Prereq.: 4.30, 4.402J, 4.43
Year: G (2)
Arr.

Supplementary work on individual or group basis. Registration subject to prior arrangement for subject matter and supervision by staff.
Staff

4.41 Materials, Techniques and Form

Prereq.: —
Year: U (2)
3-3-6

Introduction to the understanding of the uses and physical properties of building and industrial materials, techniques by which they can be manipulated, fabricated and constructed, and their behavior in structures with regard to their functional and visual appropriateness and their effect on the resultant form. Evaluation of the uses of materials and the development of techniques and structures as they have affected the visual environment.
I. H. Garabieta-Orueta

4.42 Materials

Prereq.: 1.02
Year: U (1)
3-2-3

Emphasis on newer materials and combinations. Development of properties and applications from fundamental structure of materials. Plastics and other polymeric materials. Engineering adhesives and principles of bonding. Wood derivatives and bonded structures. Ceramics. Glass. High-performance masonry. Metals and alloys. Composites of several materials: fiber-reinforced, laminates, and sandwiches. Principles of combined behavior. Deterioration of materials, protection against attack.
Staff

4.43 Environmental Control — Acoustics

Prereq.: 8.02
Year: U (1) SD
4-0-4

Principles of acoustical design for good hearing conditions and control of noise in rooms and buildings; design criteria; analysis of sound absorption and transmission; acoustical properties of room shapes, structures, and surface materials; laboratory demonstrations.
R. B. Newman

4.431 Special Problems in Architectural Acoustics (A)

Prereq.: 4.43
Year: G (1, 2)
Arr.

Broad study of functional acoustic design in architecture (based on project work in actual buildings where possible), sound distribution and diffusion in rooms, and sound transmission through building structures.
R. B. Newman

4.45 Uses of Energy in Buildings

Prereq.: 4.402J
Year: U (1)
4-0-5

Aspects of energy utilization in buildings with a special emphasis on energy conservation. Principles of natural and mechanical space-conditioning developed from basic thermodynamics. Topics: energy cost of materials and construction, thermal comfort conditions, climate analysis, climatic design of building envelopes (orientation, albedo, fenestration patterns, ventilation, etc.), thermophysical properties of building materials, heat gain and loss, energy conservation and HVAC systems design including total energy and district heating systems. Life-cycle costing, thermal performance standards and energy budgeting applied to building design, scheduling and maintenance in new and old buildings. Case studies of building types in different climatic regions of the US used to illustrate the energy consequences of design decisions.
H. Bryan

4.46 Solar Architecture (A)

Prereq.: 4.45
Year: G (2)
4-0-5

Development of principles of solar architecture. Fundamentals of heating and cooling. Optics of solar collection. Collector design: flat plate and concentrating types. Hot water, hot air, and other transfer media. Design of solar storage systems and control. Cost benefit analysis. Case studies of passive solar heating and cooling systems using existing and emerging building materials. Design methods for predicting thermal and visual performance. Integration of passive and active systems.
H. Bryan

4.468 Energy Conscious Design (A)

Prereq.: 4.143, 4.071J, 4.45, 4.46
Year: G (2)
4-4-12

Technically based methods for the predictions of the thermal performance of both active and passive design systems applied to two heavily constrained design projects in which both the technical and architectural aspects of the design are considered jointly. Selecting materials, specifying joining methods, selecting HVAC equipment, estimating operating costs for energy-related components of the design projects.
T. E. Johnson

4.474 Sunlighting and Building Systems (A) (New)

Prereq.: 4.071J or 4.45
Year: G (2)
2-0-4

Model studies of sunlighting concepts and critical analysis of existing building leading to systems in which the integration of sunlighting, artificial lighting, HVAC, structure, acoustical and other architectural elements creating optimum physical environments for the user with a minimum of energy and life cycle cost.
W. Lam

4.497-4.499 Special Problems in Environmental Controls (A)

(4.49)
Prereq.: —
Year: G (1, 2)
Arr.

Supplementary work on individual or group basis. Registration subject to prior arrangement for subject matter and supervision by staff.
Staff

4.50 Organization of the Building Industry

Prereq.: —
Year: U (2)
3-0-6

Overview of structure and performance of US building industry. Role of materials, management, land, labor, finances, and other institutional and professional factors and their functional and organizational links with the building industry. Impact of change on traditional construction practices. Survey of new production and delivery processes, along with an evaluation of emerging new organizational configurations. Guest speakers from various branches of the building industry to present examples and case studies.
Staff

4.51 Introduction to Systems Building (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-6

Development and application of technological innovation to building design including prefabrication, industrialization and systems building, with an emphasis on housing. Processes for building production and delivery, responsive to user needs. Assessment of alternate building systems utilizing basic resources such as land, labor, materials, finance, and maintenance. Survey of appropriate technologies for low-cost housing. Case studies and field trips.
E. Dluhosch

4.52 Seminar in Systems Building (A)

Prereq.: 4.51
Year: G (2)
3-0-6

Application of systems building concept to various building and functions, with an emphasis on housing. Assessment of relationship between design concept and its translation into appropriate technology. Planning, programming, procurement, and evaluation of various building systems, both in the US and abroad. Factors determining acceptance and/or resistance to "prefab" housing. Problems of flexibility, variability, and adaptability in systems building.
E. Dluhosch

4.541J Legal Problems in Construction (A)

(Same subject as 1.471J)
Prereq.: Permission of Instructor
Year: G (1)
2-0-7

Exploration and analysis of the legal concepts and processes applicable to the development of constructed facility projects. Presents common law, legislation, and regulations relevant to: professional registration; forming design organizations and management teams; designer liability for faulty design, cost overruns, and construction supervision, third party rights; analysis of construction contract and contractor's liability; copyright and patent protection for designs; arbitration; implications of systems approach to projects. Emphasis placed upon potential liabilities and risks to the various parties when translating design representation into physical reality. Case material used extensively to illustrate the legal issues being addressed.
C. Sapers

4.59 Special Topics in Industrialization of Building (A)

Prereq.: Permission of Instructor
Year: G (1, 2)
Arr.

Student-initiated, individual, or small group study of selected topics such as managerial, socioeconomic, or political problems connected with the development of the building industry. Registration subject to prior arrangement, for subject matter and supervision, with individual members of the staff.
Staff

4.601 Topical Studies in the History and Theory of Art

Prereq.: —
Year: U (1) HUM-D
3-0-6

Introduction to the history and theory of painting and sculpture from prehistoric times to late Baroque. Key objects examined in terms of style, iconography, and function and presented as expressions of the social, political, religious, and intellectual values of their respective cultures. Subject organized topically rather than in survey fashion. Discussion of the different functions of art and basic modes of artistic formation. (May be counted toward Humanities Requirement.)
B. Sell Tower

4.602 Introduction to the History and Theory of Architecture

Prereq.: —
Year: U (1) HUM-D
4-0-5

Introduction to the history and theory of architecture from its earliest artifactual traces to the present time, with an emphasis on thematic developments in the structuration of environments. History and development of architectural theory examined, along with issues arising out of contemporary practice. Current models of perception and cognition discussed in their relationships to recent architectural theory, as well as theories of spatial learning and visual symbolism. (May be counted toward Humanities Requirement.)
D. H. Friedman

4.604 Topical Studies in Modern Art

Prereq.: —
Year: U (1 or 2)
3-0-6

Painting and sculpture from the late 18th century to the present day. Neo-Classicism, Romanticism, Realism, Impressionism, Cubism, Dada-Surrealism, and ending with American Abstract-Expressionist work and its aftermath. A general survey with emphasis on the most innovative phases of modern art. (May be counted toward Humanities Requirement.)
Staff

4.616 Selected Topics in Architecture of the Ancient World

Prereq.: —
Year: G (1)
3-0-6

Analysis of role of mass, space, structure, light, surface, and related social, political, and economic factors in architecture and urban design from prehistory through Roman times.
Staff

4.626 Selected Topics in Architecture in the Middle Ages

Prereq.: —
Year: G (1)
3-0-6

Selected buildings and urban complexes from the time of Rome's conversion to Christianity to the beginning of the Renaissance. Special attention given to the influence on the builders of architectural traditions as well as significant religious, political and economic factors.
D. H. Friedman

4.636 Introduction to Renaissance Architecture

Prereq.: —
Year: U (2) HUM-D
3-0-6

Analysis of role of mass, space, structure, light, surface, and related social, political, and economic factors in architecture and urban design from the beginning of the Renaissance to the end of the Rococo. (May be counted toward Humanities Requirement.)
D. H. Friedman

4.641 Painting and Sculpture in the 19th Century

Prereq.: —
Year: U (1, 2)
3-0-6

Neo-Classical and Romantic movements of the first half of the 19th century: David, Gericault, Gros, Ingres, Delacroix. Style and subject matter of academic painting compared with Courbet's realist work. Daumier's caricatures. Formulation of Impressionism in the late 1860s: Manet, Degas, Pissarro, Monet, Renoir, and the early Cezanne. Emphasis on historical and cultural context as well as the stylistic development. (May be counted toward Humanities Requirement.)
W. V. Andersen

4.642 Modern Art from Impressionism to Cubism

Prereq.: —
Year: U (1, 2) HUM-D
3-0-6

Cezanne, Gauguin, Van Gogh, and Seurat presented against a background of Impressionism and other 19th-century styles. Their relationship to the Synthetist, Nabis, and Symbolist groups. Required readings from letters and other writings by the artists, their artist and writer friends, and their critics. (May be counted toward Humanities Requirement.)
W. V. Andersen

4.643 Advanced Study in 19th-Century Art (A)

Prereq.: Permission of Instructor
Year: G (1, 2)
Arr.

Seminar on a selected topic from 19th-century art. Students undertake original research and deliver both oral and written reports.
W. V. Andersen

4.647 Selected Topics in Architecture—1750 to the Present

Prereq.: —
Year: U (1 or 2)
3-0-6

Study of selected designs as research programs (architectural form and its intellectual, social, and technical context.) Emphasis on the 20th century. (Limited enrollment. May be counted toward Humanities Requirement.)
S. Anderson

4.648 American Landscapes, Towns and Buildings

Prereq.: —
Year: U (1)
3-0-6

Introduction to environmental history in the US, beginning with American Indian settlements and European colonial outposts in the New World, and concentrating on 19th- and 20th-century developments related to the expansion of American capitalism: land speculation, new towns, class segregated dwellings, industrial and institutional buildings. Concludes with visionary conceptions: idealistic communities, fantasy environments, science fiction environments. Emphasis on learning to "read" complex contemporary places through understanding historic components; walking tours of local sites. (May be counted toward Humanities Requirement.)
Staff

4.651 Modern Art from Cubism to the Present

Prereq.: —
Year: U (1) HUM-D
3-0-6

Cubism, Futurism, Constructivism, and other phases of early 20th-century art during which the theories, styles, and attitudes of contemporary art were formulated. Dadaism, Surrealism, and other intermediate phases leading to Abstract Expressionism in New York. Post-Painterly Abstraction styles, Pop Art, and the recent Optical Art Movement, considered both historically and critically. (May be counted toward Humanities Requirement.)
B. Sell Tower

4.653 Modern Architecture in Europe from 1895 to the Bauhaus (A)

Prereq.: 4.602 or 4.647
Year: G (2)
3-0-6

Art and architecture in Europe from the late 19th century to the time of the Nazi repression of modern art. Intensive study of the people, works, and controversies from which the European "modern movement" emerged, leading in turn to the transformation of American architecture.
S. Anderson

4.655 Symbolist Origins of Modern Art

Prereq.: 4.642
Year: U (2)
3-0-6

The impact of Gauguin, van Gogh, and Seurat on modern art. These and other Symbolist and *art nouveau* artists analyzed as sources for the art and theories of early 20th-century artists such as Kandinsky and the German Expressionists, early Picasso, Mondrian, Klee, and Kupka. Topics: primitivism, concepts of abstraction, color theories, and relationship between the arts and iconographic questions. (May be counted toward Humanities Requirement.)
B. Sell Tower

4.658 Advanced Study in 20th Century Art (A)

Prereq.: Permission of Instructor
Year: G (1, 2)
Arr.

Seminar on a single aspect of 20th-century art selected at the discretion of the instructor. Students to do original research and present both oral and written reports.
W. V. Andersen

4.659 Advanced Studies in Iconography and Symbolism (A)

Prereq.: Permission of Instructor
Year: G (1, 2)
3-0-6

Selected topics and guided research. (Open to advanced undergraduates by permission of instructor.)
W. V. Andersen

4.661 Theory and Method in the Study of Architecture and Art (A) (Revised Unit)

Prereq.: Permission of Instructor
Year: G (1)
Arr.

Study of theoretical and historiographical works pertaining to the fields of architecture, art, and environmental studies. Members of seminar will pursue work designed to elucidate and criticize their own presupposition and methods. (Open only to Ph.D. candidates and other advanced students.)
W. V. Andersen, S. Anderson

4.662 Meaning in Architecture (A)

Prereq.: Permission of Instructor
Year: G (1 or 2)
3-0-6

Theories of the origin of building and architecture; theories of the significance of materials and use (see 4.664); distinctions between artifacts and objects of design; contextual issues of patronage, society, culture. In general, an examination of theoretical and formal models (see 4.663) as they are revealed in the built environment.
Staff

4.663 Form in Architecture (A)

Prereq.: Permission of Instructor
Year: G (1 or 2)
3-0-6

An examination of intrinsic formal qualities of architecture, formal vocabularies, and innovation in architectural form. Relationship between built forms and 1) intent, 2) theoretical models, and 3) theories of form perception, as well as, secondarily, 4) meaning (see 4.662), and 5) construction methods (see 4.664).
Staff

4.664 Physical Considerations in Architecture (A)

Prereq.: Permission of Instructor
Year: G (1 or 2)
3-0-6

Materials, construction and structure; activity and use in architecture as well as the theories of form (see 4.663) and of function (see 4.662) which have been based on such physical considerations.
Staff

4.665 Criticism of Architecture (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Seminar surveying various approaches (social, environmental, economic, compositional, structural, functional, etc.) and bases for the criticism of architecture. Principal emphasis on formal bases of criticism. History of criticism, relation of criticism and history, value of criticism to the profession, criticism as a means of achieving quality in architecture, and criticism as a rational and emotional response to architecture.
Staff

4.666 Studies Toward a Theory of Architecture (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Seminar about contemporary theoretical positions. Reports by seminar members either in the context of, or in criticism of, the thesis of the seminar.
S. Anderson

4.667 Studies Toward a Theory of Environmental Design and Form (A)

Prereq.: Permission of Instructor
Year: G (1 or 2)
Arr.

Seminar with intent to stimulate thought about our contemporary theoretical positions. Studies carried out by seminar members to be either in criticism or in support of the thesis of the seminar.
S. Anderson

4.668 Studies in Environmental Cognition (A)

Prereq.: Permission of Instructor
Year: G (1 or 2)
3-0-6

Studies of environmental elements, both built and natural, that affect human behavior by virtue of having symbolic meaning, either latent or contrived. Dynamics of symbol formation, the perseverance of symbols, their contextual metamorphosis, their influence on behavior, and the techniques of unmasking and analyzing their structure. Identification and analysis of symbolic value in specific architectural components and building types, in landscape form and type, and in whole environments from small to large scale. Field work, with assigned environments analyzed by students.
W. V. Andersen

4.671 History of Urban Form (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-6

History of the city as an architectural form. Study of the physical growth of cities as an expression of a developing social structure, as well as with reference to artistic ideals.
D. H. Friedman

4.672 Elements of Urban Evolution

Prereq.: —
Year: U (1 or 2)
3-0-6

Consideration of the forces, in different periods, determining the character and principal functions of cities — military, religious, commercial, political, industrial, and utopian. Readings in literary, artistic, and historical sources. Independent individual student projects with a wide range of choice for production of term papers dealing with a particular city over a manageable time span, usually less than a century. Lectures and seminars. (Limited enrollment. May be counted toward Humanities Requirement.)
D. H. Friedman

4.673 Seminar in Urban Communal Space (A) (Revised Unit)

Prereq.: Permission of Instructor
Year: G (1 or 2)
Arr.

A working seminar conducting continuing research on the sociophysical structure of urban communal space. Attention to the literal qualities of this space and especially to the models by which the form, meaning, and use of communal space are understood and changed. The seminar to produce theoretical or critical essays, graphic analyses, formalizations or designs. (Limited enrollment.)
S. Anderson

4.681 Introduction to Building in East Asia

Prereq.: —
Year: U (2)
3-0-6

Intended to promote a better understanding of society in East Asia through the study of conscious and unconscious making, perception, and representation of the built environment as well as attitudes toward and behavior within it, both historically and at present. Historical and

anthropological approach. Successive offerings ranging from India and China to Japan. (May be counted toward Humanities Requirement.)
G. Nitschke

4.682 Selected Topics in the Study of East Asian Architecture (A)

Prereq.: Permission of Instructor
Year: G (2)
4-0-8

Research seminar on the development, structure, and module of the traditional Japanese house and garden and their relation to folk and religious architecture as well as to their urban contexts or their setting in nature. Historic and structural approach based on measured drawings and translations of early texts on the subject written by craftsmen, priests, and literati.
G. Nitschke

4.683 Introduction to the Muslim World Through Its Monuments

Prereq.: —
Year: U (2) HUM-D
3-0-6

Introduction to Muslim society in its geographical, cultural, and historical settings exploring the interaction between the universal requirements of the faith and local traditions and practices using the case-study method. Study of the salient features of a great Islamic urban setting — the city of Isfahan in the 17th century. The historical development of these features considering which are unique responses to local requirements, which are traditionally Iranian factors and which are pan-Islamic features. Provides an understanding of the social, historical, and cultural contexts of one particular Islamic urban setting and then contrasts and compares it to other Islamic cities. (May be counted toward Humanities Requirement.)
S. S. Blair

4.684 History of Islamic Architecture (A) (New)

Prereq.: Permission of Instructor
Year: G (1 or 2)
3-0-6

Study of Islamic Architecture in historical periods. Among the topics considered are the techniques, materials and organization of the building field, vernacular traditions, typological studies, case studies, restoration of monuments and interaction with the contemporary world.
Staff

4.685 Islamic Architecture and Urban Form (A) (New)

Prereq.: Permission of Instructor
Year: G (1 or 2)
3-0-6

Study of the Islamic built environment at the urban scale. Urban and rural case studies, history of urban design, preservation of historic sites.
Staff

4.686 Theory in Islamic Architecture (A) (New)

Prereq.: Permission of Instructor
Year: G (1 or 2)
3-0-6

Theoretical evaluation of the Islamic built environment on architectural and urban scale. Ideas on organization and shaping the built environment, theories of architecture, comparative aesthetics of built form.
Staff

4.687-4.689 Special Studies in the History, Theory, and Criticism of Architecture and Urban Form in the Islamic World (A) (New)

Prereq.: Permission of Instructor
Year: G (1, 2)
Arr.

Special topics in the history, theory, and criticism of architecture and urban form in the Islamic World, varying at the discretion of the instructor.
Staff

4.691-4.693 Special Studies in the History, Theory, and Criticism of Art (A)

Prereq.: Permission of Instructor
Year: G (1, 2)
Arr.

Individual projects on topics in history, theory, and criticism of art. Prior arrangement and approval of instructor necessary. (Open to qualified undergraduates by permission of instructor.)
Staff

4.696-4.699 Special Studies in the History, Theory, and Criticism of Architecture and Urban Form (A)

Prereq.: Permission of Instructor
Year: G (1, 2)
Arr.

Special topics in the history, theory, and criticism of architecture and urban form, varying at the discretion of the instructor.
Staff

4.736J Introduction to Environmental Design (A)

(4.236J)
(Same subject as 11.301J)
Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Introductory subject for incoming S.M.Arch.S. and M.C.P. students that examines both structure of environment and nature of processes changing it. Class consists of lectures and seminars. Lecture material includes topics such as economic processes and urban form, socio-spatial structure of cities, cities as behavior settings, knowledge and values of urban form, public certainty and environmental regulation, urban ecology, neighborhood change, and urban ideals and futures. In addition, there are a series of seminars which review cases from contemporary practice, current theories of design, and theories of form and professional role.
J. Beinart, G. A. Hack

4.742J Shaping the Urban Environment

(Same subject as 11.132J)
Prereq.: —
Year: U (2)
3-0-6

Analysis of case studies which present a range of design, planning, development, and management issues. Financial, political, sociological, and environmental constraints analyzed along with techniques for professional-client interaction, project management, facilities programming, project evaluation, and environmental impact review. Cases encompass inner city redevelopment, planned unit development, and new town design. (May be counted toward Humanities Requirement. ***Not offered 1981-82.***)
G. A. Hack

4.743J Neighborhood Planning (A)

(Same subject as 11.420J)
Prereq.: 11.200, 11.210, 11.220; or 4.144
Year: G (2)
3-0-6

Techniques of neighborhood planning. Class organized around issues commonly faced by planners working at the neighborhood scale. Stresses planning skills and methods useful when time and money are limited. Problems addressed include: location of new and rehabilitated housing; neighborhood business district improvement; planning and siting for community services and facilities; open space and transportation planning at the neighborhood level. Professional techniques covered: how to define information needs; how to get and use the data; mapping use of professional standards; zoning; surveying physical conditions, and resident attitudes and behavior; alternative methods of allocating resources among neighborhood units; approaches to citizen involvement, client and interagency relationships; major models for organizing neighborhood planning functions within municipal government. First several weeks devoted to study of neighborhood theory and to historical review of shifting concepts and methods of neighborhood planning. Reading assignments and planning exercises.
T. F. Lee

4.744J Site Planning

(Same subject as 11.336J)
Prereq.: —
Year: G (2)
1-8-3

Seminar acquaints students with basic considerations in site planning and provides practice in their applications to housing development. Physical aspects of environmental planning such as earthmoving, microclimate, vegetation, etc. and behavioral aspects such as social uses of public space introduced. Workshops involve work with simulation models and design exercises supplemented by a comprehensive analysis of existing housing sites.
D. Lee

4.745J Problem Setting in Environmental Programming (A)

(Same subject as 11.311J)
Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Seminar dealing with the conceptual and analytic processes which should precede the translation of human purposes into proposals for environmental modification. Formulation of issues with respect to particular environments and shaping of research strategies for their analysis. Conceptual, managerial, political, financial, and regulatory as well as physical design factors shaping environments. Short exercises drawn from programming for public buildings and facilities, service systems, and residential environments in both developed and developing countries.
T. F. Lee, E. Robbins

4.747J Theory of City Form (A)

(Same subject as 11.330J)
Prereq.: 11.001 or 4.236J or 11.301J
Year: G (2)
3-0-6

Theories about the form that settlements should take. First section discusses the nature of theory and attempts a distinction between descriptive and normative theory by examining examples of various theories of city form over time. Second section concentrates on the origins of the modern city and theories about its emerging form, including the transformation of the 19th-century city (London, Paris, Rome), theory of city organization, utopian theories, and some 20th-century realizations of theories of equalization (the socialist city in Russia and the British new towns). Third section analyzes city form in relation to various theories of citymaking, social structure, and spatial design and includes case studies of the colonial and post-colonial city (Delhi and Havana), bi-polar cities (Johannesburg and San Diego/Tijuana), and contemporary and future ideas.
J. Beinart

4.748J Environmental Programming (A)

(Same subject as 11.312J)
Prereq.: 11.361 or 4.745J (11.311J) or 4.772
Year: G (2)
3-0-6

Methods for synthesizing the broad range of financial, managerial, behavioral, regulatory, and process issues which must be reconciled in determining a set of environmental standards or the programmatic specifications for built environments. Techniques for informing decisions, including performance evaluation, in-site research, and user involvement. Application of methods to the preparation of urban design guidelines, development regulations, building programs, space-use management systems, and public infrastructure improvement programs.
G. A. Hack

4.751 Urbanization in Developing Countries: People, Dwellings, Land (A)

Prereq.: Permission of Instructor
Year: G (1)
3-3-6

Identification of changing dwellings/land situations in relation to cultural, social, economic, and physical factors. Provision of land and services for the most needy sectors of the population. The frame of reference as well as its main sources derived from actual practice in Africa and Latin America. Case studies of actual projects used extensively.
H. Caminos, R. Goethert

4.753J Urban Settlements in Developing Countries (A)

(Same subject as 11.313J)
Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Critical analysis of conflicting views on urbanization processes, squatters, and low-income housing policy. Alternative strategies with respect to: infrastructure, design and construction, land markets, financing, employment generation, building standards and regulations. Case materials of industrialized housing, aided self-help sites and services, and squatter and speculative settlements drawn from capitalist, socialist, and mixed economies. ***(Not offered 1981-82.)***
L. R. Peattie, T. F. Lee

4.761J The Finite Earth: Agendas for a More Just, Sustainable and Participatory Society

(Same subject as 11.486J, 17.440J, 21.919J, 22.83J)
Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Problems such as food supply, energy, material resources, global environment, and rapid changes in third world countries often tend to be looked on as separate; but each affects the other, and the connective tissue between them is too often lost. This subject explores several of these issues (especially food, energy, technology transfer, world security, and the views from alternative social systems) in context. Each topic cannot be developed in depth; introduces interested students to these issues;

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to ways in which they interactively influence the quality of social life for many in today's world; and to assess choices and directions for the future, both generally and as they may affect the student's own personal and professional interests. Content developed via a combination of lectures and discussion groups.
J. Beinart, M. Diskin, N. B. Herman, W. R. Johnson, D. J. Rose

4.766J Community, Class and Race: A Social Perspective (New)

(Same subject as 11.328J)
Prereq.: —
Year: G (2)
3-0-6

Undertakes to examine the nature of the community as a social reality. Emphasis on the differential meaning and empirical variability the concept "community" connotes. The methodological assumptions and problems underlying notions of community are discussed. Among other things, the subject covers: Theories of Community, the Community Study in America, the Community Study in Europe, Community Studies as Social Method, Community as Place, Community and Conflict, Class as "Community," Race and Ethnicity in the Definition of "Community," Networks as "Community," The Community and Context, Community and the State, and Is a Notion of Community Viable? Students asked to read and evaluate theoretical, descriptive, and methodological writings on community. One research or analytical paper required.
E. Robbins

4.771 Behavior in the Built Environment (A)

Prereq.: Permission of Instructor
Year: G (1)
3-3-6

Introduces Architecture student to behavioral science theories and methods as they relate to interactive affects of people in residential, working, and therapeutic settings. Basic texts and specialized readings follow lectures and assigned fieldwork. Students learn how to read and interpret social science literature and apply research methods such as behavior mapping, interviewing, and perceptual measures in systematic evaluations of environments in use.
S. C. Howell

4.772 User Needs Programming (A)

Prereq.: 4.771
Year: G (2)
3-0-6

Advanced seminar for architecture and planning students in selection and utilization of social science information in the formulation of design programs. Case studies developed from current programming issues. Representatives of public and private decision-making agencies introduced into seminar sessions and fieldwork as topic requires. Principles of information transfer and feedback stressed in evaluation of existing programs and their built/occupied results.
S. C. Howell

4.781 Research Topics in Architecture Studies (A)

Prereq.: 4.273
Year: G (1, 2)
Arr.

Research work on individual or group basis. Registration subject to prior arrangement for subject matter and supervision by staff.
Staff

4.797-4.799 Special Problems in Architecture and Social Change (A)

Prereq.: Permission of Instructor
Year: G (1, 2)
Arr.

Supplementary work on individual and group basis. Registration subject to prior arrangement for subject matter and supervision by staff.
Staff

4.801 Art and the Environment

Prereq.: —
Year: U (1)
3-0-6

Review of the history of art, architecture, and celebrations and their positions in workday life, religious life, and political life. Reconsideration of the present position of art and redefinition of the artist's options in the contemporary environment. (May be counted toward Humanities Requirement.)
O. Piene

4.802 Visual Form and Expression

Prereq.: —
Year: U (2) HUM-D
3-0-6

Practice in structuring visual form as an introduction to the language of art. Emphasis on experiencing the artist's process of seeing, thinking, and performing with the objective of developing visual awareness, imagination, and creative insight. Gestalt theories of perception and art from the past and present serve to clarify assignments involving manipulation of the visual elements that constitute the vocabulary of non-verbal expression. (May be counted toward Humanities Requirement.)
R. O. Preusser

4.821 Visual Design Projects I

Prereq.: —
Year: U (1, 2)
3-0-6

Experimental manipulation of materials, tools, techniques, physical processes, natural forces, and optical phenomena as means for visual invention, organization, and expression. Emphasis on interaction of media, concepts and design principles in determining visual form. Assignments encourage new modes of artistic performance and investigation of visual potential inherent in science and technology. (May be counted toward Humanities Requirement.)
R. O. Preusser

4.822 Visual Design Projects II

Prereq.: 4.821
Year: U (2)
3-0-6

Continuation of 4.821 enabling students to formulate and execute independent projects. (May be counted toward Humanities Requirement.)
R. O. Preusser

4.823 Form and Design I

Prereq.: —
Year: U (1)
2-4-6

Study of the visual elements of form to understand the processes of form synthesis. Studio experiments and lectures on proportion, shape, rhythm, visual quality of materials, and three-dimensional composition. Emphasis on imagination and visual sensitivity directed to enlarge the individual's ability to create an aesthetic form. (May be counted toward Humanities Requirement.)
R. Filipowski

4.824 Form and Design II

Prereq.: —
Year: U (2)
2-4-6

Three-dimensional experiments and lectures on the organization of quantities, unit to volume relationships, modularity and form, volume and structure, surface structure of volume, space composition, point, line, plane composition, and sculptural composition. Emphasis on architectonic and sculptural aesthetic of form. (May be counted toward Humanities Requirement.)
R. Filipowski

4.825 Form and Color

Prereq.: —
Year: U (1, 2)
3-0-6

Examination of color in natural form followed by experiments involving the color and form relationship to proportions, percentages, repetition, directions, quantity organization, structural order, angle position, and volume composition. A study to gain knowledge of color for the refinement of architectural form. (May be counted toward Humanities Requirement.)
R. Filipowski

4.826 Form and Color Workshop

Prereq.: *4.825*
Year: U (1, 2)
0-6-3

Sequence of study projects involving color and area, texture, periodic patterns, random configurations, color depth, black and white, visual vibrations, color and natural form, volume, structure, motion, object and the color environment, and the visual influence of color on spaces. (May be counted toward Humanities Requirement.)
R. Filipowski

4.828 Special Problems in Visual Design

Prereq.: 4.822 or 4.824
Year: U (1, 2)
Arr.

Supplementary work on individual and group basis. Registration subject to prior arrangement for subject matter and supervision by staff.
Staff

4.831 Environmental Art

Prereq.: —
Year: U (1 or 2)
0-4-8

Design and planning of environmental art installations in given and chosen existing settings. Emphasis on daring ideas in conjunction with realistic approach and possibility for execution. Artistic means ranging from large-scale painting and graphic design to kinetic architecture and natural elemental growth-and-change systems. (May be repeated for credit. May be counted toward Humanities Requirement.)
O. Piene

4.838 Special Problems in Environmental Art

Prereq.: 4.831
Year: U (1, 2)
Arr.

Supplementary work on individual or group basis. Registration subject to prior arrangement for subject matter and supervision by staff.
Staff

4.841 Environmental Light and Color I (A)

Prereq.: Permission of Instructor
Year: G (1)
2-4-6

The study of light and color as environmental design elements with emphasis on their dynamic and qualitative attributes. Experimental projects which consist of incorporating artificial illumination and color with architectural components and the spaces they define. Analysis of optical phenomena and psychological responses inherent in the perception of light and color serving as the basis for their applications to affect the visual characteristics and qualities of constructed environments.
R. O. Preusser, N. Bichajian

4.842 Environmental Light and Color II (A)

Prereq.: Permission of Instructor
Year: G (1)
2-9-9

An extended investigation of perceptual and psychic responses to light and color. Mock-ups and scale models utilized to explore their dynamic, qualitative, and psychological implications within the context of architectural and urban settings. Projects include manipulation of these elements to affect visual modifications of scale and dimension, coordination of light and movement to animate environmental spaces, and orchestrations of light and color as the means for creating expressive environments.
R. O. Preusser, N. Bichajian

4.845 Advanced Visual Design (A)

Prereq.: 4.831
Year: G (1)
0-8-12

4.846 Advanced Visual Design (A)

Prereq.: 4.831
Year: G (2)
0-8-12

Group project: processing ideas for rendering, planning, and executing a large-scale environmental art event employing natural elements, kinetic means, and human participation in a given outdoor environment. Individual projects: concepts, design and execution of kinetic and elemental installations, objects, and events based upon economy of means.
O. Piene

4.861 Life Drawing and Still Life

Prereq.: —
Year: U (1, 2)
0-3-2

Freehand drawing exercises to develop accurate observation and skill in graphic representation. Linear, light and shadow, detail and perspective renderings of varied subject matter. Control of line, value, color, texture, and form using pencil, pen, and brush. (May be repeated for credit.)
N. Bichajian

4.862 Advanced Figure Drawing

Prereq.: 4.861
Year: U (1, 2)
0-3-2

Emphasis on the formal elements of line, mass, texture, and spatial development and on the expressive, emotional value of the figure drawn on two-dimensional surfaces. Experimentation with a variety of media and papers: pen/ink, wash, graphite, charcoal.
Staff

4.865 Painting

Prereq.: —
Year: U (1 or 2)
1-4-4

Practice in the art of painting coordinated with theory related to contemporary concepts in light of historical development. Language of art with emphasis on structure and content advanced by lectures and demonstrations as framework for studio activity. Creative capacity and analytical ability challenged by studio and seminar participation. Manipulation of visual elements in painting utilizing principles of organization to realize individual expression through pictorial means. Primary goal: experiencing the artist's process and understanding visual values and meaning of art in culture. (Permission of instructor required. May be counted toward Humanities Requirement.)
R. O. Preusser

4.867 Plastic Composition

Prereq.: 4.824
Year: U (1, 2)
2-4-6

Study of plastic sculptural form based on continuity of surfaces, synthesis of diverse geometries, group form relationships, object and the landscape, and the optimum three-dimensional relationship of the object. Studies directed toward inventiveness and meaning of sculptural form. (Permission of instructor required. May be counted toward Humanities Requirement.)
R. Filipowski

4.868 Special Problems in Graphic Communication

Prereq.: —
Year: U (1, 2)
Arr.

Supplementary work on individual or group basis. Registration subject to prior arrangement for subject matter and supervision by staff.
Staff.

4.870 Words, Images, Graphics Tools and Ideas

Prereq.: —
Year: U (1)
2-4-6

Introduction to the spectrum of graphics ideas and tools available at the Visible Language Workshop. Public and personal ways of seeing, thinking, and communicating in visual and verbal modes including making ideas visible, perception and personal response, photographic vision, image making and processing, media communication. Use of print, reproduction tools, experimental photography and darkroom explorations, electrographics, typography, computer graphics, and two- and three-dimensional environmental image making tools. (Lab fee charged. May be counted toward Humanities Requirement.)
M. R. Cooper, R. L. MacNeil

4.871 Photo Graphics

Prereq.: 4.870
Year: U (1, 2)
2-4-6

A research, experiment, and print-production subject using materials and processes available by technology such as silk screen, photo relief, and dye processes as well as classical, gum bichromate, and photogravure methods. Personal expression through production of photo-originated graphic images. (Lab fee charged. May be counted toward Humanities Requirement.)
R. L. MacNeil

4.872 Experimental Color Imaging

Prereq.: 4.870
Year: U (1 or 2)
2-4-6

A production subject exploring the theories and methods of manipulating, synthesizing, and combining color images. A spectrum of processes including conventional photographics, digitized computer output, photomechanical and antique processes employed as a means for visual expression, organization, and invention in two and three dimensions. Examination of modern additive and subtractive color synthesis theories. Lectures, demonstrations, student projects to encourage the development of personal color systems and the production of new modes of artistic investigation, performance, and expression. (Lab fee charged. May be counted toward Humanities Requirement.)
R. L. MacNeil

4.873 Messages and Means I

Prereq.: 4.870
Year: U (1)
2-4-6

Explorations of multiple forms of visual and verbal information in print. Concentration on individual problems and projects involving the publication of posters, broadsides, booklets, books, and experimental print forms. Design process, including typesetting, pasteup, preparation and reproduction of artwork, platemaking, printing, binding, and distribution. Discussion, demonstrations, criticisms, visits from professionals, and possible client relationships. (Lab fee charged. May be counted toward Humanities Requirement.)
M. R. Cooper, R. L. MacNeil

4.875 Typo/Graphic/Design

Prereq.: 4.870
Year: U (1)
2-4-6

Study of traditional and experimental typography and graphic design. Production and design-based introduction to use of words, graphics, and images and their synthesis in multiple forms of visual communication and concepts and products. Understanding and use of typography and design principles as a means of gaining control over conception, organization, and expression of the form of graphic communication. Use and implication of composition and reproduction tools and technology on verbal and visual forms (letterpress, offset, computers, etc.).(Lab fee charged. May be counted toward Humanities Requirement.)
M. R. Cooper

4.876 Visual Communication Workshop

Prereq.: —
Year: U (2)
2-4-6

Analysis and use of visual design thinking and principles applied to drawing, typography, color and image organization. Development of perceptive and communicative skills based on issues as expressed through diagrams, maps (some computer graphics), photography, video, and printed matter. Conceptual development and coordinated presentation of issues and ideas using slide shows, photo essays, printed reports, videotapes or other coherent means of visualization. (Lab fee charged. May be counted toward Humanities Requirement.)
M. R. Cooper

4.878 Special Problems in Graphic Design

Prereq.: Permission of Instructor
Year: U (1, 2)
Arr.

Special work on an individual or group basis combining research and projects in such areas as: graphic messages; the exhibit as book; experiments in writing, typography, drawing, and symbol; the poster as communication; integration of print, audiovisual and electronic communication, multiple reproduction methods; the photograph as design element. Registration subject to prior arrangement for project and supervision.
Staff

4.880 Process and Presentation (A)

Prereq.: Permission of Instructor
Year: G (1, 2)
2-4-6

Production-based workshop which investigates and tests new methods of image generation to express serious personal communication concerns. Emphasis on the depth, quality, and realization of concept and product through the awareness and evaluation of the psychological and physical world. This awareness synthesized with visual communication skills and appropriate media and related to historical, theoretical, and critical frameworks. (May be repeated for credit. Lab fee charged.)
M. R. Cooper

4.884 Edges of Research, Art, and Education (A)

Prereq.: 4.880
Year: G (1 or 2)
2-3-4

Advanced seminar exploring the interaction among research, art, and education. Guest lecturers present work where this synthesis is being attempted. Reports on actual research, the psychological and philosophical intention, and the reality of experience in the making of art and in learning.
M. R. Cooper, R. L. MacNeil

4.886 Approaches to Visual Communication (A)

Prereq.: Permission of Instructor
Year: G (1 or 2)
Arr.

Laboratory work and possible apprenticeship relations with professionals in areas of graphic design.
Staff

4.889 Special Projects in Graphic Communication (A)

Prereq.: Permission of Instructor
Year: G (1, 2)
Arr.

Supplementary work on individual or group basis. Registration subject to prior arrangement for subject matter and supervision by staff.
Staff

4.895-4.899 Special Problems in Environmental Art (A)

Prereq.: Permission of Instructor
Year. G (1, 2)
Arr.

Special work on an individual or group basis using specific media such as video, holography, and multi-media. Registration subject to prior arrangement of subject matter and supervision by staff.
Staff

4.901 Creative Seeing

Prereq.: —
Year: U (1) HUM-D
3-0-6

Creative Seeing offered by photographers, filmmakers, visual designers, and art critics. While each has a unique way of presenting and visually manipulating the world, all are involved in Creative Seeing. Their common aim is to allow students to experience this level of vision by personal subjective discovery. Organized into parts each conducted within one of the fields. (Limited enrollment. Preference to freshmen and sophomores. May be counted toward Humanities Requirement.)
M. R. Cooper

4.903 Total Exposure

Prereq.: —
Year: U (1 or 2)
2-4-6

Introductory subject taught jointly by the Creative Photography Laboratory and the Visible Language Workshop. Critical analysis of the use of modern and traditional photography, photo-graphic and graphic media as means of creative self-expression and communication. Student projects which employ these media singly or in combination to explore ways of seeing, feeling, and perceiving reality. (May be counted toward Humanities Requirement.)
M. R. Cooper, R. L. MacNeil, S. Ockenga

4.906 Graduate Seminar in Photography, Photo-Graphics and Graphics (A)

Prereq.: Permission of Instructor
Year: G (1 or 2)
3-0-6

Advanced level seminar jointly offered by the Creative Photography Laboratory and the Visible Language Workshop that integrates photographic production with other disciplines. Major project is a final exhibition and catalogue totally implemented and designed by the students and evaluated by visiting professionals as well as CPL/VLW faculty. (Portfolio review required for admission.)
M. R. Cooper, R. L. MacNeil, S. Ockenga

4.908 Special Projects in Visual Arts

Prereq.: —
Year: U (1, 2)
Arr.

Supplementary work on individual and group basis on visual arts projects involving more than one medium. Registration subject to prior arrangement of subject matter and supervision by staff.
Staff

4.909 Special Projects in Visual Arts (A)

Prereq.: Permission of Instructor
Year: G (1, 2)
Arr.

Supplementary work on advanced individual and group basis on visual arts projects involving more than one medium. Registration subject to prior arrangement of subject matter and supervision by staff.
Staff

4.915 Basic Photography for Architects (A) (New)

Prereq.: Permission of Instructor
Year: G (1, 2)
3-0-9

Introduction to basic architectural photography including film, processing, printing technique, copy work filtration and metering. Study of the role of daylight and artificial light and their relation to forms, tone and texture in architectural photography. (Students must have their own 35mm camera.)
N. Bichajian

4.921 Creative Photography I: Regular Workshop (Revised Unit)

Prereq.: —
Year: U (1, 2)
4-4-4

Introductory subject covering both large and small format cameras, exposure and development of film, printing, and final presentation. Varied assignments to encourage students to explore all aspects of creative photography. Underlying assumption of this subject is that as technique grows, so do the possibilities for personal expression. (Lab fee charged. May be counted toward Humanities Requirement.)
S. Ockenga

4.931 Creative Photography II — An Historical Approach

Prereq.: 4.921 or 4.922
Year: U (1 or 2)
3-0-9

Intermediate level production subject expanding on the fundamentals of technique and vision from the point of view of photographic conventions, history, and criticism. Critical assumptions about photography and its different subject matter and styles — documentary, photojournalism, snapshot, and metaphor — examined through production and class discussion. (Lab fee charged. May be counted toward Humanities Requirement.)
S. Ockenga

4.932 Creative Photography II — A Personal Approach

Prereq.: 4.921 or 4.922
Year: U (1 or 2)
3-0-9

Intermediate level production subject emphasizing the student's unique vision. A substantial project is required. Weekly critiques of student work as well as intensive study of related well-known photographic work. (Lab fee charged. May be counted toward Humanities Requirement.)
S. Ockenga

4.933 Creative Photography II — The Projected Image

Prereq.: 4.921 or 4.922
Year: U (1 or 2)
3-0-9

Intermediate level subject exploring the projected image. Begins with 35mm black and white and color slides with consideration of the frame, space, scale, editing, and sequencing. Experimentation with multiple projectors, projection of xerox, newspaper, magazine, type, collage, etc. (Lab fee charged. May be counted toward Humanities Requirement.)
S. Ockenga

4.938 Special Projects in Photography

Prereq.: 4.921 or 4.922
Year: U (1, 2)
Arr.

Photographic production projects on an individual basis. Work in various fields of photography not covered by regular subjects. Registration subject to prior arrangements of subject matter and supervision.
Staff

4.941 Advanced Photography (A)

Prereq.: 4.931 or 4.932 or 4.933
Year: G (1, 2)
2-5-5

Production-oriented workshop in photography. Structured to let students pursue and develop their own unique styles. Advanced technical problems and various methods of evaluating images explored. (Limited enrollment.)
S. Ockenga

4.945 Advanced Photography Seminar: Visiting Artists (A)

Prereq.: Permission of Instructor
Year: G (1 or 2)
4-0-8

Evaluations of student work by a visiting artist. Intensive production workshop with emphasis on expanding and strengthening the student's personal vision in photography.
Staff

4.946 Advanced Photography Workshop (A) (Revised Unit)

Prereq.: 4.941
Year: G (1)
3-3-6

4.947 Advanced Photography Workshop (A) (New)

Prereq.: 4.946
Year: G (2)
3-3-14

Rigorous production workshop. Regularly scheduled critiques of work in progress by instructors and the class. Individual projects include exploration of scientific technical theory and craft as well as expansion of historical and contemporary slide archives. Preparation and completion of a portfolio of student's individual work.
S. Ockenga

4.949 Special Advanced Projects in Photography (A)

Prereq.: 4.931 or 4.932 or 4.933
Year: G (1, 2)
Arr.

Advanced photographic production projects on an individual basis. Work in various fields of photography not covered by regular subjects such as professional freelance photography, architectural photography, and advanced studio work. Registration subject to prior arrangements of subject matter and supervision.
Staff

4.961 Introduction to Video

Prereq.: Permission of Instructor
Year: U (1, 2)
4-6-2

Introductory workshop in portable, editing, and cable TV video systems. Production of short exercises and final project exploring shooting styles and editing techniques. Cablecasting on MIT's cable TV network. Consideration of both technological and aesthetic aspects of video. (May be counted toward Humanities Requirement.)
Staff

4.963 Video Studio Production

Prereq.: 4.961 or 4.971
Year: U (1 or 2)
4-6-2

Exploration of multi-camera video systems and the special effects generator. Workshop encompasses documentary techniques with portable systems on location, as well as studio setups for live performance. Production of short pieces experimenting with superposition, color synthesis, keying, feedback, and time delays. (Registration subject to permission of instructor. May be counted toward Humanities Requirement.)
Staff

4.965 Video Processing, Color and Special Effects

Prereq.: 4.971
Year: U (1 or 2)
4-6-2

Laboratory in electronic image manipulation and color processing for film and video makers. A practical introduction to color theory and color reproduction systems. Subject includes film-to-video transfers, resolution and bandwidth, generation loss, processing amplifiers, time base correction, audio filtering, color camera and recording systems, special effects, evaluation of different video gauges, standards for broadcasting, cablecasting, and presentation. (Registration subject to permission of instructor. May be counted toward Humanities Requirement.)
Staff

4.968 Special Project in Cable TV

Prereq.: Permission of Instructor
Year: U (1, 2)
Arr.

Supplementary work on individual or group basis. Registration subject to prior arrangement of subject matter and supervision by staff. Students expected to develop a significant project using the MIT cable TV system.
Staff

4.969 Special Problems in Video (A)

Prereq.: Permission of Instructor
Year: G (1, 2)
Arr.

Supplementary work on individual or group basis. Registration subject to prior arrangement of subject matter and supervision by staff.
Staff

4.971 Introduction to Moviemaking

Prereq.: Permission of Instructor
Year: U (1, 2)
4-6-2

Workshop in unscripted synchronous sound moviemaking with Super-8 film and portable video. Emphasis on approaches to filming real life experience, while exploring moving images in their relation to sound. Techniques of camerawork, sound recording, and editing introduced with regard to theoretical considerations of subject presentation and modes of personal expression. (Lab fee charged. May be counted toward Humanities Requirement.)
Staff

4.972 Experiments in Film Imagery

Prereq.: Permission of Instructor
Year: U (2)
4-6-2

Workshop in potentialities of the film image, extrapolating from ordinary conventions of shooting and editing in order to discover expanded kinds of vision. Experiments with light, time and motion, film emulsion and filmic structure. Manipulation of sense and sensation through montage and special effects, variables in exposure, optics and processing. (May be counted toward Humanities Requirement.)
Staff

4.973 Intermediate Motion Picture Production

Prereq.: 4.971
Year: U (1, 2)
4-6-2

Continuation of introductory moviemaking with film and video, plus studio and cablecasting facilities. Students plan and execute individual or group projects. Emphasizes refinement of technique and theory, and encourages specialized applications of movie media. Class explores potentials of combining film with video. Some work may be shown on cable or local broadcast television. (May be counted toward Humanities Requirement.)
Staff

4.974 Introductory Moviemaking Workshop (New)

Prereq.: Permission of Instructor
Year: U (1 or 2)
6-10-2

An intensive workshop in unscripted moviemaking with portable video and super-8 film. Combines a thorough introduction to video technology and double system filmmaking with screenings and discussions of movies in the documentary genre. Students expected to apply film/video technology in a series of camera, sound, and editing exercises before completing a final, more significant movie. (Lab fee charged. May be counted toward Humanities Requirement.)
B. Bergery

4.978 Independent Projects in Film/Video Production

Prereq.: Permission of Instructor
Year: U (1, 2)
Arr.

Supplementary work on individual or group basis. Registration subject to prior arrangement of subject matter and supervision by staff.
Staff

4.981 Advanced Production: Autobiographical and Biographical Filmmaking (A)

Prereq.: Permission of Instructor
Year: G (1, 2)
4-6-2

Workshop exploring the nature of autobiographical/diaristic filmmaking and film portraits. Comparison of cinematographic with literary forms of diary and portraiture, considering different ways in which experience and reflection are presented through film and writing. Analysis of historical and contemporary examples, fiction as well as documentary. Viewing and discussion of participants' work-in-progress.
Staff

4.982 Advanced Production: Problems in Editing (A)

Prereq.: Permission of Instructor
Year: G (1, 2)
4-6-2

Editing in consultation with instructor, screening of works in progress, discussion of general theoretical problems, screenings and discussions relating to the completed works of other filmmakers.
Staff

4.983 Visiting Artists Workshop (A)

Prereq.: Permission of Instructor
Year: G (1 or 2)
Arr.

Seminar in which advanced students share theoretical and technical problems of movie-making approach, structure and subject development, editing, etc., with visiting film/videomakers, fellow students, faculty, and staff. Production of participants in the class supervised by the visiting film/video makers, as an adjunct to that person's research or work-in-progress.
R. Leacock, Visiting Artists

4.984 Design Project in Film/Video Technology (A)

Prereq.: Permission of Instructor
Year: G (1 or 2)
Arr.

Independent engineering project, involving electronic or mechanical modification of low-cost moviemaking systems, video-computer interface, audio and image processing, hardware design for special applications. Registration subject to prior arrangement of research topic and approval of instructor.
Staff

4.985 Film/Video and Its Technology I (A)

Prereq.: Permission of Instructor
Year: G (1)
4-4-4

4.986 Film/Video and Its Technology II (A)

Prereq.: 4.985
Year: G (2)
4-4-4

A direct approach to technical concerns of the independent filmmaker. An investigation of processes and options available for all phases of filmvideo production. Topics: basic photochemistry, raw stocks, printing techniques, optics, lens and camera options; microphones and recording techniques, audio processing and mixing; lighting; basic electricity, electronics and power systems; basic video systems, film/video transfers; field maintenance for camera, recording, and editing equipment; budget, fundraising, rights and releases, distribution contracts. Tours of professional labs, optical houses, mixing studios with exploration of state-of-the-art equipment and techniques.
Staff

4.987 Film, Video and Space (A)

Prereq.: Permission of Instructor
Year: G (2)
4-6-2

Exploration in documentary and imaginary film/video space relating environmental properties of these media to the portrayal of place. Analysis of the spatial proportions of light, motion, time, and sound, the effects of perspective, orientation, and montage.
Staff

4.988 Film, Video and Performance (A)

Prereq.: Permission of Instructor
Year: G (1 or 2)
4-6-2

Exploration of the range of movie-making approaches to performance events, from documentary to evocative. Film/video transformations of time, space, and mood applied to music, dance, and theatre events. Group productions.
R. Leacock

4.989 Independent Projects in Motion Picture Production (A)

Prereq.: Permission of Instructor
Year: G (1, 2)
Arr.

Individual or group work of advanced and experimental scope. Registration contingent upon prior determination of subject matter and plan for treatment, as well as arrangement for staff supervision and project funding.
Staff

4.991 Introduction to the History of Film

Prereq.: —
Year: U (1 or 2)
3-5-1

Lecture-discussion in which film is primarily looked upon as it relates to the technology of filmmaking. Various film genres analyzed to reveal the relation of production technology to film form. Film clips accompany lecture. (May be counted toward Humanities Requirement.)
R. Leacock

4.992 Introduction to Film Criticism and Theory

Prereq.: —
Year: U (2)
3-3-3

Analysis of film reality through the examination of historical and contemporary examples. Works of Lumiere, Melies, Dryer, Eisenstein, Vertov, Hitchcock, Godard, Keaton, Kurosawa, Resnais, and others. The nature of objectivity/subjectivity as revealed through the filmmaker's approach to problems such as genre, point of view, the creation of film time and space, acting, the use of filmmaking as its own subject. Students view many films, some several times. (May be counted toward Humanities Requirement.)
Staff

4.995 Special Topics in the Theory of Media (A)

Prereq.: Permission of Instructor
Year: G (1 or 2)
Arr.

Supplementary studies in the history, philosophy, and theory of media. Registration subject to prior arrangement of topic and approval of instructor.
Staff

4.999 Special Topics in Film History and Criticism (A)

Prereq.: 4.991, 4.992
Year: G (1, 2)
Arr.

Individual projects in film history and criticism. Prior arrangement and approval of instructor necessary.
Staff

5 Chemistry

5.UR Undergraduate Research

Prereq.: —
Year: U (1, 2)
Arr.

Program of research to be arranged by the student and a departmental faculty member. (Department Coordinator: R. L. Danheiser)
Staff

5.03 Principles of Inorganic Chemistry I

Prereq.: 5.41
Year: U (1)
4-0-8

Presentation of theoretical principles of chemical bonding and molecular structure, and their application to the chemistry of all the elements of the periodic system.
D. Seyferth, A. Davison

5.04 Principles of Inorganic Chemistry II

Prereq.: 5.03
Year: U (2)
3-0-6

Systematic presentation of the chemistry of coordination compounds of the transition elements. Special emphasis placed on ligand field theory, to interpret the electronic spectra, magnetic properties, reaction mechanisms, structure and stabilities of these inorganic complexes. (5.61 background encouraged.)
A. Davison, E. I. Solomon

5.05 Principles of Inorganic Chemistry III

Prereq.: 5.03, 5.04
Year: U (1)
3-0-9

Continued development of systematic inorganic chemistry of the elements. Application of valence theory and advances in structural chemistry to topics not covered in 5.03 and 5.04. Emphasis placed on synthesis and reactivity, metal complexes with n- π acceptor ligands, organometallic chemistry, bioinorganic chemistry, and reactivity patterns of the heavier elements.
R. R. Schrock

5.065 Advanced Inorganic Chemistry (A)

Prereq.: 5.03
Year: G (2)
3-0-6

Extended treatment of some special topics of current interest in modern inorganic chemistry, organometallic compounds of non-transition elements; treatment in terms of modern electronic and structural theory. (Alternate years. ***Offered 1981-82.***)
D. Seyferth

5.066 Special Topics in Inorganic Chemistry (A)

Prereq.: 5.03
Year: G (1)
2-0-4

Inorganic photochemistry and electrochemistry. Inorganic and organometallic photochemistry and electrochemistry developed and highlights of the literature reviewed. Basic principles of semiconductor photoelectrochemistry and photogalvanic cells covered.
E. I. Solomon, W. H. Orme-Johnson

5.067 Inorganic Chemistry (A)

Prereq.: 5.03
Year: G (2)
2-0-4

Transition metal catalysis. Consists of 1) a discussion of principles of catalysis, evolution of catalytic systems and experimental techniques; 2) a survey of reaction types and metal catalysts; and 3) detailed exploration of several exemplary catalytic reactions from a mechanistic viewpoint.
M. S. Wrighton

5.195 Interpretive Spectroscopy (A)

Prereq.: 5.42, 5.61
Year: G (1)
3-0-6

Sec. A. Major emphasis on instrumentation and principles of interpretation of NMR and mass spectra. Computer techniques for processing, utilization, and interpretation of mass spectral data and their use in analytical aspects of chemical and biomedical problems. Combination of modern separation techniques and other spectrometric data with the above. Sec. B. Discussion of spectrometric techniques and their application to identification of organic chemical compounds. Major emphasis on complementary use of infrared, nuclear magnetic resonance, and mass spectrometry.
K. Biemann, G. A. Berchtold

5.21 Chemistry in a Technological Society (New)

Prereq.: —
Year: U (1) SD
4-0-8

Introduction to the principles of chemistry. Emphasizes the applications of these principles directly to topics in modern science and technology rather than to topic areas useful principally as the foundation for further work in chemistry. Although designed primarily for students who do not intend to take additional subjects in chemistry, this subject provides an adequate background for continuation in the chemistry sequence. Topics: atomic and molecular structure, stereochemistry, thermochemistry, kinetics, acid base and redox chemistry, descriptive chemistry. Example areas include energy, reproduction, photosynthesis, medicinal chemistry, communications, corrosion, atmospheric chemistry, materials, polymers, economics, defense, and the environment. (Enrollment limited to 30.)
G. M. Whitesides, J. M. Deutch

5.310 Laboratory Chemistry

Prereq.: *5.41*
Year: U (1, 2) LAB
2-8-2

Introduction to experimental chemistry for students who are not majoring in Course V. Principles and applications of chemical laboratory techniques including preparation and analysis of chemical materials, measurement of pH, gas and liquid chromatography, visible-ultraviolet spectrophotometry, infrared spectroscopy, electrophoresis, kinetics, data analysis, and elementary synthesis. Separate sections for students in life sciences and for students in physical sciences and engineering carry out selected series of experiment-projects focusing on chemical techniques and applications important to these areas of interest. (Enrollment limited to 100 students in Term 1 and to 180 students in Term 2.)
Term 1: *G. A. Petsko*
Term 2: *R. R. Schrock*

5.311 Introductory Chemical Experimentation

Prereq.: *5.41*
Year: U (1) LAB
2-8-2

First term of a three-term laboratory subject sequence for Course V majors. Experimental work emphasizes development of fundamental laboratory skills and techniques: volumetric and colorimetric analysis; preparation, purification, and characterization of chemical substances; and data analysis. (Enrollment limited to 80 students. Registration in Course V or permission of instructor required.)
S. T. Ceyer

5.32 Intermediate Chemical Experimentation

Prereq.: 5.310 or 5.311, *5.42, 5.60*
Year: U (2)
0-12-3

Experimental work more advanced than in 5.310 or 5.311 with emphasis on polarographic analysis, thermodynamic and kinetic measurements of organic reactions, and synthesis, purification, and analysis of organic compounds employing ir, nmr, uv, mass spectroscopy, and thin layer and gas-liquid phase chromatography.
G. A. Berchtold, R. L. Danheiser, Staff

5.33 Advanced Chemical Experimentation

Prereq.: 5.32, *5.61*
Year: U (1)
0-15-3

Advanced experimentation with particular attention to the synthesis of compounds, measurement of kinetic phenomena, and use of modern instrumentation. Included are projects involving IR, NMR, and ESR spectroscopy: enzyme and electrode kinetics; diffusion and viscosity measurements; inert atmosphere techniques; and synthesis of polymers and organometallics. (Enrollment limited to 80 students.)
J. I. Steinfeld, Staff

5.40 General Chemistry

Prereq.: —
Year: U (1) SD
4-0-8

Designed for students with no preparation beyond introductory high school chemistry. Presents a critical approach to macroscopic properties of matter, origins of atomic theory and stoichiometry, chemical equilibrium, ionic equilibria, oxidation, and reduction. Followed by electronic structure, bonding, chemical periodicity, and descriptive chemistry of the elements.
D. S. Kemp, M. S. Wrighton

5.41 Introduction to Structure, Bonding and Mechanism

Prereq.: —
Year: U (1, 2) SD
5-0-7

Correlation of chemical properties with a minimal set of empirical observations and theoretical principles. Electronic structures of atoms and molecules, structural chemistry, elementary concepts of energetics and kinetics. Description and prediction of acid-base behavior. Concept of mechanism with examples drawn from organic and inorganic chemistry. Generalized substitution reactions. Chemistry of the carbonyl grouping.
Term 1: *W. R. Roush, M. F. Roberts*
Term 2: *K. Biemann, C. G. Swain*

5.42 Organic Chemistry

Prereq.: 5.41
Year: U (2)
5-0-7

Chemistry of organic molecules: organic functional groups and their interrelations. Synthesis, structure determination, mechanism; the relationships between structure and reactivity.
W. H. Rastetter, F. D. Greene

5.43 Organic Chemistry

Prereq.: 5.42
Year: U (1)
4-0-8

Study of reaction mechanisms with emphasis on reactive intermediates, structure-reactivity relationships, and reactions of synthetic value.
R. L. Danheiser

5.50J Enzymatic Reaction Mechanisms (A)

(Same subject as 7.72J)
Prereq.: 5.42
Year: G (2)
4-0-8

Study of chemical mechanisms of enzyme-catalyzed reactions. Analysis of transformations of substrates to product molecules made with reference to stereochemistry and prosthetic group reactivity. Structural and spectroscopic data are incorporated with chemical studies to depict events in catalytic sites. Major reaction types analyzed include hydrolases, coenzyme-catalyzed reactions, group transfer reactions, biological oxidation, eliminations, racemizations, and aldolcleavage reactions.
C. T. Walsh, W. H. Orme-Johnson

5.51 Advanced Organic Chemistry: Synthesis (A)

Prereq.: *5.53*
Year: G (1)
3-0-6

Organic reactions and the methods by which they are applied to synthetic problems in organic chemistry.
W. H. Rastetter, S. Masamune

5.53 Molecular Structure and Reactivity (A)

Prereq.: 5.32, 5.42
Year: G (1)
3-0-6

Reaction mechanisms in organic chemistry: types of mechanisms, reactive intermediates, methods of investigation, relation of structure to reactivity.
F. D. Greene

5.54 Physical Organic Chemistry (A)

Prereq.: 5.53
Year: G (2)
2-0-4

Mechanisms of representative organic reactions in homogeneous liquid systems. Kinetic and other physical methods useful in studying organic reactions. Types of experimental evidence upon which current theoretical interpretations of reactivity are based.
G. M. Whitesides

5.55 Organic Chemistry: Natural Products (A)

Prereq.: 5.51
Year: G (2)
2-0-4

Chemistry and physiological action of natural products. Methods of isolation; determination of structures and synthesis.
G. H. Büchi

5.56 Special Topics in Organic Chemistry (A)

Prereq.: 5.51, 5.53
Year: G (2)
3-0-6

Advanced topics of special current interest.
K. B. Sharpless, W. R. Roush

5.57 Chemistry of Amino Acids, Peptides, and Proteins (A)

Prereq.: 5.42
Year: G (2)
3-0-6

Synthesis of amino acids and peptides. Protective groups, amideformation, deprotection. Purification and manipulation of peptides. Correlations between structure and biological activity. Conformations of peptides. Peptides and proteins as reactive organic molecules. Relationships between structure and reaction mechanism for enzymes.
D. S. Kemp

5.58 Biochemistry of Membranes (A)

Prereq.: 5.42, 7.05
Year: G (1)
3-0-6

Structure of biological membranes. Model lipid systems. Chemistry of the lipid, steroid, carbohydrate, and protein constituents of membranes and lipoproteins. Membrane assembly and polarity. Biochemical activities and specialized structure/function relationships in membranes, including energy transduction and active transport (chemiosmotic hypothesis), rhodopsin, cell surface receptors, blood group determinants, cell contact formation and specialized subcellular membrane functions such as mitochondrial oxidative phosphorylation and photosynthesis in chloroplasts. ***(Not offered 1981-81.)***

5.60 Chemical Thermodynamics

Prereq.: *18.02*
Year: U (1, 2) SD
4-0-8

Equilibrium properties of macroscopic systems. Basic thermodynamics — system, state of system, state variables. Work, heat, first law of thermodynamics, thermochemistry. Second and third law of thermodynamics — entropy, Gibbs function. Equilibrium phase rule, colligative properties of solutions, homogeneous and heterogeneous chemical equilibrium of reactions in the gas phase and solutions.
Term 1: *C. W. Garland, R. J. Silbey*
Term 2: *R. J. Silbey, I. Oppenheim*

5.61 Physical Chemistry

Prereq.: 8.02, 18.02
Year: U (1) SD
4-0-8

Introductory quantum chemistry; elementary atomic spectra; particles and waves; wave mechanics; atomic structure and the Periodic Table; valence theory; experimental methods of determining molecular structure; structure of crystals and liquids; photochemistry.
J. S. Waugh

5.62 Physical Chemistry

Prereq.: 5.60 or 10.13
Year: U (2)
4-0-8

Elementary kinetic theory and statistical mechanics; transport properties of gases and liquids; rates of chemical reactions.
F. R. McFeely

5.64J Biophysical Chemistry

(Same subject as 7.71J)
Prereq.: 5.60, 7.05
Year: U (1)
4-0-8

Forces which determine protein conformation; water structure; prediction of protein structure from amino acid sequence. Helix-coil transitions; statistical thermodynamics and partition functions. Chemical equilibria. Enzyme kinetics; control mechanisms and allosteric systems. DNA physical chemistry; superhelical conformations; reaction kinetics of nucleic acids; protein-nucleic acid interactions. Membrane structure and function.
R. A. Alberty, P. R. Schimmel, P. A. Sharp

5.65 Physical Chemistry of Macromolecular Solutions

Prereq.: 8.02, 5.60, 5.62
Year: U (2)
2-0-4

Introduction to the theory of polymer conformations and dynamics in solutions. Topics: conformations of random coil polymers and excluded volume effects, thermodynamics of macromolecular solutions, light scattering from polymer solutions, frictional properties of dilute polymer solutions, including diffusion and viscosity, models of helix-coil transitions.
J. M. Deutch

5.66 Spectroscopic Techniques in Biochemistry (A)

Prereq.: 7.05, 5.61
Year: G (2)
3-0-6

Theory and selected applications of the following techniques to protein structure and function: X-ray diffraction, NMR, ESR, CD, and light scattering. Each of these techniques is applied to the same proteins, yielding a comprehensive picture of protein structure and function.
G. A. Petsko, M. F. Roberts

5.68 Kinetics of Chemical Reactions (A)

Prereq.: 5.62
Year: G (2)
3-0-6

Experimental and theoretical aspects of reactive and inelastic molecular processes, including: collision and transition — state theories, homogeneous reactions in gas and liquid phases, molecular beam scattering, Information Theory of kinetic processes. Case studies in chemical kinetics including chemical lasers, atmospheric chemistry, combustion dynamics. (Advanced undergraduate students need permission of instructor.
J. I. Steinfeld

5.70 Introduction to Statistical Thermodynamics (A)

Prereq.: 5.62
Year: G (1)
3-0-6

Review of classical thermodynamics and an introduction to elementary statistical mechanics, with applications to simple physical and chemical systems.
I. Oppenheim

5.72 Statistical Mechanics (A)

Prereq.: 5.70, 5.73, 18.075
Year: G (2)
3-0-6

Principles and methods of statistical mechanics. Classical and quantum statistics, grand ensembles, fluctuations, molecular distribution functions, and other topics in equilibrium statistical mechanics. Advanced topics in thermodynamics, including irreversible processes. ***(Not offered 1981-82.)***

5.73 Introductory Quantum Mechanics I (A)

Prereq.: 5.61, 8.03
Year: G (1)
3-0-6

Fundamental concepts of quantum mechanics: wave properties, uncertainty principle, Schrodinger equation. Basic applications to: harmonic oscillator, hydrogen atom, WKB method. Perturbation theory and variation method. Pauli principle and spin. Introduction and use of operator and matrix methods.
F. R. McFeely

5.74 Introductory Quantum Mechanics II (A)

Prereq.: 5.73, 18.075
Year: G (2)
3-0-6

Continuation of 5.73 Permutation symmetry and angular momentum. Molecular dynamics. Time-dependent problems, radiation and matter. Scattering by a central field. Many-electron systems, approximate molecular and atomic wave functions.
J. S. Waugh

5.76 Molecular Spectra and Molecular Structure (A)

Prereq.: 5.61 or 8.05
Year: G (2)
3-0-6

Rotational, vibrational, and electronic spectra of molecules; atomic spectra; use of spectra to find dissociation energies, structural parameters, and molecular symmetries. Magnetic resonance spectroscopy, optical pumping, lasers, and nonlinear optics.
R. W. Field

5.80 Special Topics in Chemical Physics (A)

Prereq.: 5.70, 5.73
Year: G (1, 2)
Arr.

Advanced topics of special or current interest. The specific areas announced in advance of each term. ***(Not offered 1981-82.)***

5.82 Advanced Topics in Solid-State Chemistry (A)

Prereq.: 5.70, 5.73
Year: G (1 or 2)
Arr.

Selected topics from areas such as: structure of crystals, surface structure, symmetry groups, diffraction methods, lattice dynamics, order-disorder and magnetic phenomena, molecular motions in solids, relaxation phenomena, optical properties and exciton theory. ***(Not offered 1981-82.)***

5.89 Special Problems in Chemistry for Undergraduates

Prereq.: —
Year: U (1, 2)
Arr.

Program of study to be arranged by the student and a departmental faculty member.
M. S. Wrighton

5.90 Special Problems in Chemistry (A)

Prereq.: —
Year: G (1, 2)
Arr.

Directed research and study of special chemical problems. (For graduate students only.)
G. A. Berchtold

5.913 Seminar in Organic Chemistry (A)

Prereq.: —
Year: G (1)
1-0-2

5.914 Seminar in Organic Chemistry (A)

Prereq.: —
Year: G (2)
1-0-2

Discussion of current journal publications in organic chemistry by graduate students and staff members.
Term 1: *W. H. Rastetter*
Term 2: *W. R. Roush*

5.915 Seminar in Analytical Chemistry (A)

Prereq.: —
Year: G (1)
1-0-2

5.916 Seminar in Analytical Chemistry (A)

Prereq.: —
Year: G (2)
1-0-2

Discussion of topics of current interest in analytical chemistry by graduate students and staff members.
K. Biemann

5.931 Seminar in Physical Chemistry (A)

Prereq.: —
Year: G (1)
1-0-2

5.932 Seminar in Physical Chemistry (A)

Prereq.: —
Year: G (2)
1-0-2

Discussion of topics of current interest in physical chemistry by staff members and students.
Term 1: *C. W. Garland*
Term 2: *R. W. Field*

5.941 Seminar in Inorganic Chemistry (A)

Prereq.: —
Year: G (1)
1-0-2

5.942 Seminar in Inorganic Chemistry (A)

Prereq.: —
Year: G (2)
1-0-2

Discussion of current research in inorganic chemistry by graduate students and staff.
D. Seyferth

5.981J Seminar in Biochemistry (A)

(Same subject as 7.74J)
Prereq.: —
Year: G (2)
1-0-2

Presentation by visiting scientists of critical reviews of recent publications in chemistry and biochemistry with application to selected biochemical problems. Discussions by staff and students.
P. R. Schimmel, J. M. Buchanan, C. T. Walsh

6 Electrical Engineering and Computer Science

Basic Undergraduate Subjects

6.001 Structure and Interpretation of Computer Programs

Prereq.: —
Year: U (1, 2)
4-3-8

Introduction to the architecture of computer programs, emphasizing design phase of program development. Major theme is the control of complexity in large programs using such techniques as modularization, hierarchical organization, data abstraction, and decentralization of control. Topics: models of environment and control; lists and arrays; recursive and iterative constructs. Operations on tree structured data; dispatching; control abstractions. Sharing and alteration of data; modeling with list structures; storage management. Data abstractions; data hierarchies; procedures as data. Communication between procedures; environment closures; procedures with a state; procedural representation of data. Block structure, typed variables and lexical scoping; communication among program modules; stack storage management; implementation of abstract data types. LISP programming language used as a tool for discussing design topics and ALGOL family of languages used to explore the influence of compilation and efficiency requirements. (Weekly programming projects on a time-shared computer. Students with no prior programming experience should consult instructor.)
R. M. Fano, H. Abelson, G. J. Sussman

6.002 Circuits and Electronics

Prereq.: 8.02 or 8.021 or 8.022 or 8.023; *18.03* or *18.700*
Year: U (1, 2) SD
4-2-9

Fundamentals of lumped networks, resistive elements and networks, energy storage elements, dynamics of first- and second-order networks, sinusoidal steady-state analysis, network equivalence theorems, electronic devices, circuits, and applications. Alternate week laboratory. Students with appropriate experience in electronic circuits may treat the 8.02 prerequisite as a corequisite.
S. D. Senturia, C. L. Searle, J. K. Roberge

6.003 Signals and Systems

Prereq.: 6.002; 18.03 or 18.031 or 18.700
Year: U (1, 2)
4-2-9

Unilateral Laplace transform and its applications to networks and electronic systems including feedback. Description of linear time-invariant systems in the time and frequency domains; convolution, Fourier series, and integrals. Uncertainty relations and sampling theorems. Discrete-time systems and signals. Applications to analog and digital filtering systems and modulation systems. Alternate week laboratory.
W. M. Siebert, R. S. Kennedy

6.012 Electronic Devices and Circuits

Prereq.: 6.002; 8.02 or 8.033
Year: U (1, 2)
4-0-8

Modeling of electronic devices and analysis of nonlinear circuits. Physical electronics of semiconductor junction and MOS devices and development of circuit descriptions for these devices; relation of electrical behavior to internal physical behavior, and limitations of circuit models. Development of incremental and large-signal techniques for analyzing circuits containing nonlinear devices. Analysis of signal-processing circuits which employ these devices, with examples chosen from switching circuits, single-ended and differential amplifiers, and integrated-circuit amplifiers.
C. G. Fonstad, D. J. Epstein

6.013 Electromagnetic Fields and Energy

Prereq.: 6.002; 8.02 or 8.033
Year: U (1, 2)
4-0-8

Maxwell's equations and the Lorentz force law. Quasistatic forms of Maxwell's equations. Studies of electro-quasistatic fields and their sources through solutions of Poisson's and Laplace's equations. Steady conduction and polarization. Charge relaxation. Magneto-quasistatic approximation; magnetic boundary value problems, magnetization, induction, current induced in stationary and moving conductors. Electric and magnetic forces derived from energy. Electromagnetic waves; the relation of quasistatic laws to the complete Maxwell's equations. Extensive use made of engineering examples.
H. A. Haus, J. R. Melcher

6.014 Electrodynamics

Prereq.: 6.013
Year: U (1, 2)
4-0-8

Basic subject in electrodynamics, with emphasis on phenomena associated with wave propagation and radiation. Plane waves in three dimensions, field solutions of an elementary electric dipole, radiation from current distributions and arrays, diffraction and interference. Guided electromagnetic waves on continuous transmission lines, periodic structures, and metallic waveguides; propagation and evanescence; energy flow and impedance matching. Pulse propagation in dispersive systems; energy and group velocity. Natural frequencies and modes of closed electromagnetic structures; coupling to resonant structures, loaded and unloaded Q's. Examples throughout taken from the fields of acoustics, optics, and microwaves.
D. H. Staelin, J. A. Kong

6.018 Statistical Mechanics and Thermodynamics

Prereq.: 3.091 or 5.40 or 5.41; 8.02
Year: U (2) SD
4-0-8

Statistical description of large physical systems. Laws of thermodynamics developed from statistical mechanics: phase space; entropy and temperature; work and heat; chemical potential; equations of state; free energies; heat engines and refrigerators; phase transitions. Quantum statistics: Fermi-Dirac and Bose-Einstein gases; statistics of electrons in metals and semiconductors; superfluidity and superconductivity; blackbody radiation; thermal noise.
D. Adler

6.021J Quantitative Physiology: Cells and Tissues (Revised Unit)

(Same subject as 2.791J, HST 541J)
Prereq.: 2.02 or 6.002 or 6.071; 8.02; 18.03
Year: U (1)
4-2-6

Principles of mass transport, energy transduction, and electrical and mechanical signal generation in animal cells. Structure of biological membranes. Transport through biological membranes: diffusion, osmosis, solute flow, ion flow, active transport. Mechanics of connective tissues (tendon, cartilage, blood vessels, and skin) and their analysis as fiber-reinforced composite materials. Electric properties of cells: equilibrium, resting, action, and junctional potentials. Electrical and chemical intercellular interactions. Mechanical properties of muscle. Conversion of electrical, chemical, and mechanical energy. Molecular basis of contraction. (Intended for juniors and seniors in engineering; others admitted by permission of instructor.)
T. F. Weiss, I. V. Yannas

6.022J Quantitative Physiology: Organ Transport Systems

(Same subject as 2.792J, HST 542J)
Prereq.: 2.20 or 6.013; *6.021J*
Year: U (1)
3-2-7

Application of the principles of energy and mass flow to major organ systems of humans and other animals. Mechanisms of regulation and homeostasis. Anatomical, physiological, and pathophysiological features of the cardiovascular, respiratory, and renal systems. Clinical instrumentation and prosthetic devices. Emphasis on those systems, features, and devices that are most illuminated by the methods of physical sciences. (Intended for juniors and seniors in engineering; others admitted by permission of instructor.)
R. G. Mark, B. B. Mikić, R. D. Kamm

6.023J Quantitative Physiology: Sensory and Motor Systems

(Same subject as 2.793J, 16.351J, HST 543J)
Prereq.: 2.02 or 6.003 or 16.30
Year: U (2)
3-2-7

Studies of sensory and motor physiology with objectives of establishing quantitative models. Peripheral signal processing in eye, ear, and vestibular systems. Physiology and psychophysics of audition, vision, orientation, and body stabilization. Organization of neuromuscular and proprioceptive systems at level of spinal cord reflex. Postural control and kinetics of movement. Supplemented by laboratory exercises. (6.021J recommended background.)
L. S. Frishkopf, L. R. Young, R. W. Mann

6.030 Introduction to Computation

Prereq.: —
Year: U (1, 2) SD
4-3-5

Study of computational processes as algorithms. Formal and informal techniques for the representation of algorithms and their implementation on digital computers. Selected lectures on topics of current interest in computer science. Introduction to computer programming. Experience with an algebraic language in the writing and running of programs to solve elementary problems.
J. C. R. Licklider, J. Weizenbaum

6.032 Computation Structures

Prereq.: 6.031 or 6.001; 6.002
Year: U (1, 2)
4-0-8

Description and analysis of computer architecture for the purpose of designing hardware capable of supporting desired software features. Computational schemata and representation of algorithms in terms of data flow and control structures, both synchronous and asynchronous. Basic principles of computer architecture. Virtual devices, processes and machines. Relation of the structure of programming languages and data structures to machine design. Examples from current practice to illustrate interaction of algorithmic, programming language, data, and hardware structures. (6.071 or equivalent may be used in lieu of the 6.002 prerequisite with permission of the instructor.)
S. A. Ward

6.033 Computer System Engineering

Prereq.: 6.032
Year: U (1)
4-0-8

Topics on the engineering of information systems, with emphasis on problems arising when an information system serves a community of users. Contrast of problems intrinsic to purposes of use with those related to technical limitations. Multilevel memory systems; naming and binding; privacy of information. Atomicity and coordination of parallel activities. Recovery and reliability. Networks and distributed systems. Limitations on information systems arising from the laws of physics and other sources. Techniques of controlling complexity. Impact of computer systems on society. Case studies of working systems and outside reading in the current literature provide comparisons and contrasts.
J. H. Saltzer

6.034 Artificial Intelligence

Prereq.: 6.031 or 6.001
Year: U (1) SD
4-0-8

Study of the ideas and techniques that enable computers to behave intelligently. Case studies of programs that solve engineering problems like experts, diagnose disease, learn from experience, understand the visual environment, and engage in English discourse. The role of search, constraint propagation, reasoning and representation.
P. H. Winston

6.035 Computer Language Engineering

Prereq.: 6.032
Year: U (2)
4-0-8

Analysis of issues associated with design and implementation of higher-level programming languages. Generalized notions of translation and equivalence of representations. Fundamental concepts, functions, and structures of interpreters and compilers. Issues of efficiency: tradeoffs in space, time, and economy of expression. Abstraction of recurrent themes in the translation/execution process. Feature analysis of higher-level languages. Language design for reliable software; influence of language features on program quality. Very high-level language structures and implementation techniques.
M. Hammer

6.036 Problem-Solving Paradigms

Prereq.: 6.034
Year: U (2)
4-0-8

Investigation of the basic paradigms for problem solving including the use (and misuse) of logic, procedural knowledge, debugging skills, and the reformulation of problems. Detailed study of natural deduction, pattern-directed procedures, and systems for reasoning effectively and efficiently within stereotypical situations. Examples drawn from mathematics, natural language comprehension, and programming. Applications of theoretical results to human problem solving and education.
C. E. Hewitt

6.040 Exploratory Data Analysis

Prereq.: —
Year: U (2)
3-0-6

Introduction to the handling of data by a variety of statistical tools such as the median, range, etc. Model fitting and re-expression to discover important relationships. Elementary smoothing and trend-detecting techniques. (Limited to students enrolled in Concourse Program.)
P. Lavori, J. Y. Lettvin

6.041 Probabilistic Systems Analysis

Prereq.: 18.02
Year: U (1, 2) SD
4-0-8

Development of theory and applications of probabilistic concepts for engineers, administrators, and scientists. Emphasis on direct sample space formulation and solution of probabilistic situations. Topics: random variables, transform techniques, simple random processes and their resulting probability distributions, Markov processes, limit theorems, and an introduction to the issues of statistical inference and decision making under uncertainty.
A. W. Drake

6.045J Computability, Automata, and Formal Languages

(Same subject as 18.420J)
Prereq.: 18.041 or 18.061 or 18.063
Year: U (2)
3-0-9

Introduction to the basic mathematical models of computation and the finite representation of infinite objects. Finite automata and regular languages. Pushdown automata and context-free languages. Deterministic and pushdown automata and their application to parsing of programs. Turing machines and their variants. Partial recursive functions and grammars as models equivalent in power to Turing machines — Church's Thesis. Undecidable problems concerning machines, languages, grammars, and combinatorial systems. The time complexity of algorithms and NP-complete problems.
A. R. Meyer, M. Sipser

6.046 Introduction to Algorithms

Prereq.: 6.031 or 6.001, 18.031
Year: U (1)
3-0-9

General algorithmic concepts and techniques of value to the practicing programmer as exemplified in the following topics. Graph and matrix algorithms. Data structures for sets; hashing, trees, binary search, sorting. Integer arithmetic: multiple-precision arithmetic, testing primeness, evaluation of greatest common divisors. Other representations for arithmetic. Real arithmetic: evaluation of square roots, logarithms, exponentials, sines, etc. Storage allocation and garbage collection. Information organization and retrieval. Sorting. Dynamic programming. Branch and bound.
R. L. Rivest

6.061 Modeling and Analysis of Electromechanical Devices

Prereq.: 6.002, 8.02
Year: U (1)
3-0-9

Basic undergraduate elective subject dealing with fundamentals of energy-handling electric circuits and electromechanical apparatus. Emphasis placed on modeling of magnetic field devices and description of their behavior in terms of equivalent electric circuit models. Complex power flow in single- and poly-phase electric circuits. Magnetic circuits, assembly of coupled inductors and transformers, and topological relationships between magnetic and electric circuits. Lumped parameter electromechanics: energy, co-energy, and forces of magnetic origin. Elements of linear and rotating electric machinery: MMF and flux waves, induction, torque production. Modeling of synchronous, induction, and D.C. machinery. Simplification of problems through use of transformation techniques.
J. L. Kirtley, Jr.

6.071 Introduction to Electronics

Prereq.: *8.02*, 18.01
Year: U (1, 2) SD
4-2-6

Introductory subject suitable for students with little or no previous background in electronics. Elementary network theory, diode and transistor circuits, analysis and design of analog and digital circuits. Examples emphasize uses of electronics in experimental science. Alternate week laboratory.
L. D. Braida

6.074 Introduction to Telecommunications Systems

Prereq.: 6.015 or 6.003
Year: U (1)
3-0-9

An introduction to basic concepts and principles utilized in telecommunication systems as well as an overview of current and evolving communications technology. Characterization of data sources, signals and noise, sampling, information content, modulation and demodulation methods (CW and pulse), channel capacity, multiplexing and transmission systems. At end of term, there is discussion of some of the basic technological, economic and regulatory issues relating to telecommunications systems such as satellite systems and data networks. In latter part of term, outside speakers are invited to participate in the discussion.
J. P. Ruina

6.088 Machine Vision and Manipulation

Prereq.: 6.034, 6.003
Year: U (2)
3-0-9

Exploration of machine vision and manipulation, concentrating on the intelligent interaction of machines with their environment. Treatment of image analysis as the process of dealing with the image formation constraints and the processing of gray-level information in order to understand the world being imaged. Scene analysis as an activity of developing an internal symbolic model of the world. Selected topics in manipulation including particularly the use of force feedback in delicate assembly tasks, languages for automated assembly, and model-based systems for obstacle avoidance and locomotion with legs.
B. K. P. Horn

Undergraduate Laboratory Subjects

6.100 Electrical Engineering and Computer Science Laboratory

Prereq.: —
Year: U (1, 2, S)
Arr.

Opportunity for individual experimental work at the undergraduate level related to electrical engineering and computer science not covered by other subjects offered by the Department. Responsibility of students for initiation of arrangements and filing of proposal. (Permission of instructor required.)
L. A. Gould

6.101 Introductory Electronics Laboratory

Prereq.: 6.002 or 6.071
Year: U (1, 2) LAB
3-8-1

Introductory experimental laboratory involving design and construction of electronic analog and digital circuits. Introduction to electrical measuring and display instrumentation. Study of the operation and use of modern electronic devices. Independent project on design and construction of a practical electronic circuit. Project includes the conceptual design phase, generation of the circuit schematic and parts list, construction and testing of the circuit, and successful demonstration that original objectives have been met.
C. D. Paton, J. K. Roberge

6.111 Introductory Digital Systems Laboratory

Prereq.: 6.002 or 6.071
Year: U (1, 2) LAB
3-7-2

Introduction to basic concepts and techniques used for design and implementation of digital computing and control systems from both a module and a systems viewpoint. Study of logic design issues including symbology, Boolean algebra, combinational logic, memory elements, timing and synchronization techniques, and synthesis of sequential circuits. Supplementary topics: operational amplifiers, analog-digital interfaces and reliability. A combination of classes, homework, and associated laboratory experiments provides background for the conception, design, and implementation of a digital system project in an area of student's choice: e.g., calculators, electronic games, graphics, biomedical, communications, music. (Limited enrollment.)
D. E. Troxel

6.114 Real-Time Computing and Control Laboratory

Prereq.: 6.031 or 6.001; 6.032 or 6.082 or 6.111
Year: U (1, 2)
3-7-2

Laboratory devoted to experimentation with computer control of real-time events and physical systems. Lectures cover necessary computer techniques. Operating system environment. The use of high-level languages and its limitations in real-time applications. Assembly language and microcode programming and their linking with high-level language programs for overcoming time constraints. Input-output operations and interrupt systems. Use of dynamic data structures in interactive environments. System testing and evaluation. Emphasis on control of physical devices requiring different degrees of real-time interaction. (Limited enrollment.)
F. F. Lee

6.115 Microcomputer Project Laboratory

Prereq.: 6.082 or 6.111; 6.114
Year: U (2)
2-8-2

Methods of interfacing digital and analog devices to microcomputers. Construction of interfaces to selected external devices. Survey of commercially available microprocessors and microcomputers. Use of simulators and cross-assemblers. Lab exercises in data acquisition, interrupt control, and DMA. Major project: the design, construction, programming, and testing of a system which includes a microprocessor as a processing element. (Fluency in assembly language required. Limited enrollment.)
F. F. Lee

6.121 Bioelectronics Project Laboratory

Prereq.: —
Year: U (1) LAB
2-8-2

Project laboratory in the design of electronic instrumentation with biomedical applications. Classroom and laboratory work on the specification, design, construction, and evaluation of an electronic system, such as a beat-by-beat heart monitor, including several interrelated subsystems employing both analog and digital techniques. Extensive use of integrated circuits and discrete components. Differential amplifiers, active filters, pulse detection circuits, frequency-to-voltage converter, sample and hold, alarm circuits, display devices. Discussion of operation of commonly used laboratory instruments as optional laboratory exercises. Development of circuit models for active and passive devices and terminal models for more complex functional components with evaluation in the laboratory in the context of a project. Written report and oral presentation after completion of project. (Permission of instructor required. ***Not offered 1981-82.***)
R. G. Mark

6.141 Power Systems Project Laboratory

Prereq.: 6.002; *6.013*
Year: U (1, 2) LAB
0-10-2

Introduction to the concepts and techniques used in power systems engineering. Student's choice (either alone or with lab partners) of a project; independent work involving linear and nonlinear circuits both passive and active, electromagnetic phenomena, electromechanical phenomena, power electronics, and energy processing systems.
S. D. Umans

6.142 Microcomputer Controlled Energy Systems (New)

Prereq.: 6.302 or 2.14 or 10.35 or 16.30
Year: U (1, 2)
3-6-3

Project laboratory which explores use of microcomputers to control energy and power. First half involves experiments and lectures illustrating important issues involved in computer control of energy related systems. Second half involves student design and implementation of one or two systems such as control of an internal combustion engine, a residential heating system, a solar photovoltaic power system, a utility-consumer interface, and a cogeneration facility. Emphasis on issues of control, reliability, and improved effectiveness of energy use. Computer programming and electronic circuit experience required. (Limited enrollment.)
R. D. Thornton, L. A. Gould, J. H. Lang

6.150J Introduction to Microelectronic Technology (New)

(Same subject as 3.083J)
Prereq.: 6.012
Year: U (1, 2)
1-3-2

Introduction to some of the basic techniques and processes used in the fabrication of silicon monolithic integrated circuits. Lectures and laboratory sessions on the theory and technology of device fabrication and integrated circuit processing, including wafer cleaning, oxidation, photoengraving, chemical etching, diffusion, thin film deposition, and device test-

ing. (This subject is a suitable introduction for students wishing to do project lab work in 6.151 or thesis work in the microelectronics field. Also available in IAP.)
L. R. Reif, C. G. Fonstad, H. L. Tuller

6.151 Semiconductor Devices Project Laboratory (Revised Content and Unit)

Prereq.: 6.150J, 6.720
Year: U (1, 2) LAB
0-12-0

Student use of facilities of the Microelectronics Laboratory for individual or team projects in the area of design, fabrication, modeling and characterization of individual MOS or bipolar devices and of integrated circuits using these devices. Each term, the project topics are selected to fit the general areas of development in the Laboratory. (Enrollment limited.)
D. A. Antoniadis, C. G. Fonstad, L. R. Reif, S. D. Senturia

6.161 Modern Optics Project Laboratory

Prereq.: 6.013, 6.003
Year: U (1) LAB
2-8-2

Lectures, complementary laboratory exercises, and projects in physical optics, quantum optics, optical devices, and coherent optical systems. Topics include: wave and particle properties of light; reflection, refraction, total internal reflection; polarization; Fresnel's equations, Brewster's angle; coherence, interference and interferometers; Fraunhofer and Fresnel diffraction; imaging and transforming properties of a lens, spatial filtering, Schlieren and phase contrast techniques; spectroscopy and spectrometers; absorption and dispersion; electrooptic materials and devices; optical detectors: lasers and laser systems; nonlinear optics; holography; dielectric waveguides and fiber optics; optical modulation and optical communication systems. A list of suggested projects is given out about the third week of the term. All projects must be approved and supervised by a faculty or staff member. Seniors may use this laboratory as a vehicle for finding a senior thesis.
C. Warde

6.162 Image Transmission Systems Project Laboratory

Prereq.: 6.012
Year: U (1, 2) LAB
0-12-0

Student use of facilities of the Image Processing Laboratory of the Cognitive Information Processing Group in RLE for projects related to picture transmission or reproduction systems. Facilities available for computer simulation studies as well as hardware projects. Possible topics: image enhancement and compression; implementation of image processing algorithms in hardware; optical, mechanical, or electronic development of scanners; image processing software development; development of apparatus for study or demonstration in visual psychophysics.
W. F. Schreiber

6.163 Strobe Project Laboratory

Prereq.: —
Year: U (1, 2) LAB
2-8-2

A project laboratory for experiments, involved mainly with the characteristics of electronic flash sources of light and their applications to photography and to measurement problems. A program of experimentation concerned with electronic flash organized with each group of students, at the start of the term. (Permission of instructor required.)
H. E. Edgerton, C. E. Miller

6.170 Laboratory in Software Engineering

Prereq.: 6.031 or 6.001
Year: U (1, 2)
3-6-3

Introduction to concepts and techniques relevant to the production of large software systems. Students taught a programming method based on the recognition and description of useful abstractions. Topics: programming methodology; procedural, data and control abstractions; specifications; top down design, implementation and testing. Several programming projects of varying size undertaken by students working singly and in groups.
J. V. Guttag, B. H. Liskov

6.182 Psychoacoustics Project Laboratory

Prereq.: —
Year: U (1) LAB
3-4-5

Introduction to the problems and methods involved in the measurement of human auditory abilities. Application of on-line computation to the control and analysis of experiments involving the measurement of hearing. Classroom discussion of auditory function, principles of psychoacoustic measurement, models for psychoacoustic performance, experimental apparatus, and computer control techniques. Project topics: absolute and differential auditory sensitivity, operating characteristics of human observers, span of absolute judgment, adaptive measurement procedures, scaling sensory magnitudes, etc. Oral presentation and written report. (Knowledge of probability helpful. Alternate years. ***Not offered 1981-82.***)
L. D. Braida, N. I. Durlach

Advanced Undergraduate Subjects and Graduate Subjects by Area

Systems Science and Control Engineering

6.201 Introduction to Dynamic Systems (New)

Prereq.: 6.003; 18.03 or 18.031
Year: U (1)
3-0-9

Introduction to modern system theory, illustrating primarily applications to control, communications and operations research. Emphasis on modeling, analysis, control and optimization of dynamic behavior in discrete- and continuous-time multi-input-output systems. Topics: linear and nonlinear state-space descriptions; structure, behavior and control of linear time-invariant systems (modal properties, state feedback, optimal closed-loop modes, observers); analysis of nonlinear systems (equilibria, linearization, summarizing functions); least-squares parameter estimation; basic ideas of optimal control (illustrations of the maximum principle and dynamic programming).
G. C. Verghese, S. K. Mitter

6.202 Introduction to Decision Making with Uncertainty (New)

Prereq.: 6.041 or 18.440 or 18.313; 18.031 or 18.700
Year: U (2)
3-0-9

Introduction to techniques for analyzing dynamic systems which are subject to random disturbances over time. Emphasis on methods for acquiring, processing, and using information in a noisy environment, in support of automated decision making. Topics: discrete time systems modeled as Markov chains or linear difference equations, the Kalman filter, and dynamic programming in deterministic and stochastic settings. Examples illustrate applications in operations research, communications, and automatic control.
R. R. Tenney

6.230 Linear System Theory (A)

Prereq.: 6.003; 18.031 or 18.700
Year: G (1)
3-0-9

Basic graduate subject on linear systems. Review of concepts related to vector spaces. Interpretation of signals, linear systems, the convolution integral, and Fourier and Laplace transforms in terms of vector space concepts. Optimization concepts and their application to signal approximation and system modeling. The concept of state for causal systems and the representation of systems in state space form. Solution of the state equation. Controllability and observability. Realization and structures for multi-input, multi-output linear systems. Stability concepts.
A. V. Oppenheim, A. S. Willsky

6.231 Dynamic Programming and Stochastic Control (A)

Prereq.: 6.041 or 18.313 or 18.440
Year: G (2)
3-0-9

Introduction to sequential decision making via dynamic programming. Unified approach to optimal control of stochastic dynamic systems and Markovian decision problems. Applications from control theory and operations research include linear-quadratic problems, inventory control, investment and resource allocation models. Optimal decision making under perfect and imperfect state information. Certainty equivalent and open loop-feedback control, self-tuning controllers. Infinite horizon problems, successive approximation, policy iteration.
D. P. Bertsekas

6.232 Multivariable Control Systems (A) (Revised Content)

Prereq.: 6.230, 6.432
Year: G (1, 2)
3-0-9

Basic graduate subject in synthesis of multivariable control systems using both time domain (state variable) and frequency domain techniques. Review of stability concepts; the multivariable Nyquist criterion. Frequency domain synthesis approaches: inverse Nyquist arrays; characteristic loci. The Linear-Quadratic-Gaussian (LQG) optimal control approach to multivariable control synthesis. Full state and partial state feedback realizations; the use of Kalman filters in designing dynamic compensators. Properties of optimal LQG-based designs: root loci and robustness properties; disturbance rejection; integral control; gain and phase margins. Computer-aided design homework.
B. C. Levy, M. Athans

6.251J Introduction to Mathematical Programming (A)

(Same subject as 15.081J)
Prereq.: 18.700
Year: G (1, 2)
3-0-9

A first subject in mathematical optimization emphasizing methodology. Linear programming: simplex method, duality, sensitivity analysis, geometric view. Transportation and network flow problems. Elements of integer programming. Introduction to generalized and nonlinear programming.
S. K. Mitter, J. B. Orlin

6.252J Nonlinear Programming and Discrete-Time Optimal Control (A)

(Same subject as 15.084J)
Prereq.: 18.700, *18.100*
Year: G (2)
3-0-9

Unified approach to mathematical programming and discrete-time optimal control. Convex analysis. Global and local duality theory for nonlinear programming. Discrete-maximum principle of optimal control. Unconstrained minimization methods. Algorithms for nonlinear programming. Knowledge of 6.251J/15.081J useful but not required.
S. K. Mitter, J. F. Shapiro

6.253 Algebraic System Theory (A)

Prereq.: 6.230; 18.061 or 18.063
Year: G (2)
3-0-9

Advanced topics in system theory. Topics include the module structure of linear systems from an input/output point of view, the concepts of state and Nerode equivalence. Polynomial matrix descriptions and modern frequency domain analysis of linear systems. (A,B) invariant and controllability subspaces, and the geometric control theory of Wonham and Morse. Role of algebraic geometric concepts in the study of output feedback. Automata theory and machine decomposition. Systems over groups, rings and finite fields. Bilinear and multilinear systems. Subject content varies from year to year. (Alternate years. ***Not offered 1981-82.***)
B. C. Levy, G. C. Verghese

6.254 Qualitative Theory of Dynamical Systems (A)

Prereq.: 6.230, 18.100
Year: G (1)
3-0-9

Introduction to nonlinear dynamical systems with emphasis on stability theory. Solvability of nonlinear equations. Dynamical systems in input/output and in state space form. Feedback systems. Input/output stability concepts. Stability criteria based on the small loop gain theorem and on passivity conditions. Circle criterion, Popov's criterion and other frequency-domain stability criteria. Lyapunov stability theory. Dissipative systems. Stochastic dynamical systems and stochastic stability. (Alternate years. ***Not offered 1981-82.***)
S. K. Mitter

6.255 Optimal Control Theory (A)

Prereq.: 6.230
Year: G (1)
3-0-9

Advanced topics in deterministic and stochastic optimal control theory. Topics: nonlinear control, the Pontryagin Minimum Principle, differential dynamic programming, static and dynamic games (Nash, Stackelberg, and Pareto solution concepts), team theory, and large scale systems. Applications and computational aspects also discussed. (Alternate years. ***Not offered 1981-82.***)
R. R. Tenney, M. Athans

6.262 Markov Models and their Applications (A)

Prereq.: 1.07 or 6.041 or 6.431 or 18.313
Year: G (1)
3-0-9

Formulation and analysis of dynamic probabilistic models, emphasizing Markov processes and their extensions. Linear systems theory applied to discrete state, discrete and continuous time, stationary and nonstationary, Markov and semi-Markov processes. Dynamic programming and its application to the control of Markov systems. Partially observable Markov processes. Applications in societal and engineering systems: population growth, social mobility, disease and rumor propagation, systems reliability and maintenance, and congestion processes in communication networks and in the delivery of public services. Discussion of unsolved problems and promising areas of research.
R. C. Larson, A. W. Drake

6.263 Data-Communication Networks (A)

Prereq.: 6.041; *6.432* or *6.251J*
Year: G (1)
3-0-9

Modeling of the data and control processes in computer communication networks. Development and utilization of elementary concepts from information theory, queueing theory, linear programming, nonlinear optimization, algorithms, and computer architecture to study the problems of line protocols, network protocols, quasi-static and dynamic routing, congestion control, and deadlock prevention. Introduction to distributed algorithms for network control. Special issues arising in radio and satellite networks. Critical description of the design of some existing networks. Emphasis varies from year to year, according to student interests and current research interests.
D. P. Bertsekas

6.264 Queueing Theory with Applications (A) (New)

Prereq.: 6.262 or 6.432 or 15.973J or 18.445J
Year: G (2)
3-0-9

Introduction to the analysis of queueing systems (waiting lines), with applications in communications, computers, manufacturing, transportation and urban systems. Material presented varies from year to year, depending partly on student interests. Typical topics: simple Markovian queues, networks of queues, general (non-Markovian) single and multiple server queues, priority queues, bounds and approximations, optimization of queueing systems. Current research opportunities discussed. Term project required. (Alternate years. ***Offered 1981-82.***)
P. A. Humblet, R. C. Larson

6.271 Introduction to Operations Research

Prereq.: Permission of Instructor
Year: G (1)
3-0-9

6.272 Introduction to Operations Research

Prereq.: 6.271
Year: G (2)
3-0-9

A two-term introduction to some important techniques and problem formulations of operations research, sometimes defined as a technology for aiding decision making. Emphasis on overall approach of operations research, rather than mathematical theory, within various industrial and public sector application areas. Topics include linear programming models and methods, network analysis, optimal sequential decision making, decision analysis, Markov models, queueing models, inventory theory, and simulation. Several recently published studies critically reviewed. (Restricted to Fellows of the Center for Advanced Engineering Study.)
R. C. Larson

6.281J Logistical and Transportation Planning Methods (A) (Revised Content and Unit)

(Same subject as 1.203J, 11.526J, 13.665J, 15.078J, 16.76J, TPP 43J)
Prereq.: 6.431, 15.075
Year: G (1)
3-0-6

Quantitative techniques of operations research with emphasis on applications in transportation systems analysis (urban, air, ocean, highway, pick up and delivery systems) and in the planning and design of logistically oriented urban service systems (e.g., fire and police departments, emergency medical services, emergency repair services). Unified study of functions of random variables, geometrical probability, multi-server queueing theory, spatial location theory, network analysis and graph theory, and relevant methods of simulation. Discussion of implementation difficulties. Examples of applications: design of ambulance systems having both specialized and general-purpose vehicles; emergency response to oil spills; estimation of energy consumption by commuters in a metropolitan area; design of dial-a-ride transportation systems; controlling randomness in mass transit systems; evaluation of technologies for vehicle location, routing and control.
R. C. Larson, A. I. Barnett, A. R. Odoni, H. N. Psaraftis

6.291 Seminar in Systems and Control Research (A)

Prereq.: Permission of Instructor
Year: G (1, 2)
3-0-9

A seminar dealing with advanced topics in systems and control theory and applications. Selected topics according to student and instructor interest. (See instructor for specific topics to be offered in a particular term.)
S. K. Mitter

Electronics, Computers and Systems

6.301 Solid State Circuits

Prereq.: 6.012
Year: U (1)
3-3-6

Analysis and design of transistor circuits, based directly on the semiconductor physics and transistor circuit models developed in 6.012. High-frequency and low-frequency design calculations of multistage transistor circuits using a computer. The charge-control model. Introduction to operational-amplifier design and application. Some previous laboratory experience assumed.
J. K. Roberge

6.302 Feedback Systems

Prereq.: 6.003
Year: U (2)
3-2-7

Primary entry-level subject for undergraduates intending to study automatic control. Properties and advantages of feedback. System modeling. Stability analysis based on root-locus and Nyquist techniques. Relationships between time-domain and frequency-domain performance indices. Compensation of single- and multiple-loop feedback systems. Introduction to nonlinear analysis. Examples drawn from a variety of electronic and electromechanical systems. Some previous laboratory experience assumed.
L. A. Gould

6.311 Telephony

Prereq.: 6.002 or 6.071 or 6.101
Year: U (2)
2-0-4

Review of current telephone technology. Examination of the sequence of events occurring as a call is originated, connection made, and call completed for commonly used systems including manual switchboards, step-by-step, cross-bar, and ESS offices. Interoffice connection, signal methods, and traffic problems. Technical and economic characteristics of equipment used for voice and data communications. Tours of representative facilities arranged. (Alternate years. ***Offered 1981-82.***)
S. K. Burns

6.312 Acoustics

Prereq.: 6.002
Year: U (1)
3-1-8

Sound generation and propagation in elastic media. Simple sources and arrays of sources. Derivation of lumped parameter acoustical elements and circuits from solutions of wave equations. Radiation impedance. Conversion among acoustical, electrical, and mechanical energy. Modeling and analysis of electro-acoustical devices such as microphones and loudspeakers. Sound in rooms. Interaction of sound and humans.
A. G. Bose

6.331 Advanced Circuit Techniques (A)

Prereq.: 6.301, 6.302
Year: G (2)
3-2-7

Following a brief classroom discussion of relevant principles, each student completes the paper design of several advanced circuits such as multiplexers, sample-and-holds, gain-controlled amplifiers, analog multipliers, digital-to-analog or analog-to-digital converters, and power amplifiers. One of each student's designs may be presented to the class, and one may be built and evaluated. Associated laboratory emphasizing the use of modern analog building blocks. (Enrollment limited. Permission of instructor required. Alternate years. ***Not offered 1981-82.***)
J. K. Roberge

6.332 Advanced Instrumentation Electronics (A)

Prereq.: 6.003
Year: G (1)
3-0-9

Examination of the theory and practice of electronic transduction, circuits, and systems in modern instrumentation, including a critical review of alternative implementations and engineering compromise. Emphasis on analog and pulse-signal processing as opposed to purely digital techniques. Topics: representations of signals, noise, and linear systems, time-varying linear systems, nonlinear waveform processing. Feedback and associated analytic techniques reviewed and applied to modern implementations of switching regulators. Parameter feedback characterized by phase-loops examined. Pulse and timing circuits investigated and some modern integrated timing circuits examined. Digital-analog interfaces discussed, and microprocessor-controlled signal processors and microprogrammed controllers briefly reviewed through examples. Selected examples discussed by guest lecturers.
S. K. Burns

6.333 Electronic Circuits (A)

Prereq.: 6.012, 6.003
Year: G (2)
3-0-9

Theory, analysis, and design of linear and nonlinear electronic circuits with emphasis on the use of computers to solve symbolic and numerical circuit problems. Topics: network representations and transformations; time and frequency-domain response; basic limitations and optimal design; sensitivity and noise; simulation. Examples from linear amplifier and oscillator circuits, power switching circuits, feedback control, and use of circuit models for simulation of energy systems.
R. D. Thornton

6.334 Power Electronics (A)

Prereq.: 6.012, 6.013
Year: G (2)
3-0-9

The application of electronics to energy conversion and control. Electrical and thermal characteristics of power semiconductor devices — diodes, bipolar and field effect transistors, and thyristors. Magnetic circuits for energy conversion. Active and passive filtering techniques. Emphasis on device limitations, computer-aided analysis and design, and system control. Application examples include multipulse controlled rectifiers, high frequency induction heating, dc-dc conversion, cycloconverters, motor drives, and battery electronics. A background in elementary device physics is assumed.
J. G. Kassakian

6.341 Digital Processing of Signals (A)

Prereq.: 6.003; 18.075 or 18.04; *6.041* or *6.431*
Year: G (1, 2)
4-0-8

Representation, analysis, and design of discrete signals and systems. Z-transforms and the discrete Fourier transform. The fast Fourier transform (FFT) algorithm. High-speed convolution and correlation. Time and frequency domain design techniques for recursive (IIR) and nonrecursive (FIR) systems. Finite word-length implementation of discrete-time linear systems. Realization of discrete-time linear

systems. Additional topics may include homomorphic signal processing, power spectrum estimation, and applications to speech and image processing.
J. H. McClellan, A. V. Oppenheim

6.342 Advanced Topics in Digital Signal Processing (A)

Prereq.: 6.341
Year: G (2)
3-0-9

Parametric signal modeling. Spectrum analysis including the maximum entropy method (MEM). Adaptive filtering. Two-dimensional and multi-dimensional signal processing. Homomorphic filtering and the complex cepstrum. Fast algorithms based on number theory. (Alternate years. ***Offered 1981-82.***)
J. H. McClellan

6.343 Digital Speech Processing (A)

Prereq.: 6.341
Year: G (2)
4-0-8

Applications of digital techniques to the processing of speech signals. Digital models for the speech signal. Time- and frequency-domain models for speech processing. Digital representations of the speech waveform. Speech analysis techniques, including homomorphic and linear prediction analyses. Principles of speech bandwidth compression and speech synthesis. Survey of applications in the area of human-machine communication, including voice-response systems, speaker recognition systems, and speech recognition systems. (Alternate years. ***Not offered 1981-82.***)
V. W. Zue

6.361 Image Processing (A)

Prereq.: 6.015 or 6.003
Year: G (1)
3-0-9

Optical, electrooptical, electronic, and computer image processing techniques with applications to image restoration, quality improvement, and efficient coding for storage or transmission. Mathematical description of images. Relevant properties of human vision. Measures of quality. Scanning, sampling, and quantization. Fourier analysis and linear spatial filtering. Nonlinear processing. The halftone process. Technology of facsimile and printing systems. Color. Holography. Term paper or project required.
W. F. Schreiber

6.371 Introduction to VLSI Systems (A)

Prereq.: Permission of Instructor
Year: G (1, 2)
3-3-6

Provides background in integrated devices, circuits, and digital subsystems needed for design and implementation of integrated systems. Design methodology, use of ratioed design rules and library modules, symbolic layout languages, computer-aided design techniques. Students required to complete, through layout, the design of a digital subsystem in NMOS. Selected projects form a multi-project chip set leading to wafers available after the end of the term for possible packaging and testing by the student. (Limited enrollment. Permission of instructor required.)
J. Allen

6.372 Advanced Topics in VLSI Systems (A) (New)

Prereq.: 6.012; 6.371
Year: G (2)
3-0-9

Study of NMOS circuits in high performance integrated systems. Design techniques including: bootstrapping, level shifting, precharging, differential sensing. Examination of fundamental properties of correctly constructed digital systems; clocking methodologies; design of finite state machines. Several industrial designs examined. A class project undertaken. (Limited enrollment.)
L. A. Glasser

Probabilistic Systems and Communication

6.431 Applied Probability

Prereq.: 18.02
Year: G (1, 2)
4-0-8

Development of theory and applications of probabilistic concepts for engineers, administrators, and scientists. Emphasis on direct sample space formulation and solution of probabilistic situations. Topics: random variables, transform techniques, simple random processes and their resulting probability distributions. Markov processes, limit theorems, and an introduction to the issues of statistical inference and decision making under uncertainty. Requires the preparation of a report and/or advanced home problems.
A. W. Drake

6.432 Stochastic Processes and Applications (A)

Prereq.: 6.003; 6.041 or 6.431 or 18.313
Year: G (1, 2)
4-0-8

Basic graduate subject in stochastic processes and applications. Intended primarily for students interested in communication, control, or operations research, but also an appropriate foundation for study of stochastic phenomena in signal processing and biomedical engineering. Applications covered include: hypothesis testing, parameter estimation, discrete-time Kalman filter, stochastic processes in linear systems, and queueing processes. Stochastic process theory is developed in sufficient depth to permit thorough treatment of these applications.
J. H. Shapiro

6.435 System Identification (A)

Prereq.: 6.003; 6.041 or 6.431 or 18.313
Year: G (1)
3-0-9

Determination of valid mathematical models for physical and social systems using observations of their behavior. Different philosophies of modeling; state space, time series. Multiple input-output, nonlinear, and time varying systems. Parameter estimation algorithms: full information maximum likelihood, least squares. Parameter identifiability. Model validation; statistical hypothesis testing, reasonability. Bad data-anomaly detection, robust estimation. Discussion of available software packages. (Alternate years. ***Not offered 1981-82.***)
F. C. Schweppe

6.441 Transmission of Information (A)

Prereq.: 6.041 or 6.431 or 6.432 or 18.313
Year: G (2)
3-0-9

Introduction to the quantitative study of information with emphasis on concepts fundamental to the engineering of reliable, efficient communication systems. Mathematical definition of information and study of its properties; efficient representation of message sources; communication channels and their capacity; coding for reliable transmission of data over noisy channels. Additional topics of interest such as representing data and control information in data communication networks are included.
R. G. Gallager

6.451 Principles of Communication (A)

Prereq.: 6.015 or 6.003; 6.041 or 18.313
Year: G (1)
3-0-9

Probabilistic formulation of optimal communications problems. Mathematical description of signals and noise. Digital modulation and signal design. Decision regions and optimum receivers. Intersymbol interference. Introduction to channel capacity and error-free communication over noisy channels. Interchange of bandwidth and signal power. Convolutional codes. Topics of current interest.
P. A. Humblet

6.452 Stochastic Filtering and Detection (A)

Prereq.: 6.230, 6.432
Year: G (2)
3-0-9

A unified approach to the areas of filtering, detection, and system identification. Detection of known and stochastic signals in Gaussian and Poisson noise. Linear filtering, Wiener and Kalman filters, parameter identification. Nonlinear filtering for signals in Gaussian noise and point process observations. Applications to areas such as control, communications, radar, sonar, optical communications, and computer networks.
A. B. Baggeroer, S. K. Mitter

6.453 Optical Detection and Communication (A)

Prereq.: 6.041; 6.611 or 6.631J
Year: G (2)
3-0-9

Basic graduate subject in optical detection and its applications. Phenomenological description of photodetectors. Shot noise, thermal noise, gain-fluctuation noise statistics. Signal-to-noise ratios of direct detection and heterodyne detection systems. Application of noise analysis to free-space, atmospheric, and fiber optic communications. Application of noise analysis to optical detection for phase-sensing interferometers, photon correlation instruments, and optical radars.
J. H. Shapiro, R. S. Kennedy

6.454 Advanced Topics in Optical Communication Research (A)

Prereq.: 6.453
Year: G (1)
3-0-9

Discussion of advanced topics and current research activities in optical detection, propagation, and communication. Material presented and detailed prerequisites vary from year to year. Typical topics: quantum issues in detection and communication; fiber-optic and waveguide-optic communications; optical wave propagation, imaging, and communication in multiple-scattering atmospheres. Term paper required. (Alternate years. ***Not offered 1981-82.***)
R. S. Kennedy, J. H. Shapiro

6.455J Marine Data Systems (A)

(Same subject as 13.74J)
Prereq.: 2.02 or 6.003 or 13.004; 6.041, 18.075
Year: G (1)
3-0-9

Analysis of systems and techniques used in the measurement of oceanographic data. Review of linear systems; applications to data recording and control systems, analog and digital filters. Temporal random processes, correlation and spectral analysis, Gaussian processes, characterization of time series data in oceanography. Sonar, radar, echosounders, and seismic systems; transmitters and receivers for estimating range and velocity of reflectors in media with ambient noise and reverberation. Space/time random processes, frequency-wave number characterizations, sensor arrays and spatial processors; applications in arrays for ambient noise and passive sonar, surface, and internal waves. Measurement of power spectra and wave number functions by indirect, direct, and adaptive methods. (Alternate years. ***Not offered 1981-82.***)
A. B. Baggeroer, R. C. Spindel (Woods Hole Staff)

Bioelectrical Engineering

6.501 Sound, Speech, Hearing

Prereq.: 6.003
Year: U (2)
3-0-9

Introduction to the physical, physiological, and psychological bases of auditory communication. Physical acoustics, properties of neural and muscular elements, the vocal tract and speech generation, signal transmission in the auditory system, perception of attributes of speech and speechlike sounds, and the linguistic units that underlie speech events. Disorders of human communication. (Alternate years. ***Offered 1981-82.***)
K. N. Stevens, W. T. Peake, D. H. Klatt

6.523J Computers and Patient Care

(Same subject as HST 550J)
Prereq.: —
Year: G (2)
2-0-4

A seminar designed to give an overview of present and potential uses of computers in patient care applications. Typical topics: hospital administrative activities, automated medical histories, input of physician progress notes and orders, ambulatory medical record, patient monitoring, automated medical consultation and diagnosis, medical education and clinical simulations, data collection and analysis in clinical investigations. (Open to undergraduates.)
G. O. Barnett

6.524J General Physiology

(Same subject as 7.51J)
Prereq.: —
Year: U (2) SD
3-0-9

Form-function relations. How local actions determine global geometry in development. Strategies of growth. Special problems in respiration, circulation, excretion, and animal movement illustrating how function and form direct each other. Structure and action of muscle. Physiology of perception. How the senses of predators affect the evolution of their prey. Mimesis and protective coloration of prey as guides to the nature of vision in predator. Tactics of color vision and form vision. Introduction to the physiology of nerve membrane and to the action of nervous tissue.
J. Y. Lettvin, E. R. Gruberg

6.532J Sensory-Neural Systems (A)

(Same subject as 16.352J)
Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Detailed consideration of a number of sensory-neural systems with respect to anatomy, physiology, and mode of operation. Reading of relevant papers and critical discussion of the methods and results described. Topics selected on the basis of their current research interest, with emphasis on systems in which physical input and sensory cell/neuron output

can be quantitatively related. Examples from vertebrate and invertebrate species including mechanical, visual, and other modalities. (Alternate years. ***Not offered 1981-82.***)
L. S. Frishkopf, C. M. Oman

6.541J Speech Communication (A)

(Same subject as 24.968J)
Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Survey of structural properties of natural languages with special emphasis on the sound pattern. Survey of physiology of speech production, articulatory phonetics. Acoustical theory of speech production: the vocal tract as a generator of acoustical signals; acoustical correlates of vocal-tract configurations, both stationary and dynamic; acoustical and articulatory descriptions of phonetic features. Perception of speech: the auditory capabilities of humans; evidence for perceptual correlates of phonetic categories. Mechanical recognition and generation of speech. (Recommended prerequisites: engineering and science students, 6.501; linguistics students, mathematical background equivalent to 6.003. Alternate years. ***Not offered 1981-82.***)
K. N. Stevens, M. Halle, S. J. Keyser

6.542J Laboratory on the Physiology, Acoustics and Perception of Speech (A)

(Same subject as 24.966J)
Prereq.: Permission of Instructor
Year: G (1)
2-2-8

Experimental investigations of speech processes. Topics include: a) interpretation of X-ray motion pictures, b) measurements of pressure and volume velocity, c) computer-aided waveform analysis and spectral analysis of speech, d) synthesis of speech with an articulatory model and with a terminal analog model, e) identification and discrimination of speech-like sounds, f) the perceptual reality of phonetic features, and other topics. (Recommended prerequisites: engineering and science students, 6.501; linguistics students, mathematical background equivalent to 6.002 or 18.03. Alternate years. ***Offered 1981-82.***)
D. H. Klatt, M. Halle

6.543 Natural Language Processing (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Computational theories for the analysis of natural language. Study of word formation, lexical structure, syntax and parsing, sound structure, and semantic formalism. Representation of underlying syntax and semantics in speech. Applications to text-to-speech conversion, speech recognition, question answering, and language understanding systems. (Alternate years. ***Offered 1981-82.***)
J. Allen

6.551 Signal Processing by the Auditory System: Physiology (A)

Prereq.: 6.003, 6.023J
Year: G (2)
3-0-9

Intended for graduate students interested in sensory physiology. Discussion centering on responses of the auditory system to acoustic stimuli. Presentation aimed at understanding of the physiological mechanisms involved in transmission and processing of signals. When possible, discussion of the physiological process underlying normal behavior of organisms and hearing pathologies. Major emphasis on the more peripheral parts of the system: signal transmission in the external ear, middle ear, cochlea, auditory nerve, cochlear nucleus, superior olivary complex. Some discussion of the anatomy and physiology of higher levels. (Appropriate background other than the listed prerequisites may be accepted by the instructor. Alternate years. ***Offered 1981-82.***)
W. T. Peake, T. F. Weiss, N. Y. Kiang

6.552 Signal Processing by the Auditory System: Perception (A)

Prereq.: 6.015 or 6.003; 6.041 or 6.431
Year: G (1)
3-0-9

Study of behavioral aspects of human hearing in relation to current physiological knowledge. Examination of performance in processing information from acoustic stimuli. Correlations between behavior and physiology that reflect the tono-topic organization and stochastic responses of the auditory system. Mathematical models of psychophysical relations that incorporate quantitative knowledge of physiological transformations by the peripheral auditory system. Discussion of related research on diagnosis and aids for partially deaf. Necessary background material in auditory physiology and statistical decision theory presented. (Alternate years. ***Offered 1981-82.***)
H. S. Colburn, L. D. Braida

6.561J Fields, Forces and Flows: Background for Physiology (A)

(Same subject as HST 544J)
Prereq.: 6.013, 6.021J
Year: G (1)
3-0-9

Conduction, diffusion and convection in electrolytes. Fields in heterogeneous media typical of physiological systems. Equilibrium double layers. Force-stress relations. Maxwell stress tensor and electrical forces in physiological systems. Fluid continua, stress-strain-rate relations and equations of motion for viscous, incompressible flow. Continuum mechanics of solids including equations of motion for elastic media and models useful in representing heterogeneous media. Case studies relevant to physiological systems, e.g., membrane/electrolyte, electrode/electrolyte interfaces; equilibrium configuration of muscle, connective tissue structures; flow through charged porous membranes; ECG; interaction of biomaterials with electric fields: examples from orthopaedic research; electromechanical transduction including electrophoresis electroosmotic flows, electromechanical coupling in charged membranes, diffusion-reaction problems in biomaterials and tissues. (Appropriate background other than the listed prerequisites may be accepted by instructor.)
A. J. Grodzinsky

6.562J Ultrasound: Physics, Biophysics and Technology (A)

(Same subject as 2.76J, HST 530J)
Prereq.: Permission of Instructor
Year: G (1)
4-1-7

Physics and technology of generation and detection of ultrasound. Transducers and arrays. Propagation and fields. Diagnostic, therapeutic, and processing applications in medicine and industry. State of the art of imaging and Doppler systems. Biophysics, biological effects, linear and nonlinear phenomena. Hazards and safety levels. (Alternate years. ***Not offered 1981-82.***)
F. R. Morgenthaler, P. P. Lele

6.564J Medical Engineering Measurements (A except VI)

(Same subject as HST 580J)
Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Basic principles of medical measurements and transducers which form the basis of instrumentation with emphasis on present and emerging techniques. Measurement topics include temperature, force, displacement, pressure, sound, flow, bioelectric potentials, chemical electrodes, non-invasive blood gas, optical transducers, biochemical assays and microbiological determinations. General instrument concepts and sources of noise. Emphasis is on understanding the interaction of transducers with a biological system. Knowledge of elementary physics and circuit theory is assumed. Students in HST Medical Engineering and Medical Physics Program must take HST 581J concurrently.
R. G. Mark, J. C. Weaver

6.565J Medical Engineering Measurements Laboratory (A except VI)

(Same subject as HST 581J)
Prereq.: 6.564J
Year: G (2)
0-4-2

Laboratory to accompany 6.564J Medical Engineering Measurements. Static and dynamic testing of biomedical transducers and instrumentation, first with artificial-physical inputs and then with biomedical inputs. Investigations into transduction principles and their practical application with emphasis on limitations and clinical constraints. Engineering design and clinical utilization aspects of transducers and instrumentation. Students in HST Medical Engineering and Medical Physics Program must take HST 580J concurrently.
R. G. Mark, E. D. Trautman

Electrodynamics

6.601 Fields, Forces and Motion

Prereq.: 6.013
Year: U (1)
3-0-9

Basic subject dealing with electromechanical interactions in lumped-parameter and continuum systems. Review of integral and differential electromagnetic laws, including motion. Lumped electrical and mechanical elements: thermodynamics of discrete electromechanical coupling, equations of motion. Energy conversion exemplified by synchronous and induction rotating machines. Linear incremental and nonlinear potential-well transducers, transient and steady-state dynamics; electromechanical time constants, constant flux, and constant potential dynamics. Field transformations, electrical conduction, magnetic diffusion and charge relaxation in moving conductors, electric and magnetic Reynolds numbers, DC rotating machines. Electromagnetic force densities and stress tensors. Coupling to thin rods, strings and membranes: Delay lines and acoustic systems. Non-dispersive mechanical and electromechanical waves: characteristics and eigenmodes. Electromechanical dispersive waves with material convection to exemplify interactions with electron beams, plasmas and solids: absolute and convective instability, wave evanescence and amplification.
J. R. Melcher

6.611 Introduction to Optical Electronics

Prereq.: 6.013, 6.003
Year: U (2)
3-0-9

Introduction to Fourier optics. Spatial and temporal coherence of lasers and applications made possible by coherence. Characteristics of optical system components: propagation media, resonators, fiber guides; detectors and their signal-to-noise ratios; laser media, types and properties; modulation techniques. Discussion of specific applications.
J. H. Shapiro

6.631J Optics and Optical Electronics (A)

(Same subject as 16.381J)
Prereq.: 6.014 or 8.07
Year: G (1)
3-0-9

A first-year graduate subject on fundamental concepts and techniques of modern optics and quantum electronics. Review of Maxwell's equations and the vector properties of light. Interference and interferometers. Temporal and spatial coherence. Scalar diffraction theory and the Fresnel and Fraunhofer approximations. Propagation of spherical and Gaussian-spherical beams. Lenses, imaging, and spatial filtering. Resonant and nonresonant scattering. Nonlinear optics; electrooptic effect. Thin film and "fiber" waveguides. Modulators and deflectors. Additional topics selected from: switches, frequency conversion, and detectors.
H. A. Haus, S. Ezekiel

6.632 Advanced Electromagnetic Theory (A)

Prereq.: 6.014 or 8.03
Year: G (1)
3-0-9

A first-year graduate subject on electromagnetic field theory with emphasis on mathematical approaches, problem solving, and physical interpretation. Examples deal with guidance, propagation, radiation, and scattering of electromagnetic waves; metallic and dielectric waveguides, resonators, antennas, and radiating structures, Cerenkov radiation, moving media, plasmas, crystals, integrated optics, lasers and fibers, remote sensing, geophysical probing, dipole antennas, and stratified media.
J. A. Kong

6.633 Electrodynamics of Waves, Media and Interactions (A)

Prereq.: 6.014; 18.075 or 18.04
Year: G (2)
3-0-9

Intended for first-year graduate students and seniors whose interest is in the interaction of electromagnetic fields with charged particles and continuous media. Wave propagation and dispersion relations in media with temporal and spatial dispersion. Linear response functions in time and space; contour integration in complex frequency and wave-number planes. Energy, momentum, and their flow associated with small-amplitude wave propagation in passive and active media. Linear and nonlinear coupling of modes in stable and unstable systems. General stability criteria and techniques for identifying and classifying wave-type instabilities. Examples treated: plasma waves in gases and solids; acoustic waves and their interactions with electrons in piezoelectric semiconductors; electron-beam waves, and their interactions with plasmas and slow-wave structures; laser-plasma interactions.
A. Bers

6.634 Nonlinear Optics (A) (New)

Prereq.: 6.014 or 8.07
Year: G (1)
3-0-9

Nonlinear optical phenomena with an emphasis on techniques and devices. Pulse propagation in nonlinear amplifying and absorbing media. Nonlinear polarization: harmonic generation, frequency mixing, optical Kerr effect, self-phase modulation, stimulated Raman and

Brillouin scattering, phase conjugation, continuum generation. Nonlinear spectroscopy of atoms, molecules, and solids. Ultrafast processes, picosecond techniques.
E. P. Ippen, M. M. Salour

6.635 Topics in Electrodynamics (A)

Prereq.: 6.014 or 6.632 or 8.07
Year: G (2)
3-0-9

Material covered differs from year to year according to interest of students and instructor in charge. Typical topics include electrodynamics of moving media, waves in dispersive media, quantum optics, remote sensing, radiative transfer theory and random media. (Offered when there are suitable topics with enough student and staff interest.)
J. A. Kong

6.636 Techniques of Physical Measurements (A)

Prereq.: Permission of Instructor
Year: G (2)
2-4-6

Techniques of physical measurements for advanced undergraduates and graduate students planning to do experimental research. Topics: 1/f noise; lock-in amplifiers; power spectra; box cars; sampling oscilloscopes; pulse height analyzers; fast Fourier transforms; transducers; digital versus analog processing; multichannel analyzers; ultrafast (picosecond) photographic measurements; digital wavelength measurements; fast feedback loops; optical multichannel analyzers; opto-electric picosecond switching. Includes general discussions of elementary noise theory and the principles used to design measurements. (Alternate years. ***Not offered 1981-82.***)
M. M. Salour

6.638 Electrical and Optical Processes in Gases (A)

Prereq.: 8.03, 8.211
Year: G (2)
3-0-9

Basic processes in plasmas, lasers, and electrical insulation. Collisions involving particles and radiation fields including classical and quantum effects, resonant and non-resonant excitations and recombinations. Collective particle behavior, mobility, diffusion, and distribution functions with Max-Boltzmann, Druyvesteyn, and Fokker-Planck approximations. Analysis of surface effects, charge multiplication, breakdown, excitation and inversion mechanisms, and plasma properties. Applications in diagnostics, lasers, switches, dielectrics, and ion sources. (Alternate years. ***Offered 1981-82.***)
C. M. Cooke

6.641 Microwave Circuits (A)

Prereq.: 6.014
Year: G (2)
3-1-8

Electromagnetic wave propagation on uniform and periodic structures, waveguide, stripline, and microstrip. Equivalent circuit representations for apertures and obstacles. Multiport junctions. Non-reciprocal ferrite devices. Cavity and confocal resonators. Filters. Boundary value problems. Perturbation theory. Measurement theory and devices. Sources and detectors. Laboratory. (Alternate years. ***Offered 1981-82.***)
R. L. Kyhl

6.642 Antennas and Radiation (A)

Prereq.: 6.014
Year: G (2)
3-0-9

General theory of radiation and its application to the analysis of representative types of antennas; emphasis placed on the design of antenna arrays, microwave reflectors, and lenses. (Alternate years. ***Not offered 1981-82.***)
J. A. Kong, F. R. Morgenthaler

6.651J Introduction to Plasma Physics I (A)

(Same subject as 8.613J, 22.611J)
Prereq.: 6.014 or 8.07; 6.018 or 8.04; 18.04 or 18.075
Year: G (1)
3-0-9

Introduction to plasma phenomena relevant to energy generation by controlled thermonuclear fusion and to astrophysics. Coulomb collisions and transport processes. Motion of charged particles in magnetic fields; plasma confinement schemes. Low-frequency plasma dynamics; MHD models; simple equilibrium and stability analysis. Two-fluid hydrodynamic plasma models; wave propagation in a magnetic field. Introduction to kinetic theory; Vlasov plasma model; electron plasma waves and Landau damping; ion-acoustic waves; streaming instabilities; derivation of the collision operator; Spitzer conductivity.
A. Bers, K. Molvig, M. Porkolab

6.652J Introduction to Plasma Physics II (A) (New)

(Same subject as 8.614J, 16.59J, 22.612J)
Prereq.: 6.651J or 8.613J or 22.611J; 18.075
Year: G (2)
3-0-9

Linear waves and instabilities in magnetized plasmas; solutions of Vlasov-Maxwell equations in homogeneous and inhomogeneous plasmas; conservation principles for energy and momentum; negative energy waves; absolute and convective instabilities. Quasi-linear theory and conservation principles: evolution of unstable particle distribution functions. Collisional transport theory; Fokker-Planck equations; particle diffusion, thermal conductivity, and viscosity in magnetized plasmas.
A. Bers, R. Davidson, J. McCune, K. Molvig

6.661 Receivers, Antennas, and Signals (A)

Prereq.: 6.014
Year: G (1)
3-0-9

Detection and measurement of radio and optical radiation typical of signals encountered in astronomy, radar, and communications systems. Statistical analysis of the associated signal processing systems, including radiometers, spectrometers, interferometers, and digital correlation systems. Matched filters and ambiguity functions. Characterization and measurement of random electromagnetic fields, including their spatial, angular, time, and polarization correlation properties. Angular filtering properties of antennas, interferometers, and aperture synthesis systems. Radiative transfer and parameter estimation. (Alternate years. ***Not offered 1981-82.***)
D. H. Staelin

6.663J Techniques of Radar Astronomy (A)

(Same subject as 12.627J)
Prereq.: 18.03, 18.075
Year: G (1)
3-0-9

Discussion of the techniques required in generating high-power radio emissions and in detecting their echoes from extraterrestrial objects and plasmas. Interpretation of the received signal in terms of the characteristics of the interplanetary plasma and planetary atmospheres as they affect propagation, and in terms of the detailed characteristics of the surfaces of planets and satellites as they affect reflection. Radar equation. Ambiguity function and its calculation for waveforms of interest to radar astronomy. Modulation and detection techniques. Digital processing in data reduction. Target scattering function and its general-

ization in terms of arbitrary polarization; scattering matrix, using Stokes' Vector formalism. Angular scattering laws and their relationship to statistical properties of a planetary surface. Use of interferometric techniques in mapping local scattering characteristics and topography. (Alternate years. ***Offered 1981-82.***)
D. H. Staelin, G. H. Pettengill

6.664J Radio Interferometry (A)

(Same subject as 8.952J, 12.626J)
Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Principles, techniques, and applications of radio interferometry, emphasizing current research using very long baselines. Techniques applicable to natural continuum as well as artificial sources. Synthesized wide band group-delay interferometry, continuous phase-delay interferometry, and differential interferometry. Inference of astronomical and geophysical parameters from interferometric observations: tests of relativity theory; source angular brightness distributions, positions, and proper motions; propagation-medium effects; geodesy; solid earth tides; polar motion and spin rate; tracking of artificial satellites, lunar and planetary probes. (Knowledge of electronic signals, systems, and noise theory required. Alternate years. ***Offered 1981-82.***)
D. H. Staelin, C. C. Counselman, I. I. Shapiro

6.671 Continuum Electromechanics I (A)

Prereq.: 6.013; 6.601 or 2.03J
Year: G (2)
3-0-9

Dynamics of fields on time scales long compared to transit times for electromagnetic waves. Differential and integral laws for moving magnetizable and polarizable media. Transfer relations as an approach to field descriptions in cartesian, cylindrical, and spherical coordinates. Electromagnetic forces, force densities and stress tensors including magnetization and polarization. Electromechanical kinematics and the modeling of energy convertors. Classification of energy-conversion processes. Charge migration and relaxation, and magnetic diffusion and induction interactions in the face of imposed material motion. Introduction to electromechanics of continua with two-way coupling between flows and fields. Space-rate, time-rate, and amplitude parameter expansions. Temporal and spatial modes in linear systems. Method of characteristics. Applications to rotating machines and transducers, non-conventional energy convertors, printing schemes, air-pollution control systems and material processing.
J. R. Melcher

6.672 Continuum Electromechanics II (A)

Prereq.: 6.671
Year: G (1)
3-0-9

Laws, approximations, and relations of fluid mechanics. Mechanical and electromechanical transfer relations. Statics and dynamics of electromechanical systems having a static equilibrium. Electromechanical flows. Field coupling with thermal and molecular diffusion. Electrokinetics. Streaming interactions. Applications to materials processing, plasma confinement, electrical atomization, magnetohydrodynamic and electrohydrodynamic pumps and generators, double-layer transduction in physiochemical systems, heat transfer augmentation, continuum feedback control of electromechanical systems, electron beam devices, and plasma dynamics.
J. R. Melcher

6.681 Electric Power Systems I (A)

Prereq.: 6.011 or 6.002 or 2.03J; 6.013
Year: G (1)
3-0-9

First semester of two-term sequence providing the basis for analyzing present and future electric energy systems. Introduction to the fundamental techniques for evaluating electric power systems and energy processing devices. Modeling of generating units, transformers, and transmission lines using concepts and techniques from circuit theory and electromagnetic field theory. Steady-state analysis and control of an interconnected power system. Examples include load flows, voltage regulation, and protective relaying. Steady-state performance of synchronous alternators. Development of the constraints governing the generation and transmission of electric energy. (Alternate years. ***Not offered 1981-82.***)
G. L. Wilson, S. D. Umans

6.682 Electric Power Systems II (A)

Prereq.: 6.681
Year: G (2)
3-0-9

Dynamic performance and control of electric power systems. Refinement of component models to represent transient electrical phenomena. Analysis of control systems for turbine-generators and synchronous condensers. Emphasis on the dynamics of synchronous alternators and their excitation systems as they influence the stability of an electric power system. Modeling and performance of transmission systems and the resulting constraints on energy transmission. (Alternate years. ***Not offered 1981-82.***)
G. L. Wilson, S. D. Umans

6.683 Planning and Operation of Power Systems (A)

Prereq.: 18.03 or 18.700
Year: G (2)
3-0-9

Summary of power plant and transmission line models. Special analytical and digital computation techniques needed to study large interconnected systems; sparse matrices, numerical integration, decomposition. Choice of approximation depending on time scale and phenomenon of interest. Operation and control of interconnected systems; hierarchical structure, human-computer interface, security assessment, system monitoring-estimation-identification. Design techniques for planning long-term expansion of generation-transmission systems; decomposition of problem, load-demand modeling, probabilistic reliability measures. Trade-off curves. Incorporation of customer owned solar, wind, cogeneration. Rate setting. Load management. Environmental effects. (Alternate years. ***Not offered 1981-82.***)
F. C. Schweppe

6.684 Strategic Planning and Technology Assessment: Electric Power and Energy Systems (A)
(New)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Consideration of three engineering management processes: strategic planning, technology assessment and coupling of strategic and technology planning. General treatment of processes and procedures with detailed case studies for electrical power and energy systems both from the industrial and national view points. Special issues include: energy and electric power demand and supply forecasts, capital and financial issues, impact of regulatory requirements, the questions of economy of scale, the assessment of new energy conversion options, dynamic characteristics of industry and technological substitution, engineering management systems. Emphasis on decision making process in the face of uncertainties. Case study of energy strategy for one utility. Different energy policy scenarios. Invited lectures by outstanding experts.
T. H. Lee

6.685 Dynamics of Electric Machines (A)

Prereq.: 6.061 or 6.601
Year: G (2)
3-0-9

Treatment of transformers, electromechanical transducers, rotating and linear electric machines. Lumped-parameter electromechanics of interaction. Consideration of the basic machine types: D.C., induction, synchronous. Development of device characteristics: energy conversion density, efficiency; and of system interaction characteristics: regulation, stability, controllability, and response. Problems taken from current research. (Alternate years. ***Not offered 1981-82.***)
J. L. Kirtley, Jr.

6.686 Advanced Electrical Energy Processing Laboratory (A)

Prereq.: 6.601
Year: G (1, 2)
Arr.

Graduate subject planned for the individual student; special problems on electrical energy conversion, control, and utilization.
G. L. Wilson

6.690 Special Topics in Power System Engineering (A)

(6.684)
Prereq.: 6.682
Year: G (2)
3-0-9

Treatment in depth of special topics in power system technology by notable experts in the field.
G. L. Wilson

Solid-State Materials and Devices

6.720 Semiconductor Devices

Prereq.: 6.012
Year: U (2)
3-0-9

The physics, modeling, fabrication, and application of selected semiconductor devices. Emphasis on devices in integrated circuit contexts. Topics: metal-oxide-semiconductor (MOS) devices including charge coupled devices (CCDs) and MOSFETs; MOS logic and memory; planar diffused and lateral bipolar transistors; bipolar logic including current injection logic (I^2L); Schottky barriers, MESFETs and light emitting diodes. Use of the energy band viewpoint is introduced.
C. G. Fonstad

6.725 Solar Energy Systems

Prereq.: 6.012 or 6.071
Year: U (1)
3-0-9

An examination of the utilization of solar energy for heating, cooling, and power generation. Topics: solar radiation, black body radiation, sensitivity of materials to solar radiation, heat transfer, flat plate collectors, heat mirrors, energy storage, systems analysis of a solar heating system, photovoltaic generation, photoelectrolysis, alternate energy sources. Several guest lectures on topics of intensive current research. Some background in thermodynamics helpful.
R. D. Thornton, G. W. Pratt, Jr.

6.731J Physics of Solids I (A except VIII)

(Same subject as 8.231J)
Prereq.: 8.04 or 8.211; 6.018
Year: G (1)
4-0-8

First term of a two-term sequence presenting the basic concepts of the quantum theory of solids. Emphasis on physical models which provide a quantitative description of solids. Topics: periodic structure and symmetry of crystals; diffraction, reciprocal lattice; chemical bonding in simple molecules and solids; lattice dynamics, phonons, thermal properties; free electron gas; nearly free electron approximation; tight binding approximation; semiconductors: electrons, holes, impurities; materials with s, p, d, f electrons.
M. S. Dresselhaus, R. J. Birgeneau

6.732J Physics of Solids II (A)

(Same subject as 8.500J)
Prereq.: 6.731J
Year: G (2)
4-0-8

Second term of a two-term sequence presenting the basic concepts of the quantum theory of solids. Emphasis on physical models which provide a quantitative description of solids. Topics: dynamics of electrons in solids, Fermi surfaces, transport phenomena, such as electrical and thermal conductivity, with applications to metals and semiconductors; optical properties of solids with applications to metals, semiconductors and insulators; magnetic phenomena in solids such as paramagnetism, diamagnetism, ferromagnetism, resonance studies in a magnetic field; superconductivity.
M. S. Dresselhaus, R. J. Birgeneau

6.734J Application of Group Theory to the Physics of Solids (A)

(Same subject as 8.513J)
Prereq.: 6.731J
Year: G (1)
3-0-9

Group theory techniques: mathematical background, representation theory, character tables, basis functions, double groups, time reversal symmetry. Applications: crystal field structure, selection rules, directed valence and bonds, molecular vibrations, group of the wave vector with application to energy bands, lattice modes. Application of double groups to crystal field theory and energy band structure. (Alternate years. ***Not offered 1981-82.***)
M. S. Dresselhaus, G. F. Koster

6.741J Theory of Solids I (A)

(Same subject as 8.511J)
Prereq.: 6.732J
Year: G (1)
3-0-9

First term of a theoretical treatment of the physics of solids. Theory of electron motion in crystal lattices: separation of electron and nuclear motion; Hartree-Fock approximations; one electron states in periodic potentials; energy bands; OPW pseudopotential, and APW approximations; survey of electronic properties of crystals. Lattice dynamics: normal modes; quantization; phonon excitation; thermal properties of solids.
D. Adler, J. D. Joannopoulos

6.742J Theory of Solids II (A)

(Same subject as 8.512J)
Prereq.: 6.741J
Year: G (2)
3-0-9

Second term of a theoretical treatment of the physics of solids. Semiconductors: survey of band structures; effective mass theory; effective g-factor; transport; optical properties. Metals: band structures; electron dynamics; transport; magnetic properties; optical properties. Many body theory: the random phase approximation; collective effects in normal metals; Fermi liquid theory; superconductivity.
D. Adler, J. D. Joannopoulos

6.743 Conduction Processes in Solids (A)

Prereq.: 6.731J
Year: G (1)
3-0-9

Topics in transport theory, including irreversible thermodynamics, Onsager relations, crystal symmetry, energy band theory, effective mass approximation, Boltzmann transport theory, electrical and thermal conductivity, thermoelectric, thermomagnetic, and galvanomagnetic effects. (Alternate years. ***Offered 1981-82.***)
D. Adler

6.751 Quantum Electronics (A)

Prereq.: 6.731J or 8.05
Year: G (2)
3-0-9

A study of the basic phenomena of quantum electronics including the development of the background quantum mechanics and optical properties of solids. Quantization of the electromagnetic field and spontaneous plus stimulated optical transitions between energy levels. Resonant processes including electric dipole transitions, absorption dispersion and saturation. The laser and its operating characteristics. Rate equations, optical pumping, Q-switching, and mode locking. Nonlinear optics. Electrooptical devices including pico-second switches and pulse generation, optical logic gates, and an all photon transistor. Fiber optics.
G. W. Pratt, Jr.

6.753 Microwave Magnetics (A)

Prereq.: 6.014 or 6.601
Year: G (2)
3-0-9

Introduction to the propagation and mutual interaction of microwave photons, magnons, and phonons in ferro-, antiferro- and ferrimagnetic crystals. Elementary domain theory, including magnetic bubbles. Linear and nonlinear effects associated with magnetic resonance. Propagation of electromagnetic, magnetostatic and magnetoelastic waves in ferrite-loaded waveguides and thin ferrite films; reciprocal and non-reciprocal microwave circuit elements such as rotators, isolators, and circulators. Detailed study of the electromagnetic, quantum-mechanical exchange and elastic channels of power flow. Applications to fundamental spectroscopy and to the field of microwave signal processing devices. (Alternate years. ***Offered 1981-82.***)
F. R. Morgenthaler

6.754 Signal Processing with Coherent Wave States in Crystals (A)

Prereq.: 6.014; 6.015 or 6.003
Year: G (2)
3-0-9

The study of coherent waves that arise from collective excitations in dielectric, magnetic, and piezoelectric crystals, for use in processing electromagnetic signals in the microwave and optical portions of the spectrum. A review of the signal characteristics and processing methods currently used in modern radar and spread-spectrum communications followed by a treatment of the propagation of bulk and surface waves of electromagnetic, ultrasonic, and magnetostatic varieties, together with their application to signal processing systems which may include frequency-dependent (or independent) delay, convolution, and correlation or auto-correlation. The second half of the subject employs several guest lecturers with expertise in industrial state-of-the-art techniques. (Alternate years. ***Not offered 1981-82.***)
F. R. Morgenthaler

6.761J Electronic Materials (A)

(Same subject as 3.76J)
Prereq.: 3.15 or 6.012
Year: G (1)
2-0-6

Various aspects of electronic materials such as preparation, purification, crystal growth, crystal structure, characterization, electronic properties, band structure, and device applications. Special emphasis on relationships between structural characteristics, atomic bonding, and physical properties in classes of materials such as elemental and compound semiconductors, thermoelectrics, and superconductors. Extensive rather than intensive coverage.
H. C. Gatos

6.762 Dielectric and Optical Materials and Devices (A)

Prereq.: 6.013
Year: G (1)
3-0-9

Introduction to solid-state devices that depend on polarization processes rather than on charge transport. Tensor properties and their relation to crystal symmetry. Physical models for the dielectric and optical properties of solids. Nonlinear dielectrics: ferroelectrics, parametric amplifiers. Elasticity. Coupled effects: pyroelectric and piezoelectric properties and applications. Optical properties: wave propagation in anisotropic crystals, the indicatrix, electro-optical and photoelastic effects; optical modulators and beam deflectors. Special topics selected from among the following as time permits: nonlinear optics, frequency doubling, parametric conversion, thin film optics, optical fibers. (Alternate years. ***Offered 1981-82.***)
D. J. Epstein

6.770 Microelectronics Project Laboratory

Prereq.: 6.012, 6.150J
Year: G (1, 2)
0-12-0

A project laboratory intended for first-year graduate students interested in semiconductor devices and integrated circuit fabrication. Once a student is familiar with basic processing and characterization technology, a project is arranged that falls in one or more of the following categories: new device configurations; process development and characterization; modeling of devices or processes; instrumentation for characterization. Successful projects may develop into S.M. thesis projects. A limited number of students who do not have previous processing experience (6.150J or equivalent) may be permitted to enroll. (Total enrollment limited. Permission of instructor required.)
D. A. Antoniadis, C. G. Fonstad, L. R. Reif, S. D. Senturia

6.771 Physics of Semiconductor Devices (A)

Prereq.: 6.018, 6.012
Year: G (1)
3-0-9

The physical basis of semiconductor device operation. Brief review of Fermi-Dirac statistics and application to determination of carrier concentration in semiconductors; quasi-neutrality and depletion; transport by drift and diffusion; generation-recombination processes; solution of boundary-value problems appropriate to device geometries; p-n junctions; MOS capacitors; models for bipolar and field-effect transistors; extraction of device parameters from characterization measurements; device limitations.
S. D. Senturia

6.772 Integrated Circuit Devices and Processes (A)

Prereq.: 6.771
Year: G (2)
3-0-9

Silicon integrated circuit technology. Theory and practice of IC fabrication and device design with emphasis on their relation to circuit performance. Topics: materials and fabrication processes; large-signal models for bipolar and field-effect transistors; components and functional blocks for modern digital ICs; circuit and

block layout considerations in LSI; computer-aided analysis and design of processes, devices and circuits using state-of-the-art simulators.
D. A. Antoniadis

6.773 Topics in Semiconductor Device Research (A)

Prereq.: 6.720, 6.018; or 6.771
Year: G (2)
3-0-9

Relationship of the electrical properties of semiconductor materials to device performance. Topics selected primarily from current device research areas and vary with instructor and year. In recent years subject matter has included Schottky barriers and heterojunctions, charge coupled devices, surface acoustic wave devices, diode lasers, integrated and guided-wave optical components and circuits, and the permeable base transistor. (Alternate years. ***Offered 1981-82.***)
A. L. McWhorter, R. H. Rediker

6.774 Integrated Circuit Fabrication Technology (A) (New)

Prereq.: 6.720 or 6.771; 6.150J
Year: G (1)
3-0-9

Fundamental principles of the processes used in the fabrication of silicon monolithic integrated circuits. Physical models of bulk crystal growth, thermal oxidation, solid state diffusion, ion implantation, epitaxial deposition, chemical vapor deposition, and thin film deposition. Pattern generation, photolithography, and etching. Layout of devices and integrated circuits. Technological limitations on integrated circuit design and fabrication.
L. R. Reif

6.775 Design of Analog MOS LSI (A) (New)

Prereq.: 6.301
Year: G (1)
3-0-9

A detailed exposition of the principles involved in designing analog circuits in MOS LSI. The analog MOS circuit environment. Device physics, small signal and large signal models. Biasing. Basic circuit building blocks. Operational amplifier design. Large signal considerations: transient response and distortion. Temperature insensitive reference voltage sources. Principles of switched capacitive networks. Applications: fully integrated, high performance filters, comparators, A/D and D/A converters, PCM encoders and decoders; other signal processing circuits. Both CMOS and NMOS technologies covered. A comprehensive design project is a required part of the subject. (Limited enrollment.)
D. A. Antoniadis

6.780J Materials for Advanced Energy Systems

(Same subject as 3.74J)
Prereq.: 2.40 or 3.00 or 5.60 or 6.018; 3.15 or 6.012
Year: G (2)
3-0-6

Development of new energy technologies and improvement of more conventional systems requires development of new materials and an understanding of materials failures. An overview given of relationship between properties of materials, fabricability of materials, and their use in specific energy systems (nuclear, solar, storage batteries, coal gasification, fuels cells, turbines, MHD). Emphasis on failures in current technologies and needs for new systems and specifically research problems faced by practicing engineers and scientists. (Alternate years. ***Offered 1981-82.***)
D. Adler, H. K. Bowen, M. S. Dresselhaus

6.781 Submicrometer Structures Technology

Prereq.: —
Year: G (2)
3-1-6

Detailed survey of techniques used to fabricate and analyze structures with dimensions smaller than a micrometer, and a study of selected applications of artificial microstructures. Review of optical and electron microscopy. Surface characterization, preparation, and measurement techniques. Description of optical projection, holographic, X-ray, ion, and electron lithography, and a comparison of their advantages and disadvantages. Aqueous, ion-bombardment, and reactive plasma etching techniques. Relief structure formation using thin-film deposition, oxide growth, and plating. Thermal and ion-implantation methods of doping. Applications of artificial microstructures selected from: microelectronic devices, guided-wave optical devices. SAW devises, manipulation of organic molecules, graphoepitaxy and X-ray optics. (Registration for undergraduate students by permission of instructor.)
H. I. Smith

6.791 Special Topics in the Solid State and Its Application (A)

Prereq.: —
Year: G (1)
3-0-9

6.792 Special Topics in the Solid State and Its Application (A)

Prereq.: —
Year: G (2)
3-0-9

Primarily for those interested in research on solid-state materials and devices for electrical and electronic applications. Topics and staff to be announced each term. Given independently or sequentially as circumstances require. (Permission of instructor required.)
D. J. Epstein

Computer Science

6.821 Concepts in Modern Programming Languages (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Core graduate subject in programming languages. Analysis of concepts in programming languages, with emphasis on abstraction mechanisms. Formal semantics. Functional and imperative languages. Procedure call and parameter passing mechanisms. Conversions and coercions. Generic and polymorphic definitions. Abstract data types. Storage models and implementation techniques. Program libraries. Several languages studied in detail, with attention given to design goals and interactions of features. (Background in programming languages, compiler construction, and programming experience required. Enrollment may be limited to regular graduate students in Course VI.)
J. F. Guttag, B. H. Liskov

6.822 Algorithms and Computational Complexity (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Core graduate subject in theoretical computer science. Design and analysis of algorithms for basic computational tasks; probabilistic and parallel algorithms. Emphasis on proofs of correctness and efficiency. Proofs of lower bounds on efficiency for problems like sorting, polynomial evaluation. Introduction to computational complexity theory; inherently complex decision problems; efficient reducibility; com-

putational equivalence of problems, NP-completeness. Propositional and predicate calculus. Complexity of decision problems in logic and automata theory. (Knowledge of data structures, algorithms, finite automata, and computability at the undergraduate level expected. Enrollment may be limited to regular graduate students in Course VI.)
A. R. Meyer

6.823 Computer System Architecture (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Core graduate subject in computer system architecture. Study of the evolution of computer architecture and the factors influencing the design of hardware and software elements of computer systems. Emphasis on the relationship of hardware organization and systems programming to the structure of application programs and the languages in which they are expressed. Consideration of issues including referencing schemes for accessing programs and data, coordination of concurrent activities, protection, and reliability. Context of discussion encompasses systems for high performance numerical computation, object oriented systems, distributed systems, and data base computers, as exemplified by past, contemporary, and hypothetical system architectures. (Knowledge of programming languages and computer systems at the undergraduate level expected.Enrollment may be limited to regular graduate students in Course VI.)
Arvind, J. B. Dennis

6.824 Artificial Intelligence (A) (New)

Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Intensive introduction to central issues of constructing intelligent systems. Covers three major topics. 1) Survey of historically important trends in AI research: generality in problem solving and advice taking, importance of the form and content of a program's knowledge. 2) Comparison of formalisms for knowledge representation: predicate logic, semantic networks, "frame" systems, production rules. 3) Problem-solving techniques: goal-directed behavior, natural deduction, production system architectures, agendas, planning networks, dependency directed control schemes, truth maintenance, reflective reasoning. Students expected to have a good working knowledge of LISP, which is used often to illustrate computational examples. (Enrollment may be limited to regular graduate students in Course VI.)
P. Szolovits, R. Davis, H. E. Shrobe

6.830 Program Semantics and Verification (A)

Prereq.: 6.822
Year: G (2)
3-0-9

Mathematical approaches to defining semantics of simple programming languages: denotational, state-machine, relational, and axiomatic semantics. Formal systems for program verification: soundness and completeness. Logics of programs and relation to classical infinitary logic. Further topics selected from: semantics and verification of complex languages with concurrent and parallel constructs; program schemes; lambda calculus; current verification technology. (Knowledge of programming languages at the undergraduate level expected.)
V. R. Pratt

6.831 Programming Language Processors (A)

Prereq.: 6.035
Year: G (1)
3-0-9

A study of the basic problems in the design and implementation of programming language processors; discussion and evaluation of current implementation techniques, and exploration of applicable theory. Topics: formal definition of the syntax and semantics of programming languages, parsing, code generation techniques, optimization of register use, data structure representation and accessing, and compiler-compilers. Implementation problems of several specific languages examined. (Limited enrollment.)
S. A. Ward

6.835 Theory of Concurrent Systems (A)

Prereq.: 6.035, 6.033
Year: G (1)
3-0-9

Study of mechanisms and theories for concurrent systems. Role of specifications as the interface language between users and implementors of modules in concurrent systems. Associating invariants with modules in order to prove that the modules satisfy their specification. Properties of systems with a fixed number of processes. Study of Communicating Sequential Processes. Use of networks for communicating between a variable number of processors. "Lazy" and "eager" evaluators. Laws for communicating parallel processes. Specifications for modular synchronization primitives such as path expressions, monitors, and serializers. Proof techniques based on partial orders of events. ***(Not offered 1981-82.)***
C. E. Hewitt

6.837 Data Base Management Systems (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-9

A study of the principal issues involved in the design, implementation, and use of modern data base management systems, with emphasis on issues of practical significance. Information systems and data bases. Data models, data description languages, data manipulation languages. Conceptual schemas and representations of data base semantics. Feature analysis of several existing systems as an illustration of recurrent themes. Implementation techniques: file structures, access methods, query processing. Data base design. Data base system architecture with detailed case studies. Data base control: integrity, concurrency, security. Interface of data base systems to teleprocessing monitors; transaction processing and report writing. Distributed data bases. As time permits, consideration of current research problems.
M. Hammer

6.840J Theory of Computation (A)

(Same subject as 18.427J)
Prereq.: 6.045J
Year: G (2)
3-0-9

A graduate introduction to computability, undecidability, computational complexity, automatic theorem proving, and the expressiveness of programs (program schemes). Includes: finite automata-based decision procedures for formal logical theories. Elementary recursion theory: Gödel numberings, reducibility, degrees of undecidability. Elementary complexity theory: time and space measures on computation, inherently complex decidable predicates, the nonexistence of optimal algorithms (the speed-up theorem), efficient reducibility. Undecidable theorem-proving problems: predicate calculus and arithmetic. Inherently complex decidable problems: examples from logic and automata theory. Proving theorems about programs: uninterpreted program schemes; proving formal correctness, equivalence and termination assertions. (Permission of instructor required.)
A. R. Meyer, M. Sipser

6.845 Topics in Computer Systems Research (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Seminar on a selected, active research topic in the engineering of computer-based information processing systems. Emphasis on software and hardware viewed as a single system, and on case studies of actual production and experimental system implementations. Usually includes extensive reading in current journals, with class discussion and preparation of reports. Content varies from year to year. Typical topics include information protection, design of physically distributed information systems, and computer system performance analysis. (See instructor for topic to be offered. Limited enrollment.)
J. H. Saltzer

6.847 Data Flow Computer Systems (A)

Prereq.: 6.031 or 6.001; 6.032
Year: G (1)
3-0-9

Covers dataflow concepts as they affect program structure, programming language design, and the organization of high performance and distributed computer systems: suitability of functional languages for programming concurrent applications; dataflow program graphs; instruction execution mechanisms for highly parallel execution of dataflow programs; the Unraveling interpreter; multiple processor packet communication dataflow architectures; architectural support for static and dynamic allocation of instructions; design considerations for data structure memory; data vs demand driven execution models; computation with streams and nondeterministic operators; dataflow systems for distributed computation; consideration of application areas and performance analysis of example applications.
Arvind, J. B. Dennis

6.848 Data Base Theory (A)

Prereq.: 6.822
Year: G (2)
3-0-9

Recent advances in theoretical aspects of data base design and management. Emphasis on topics pertaining to complexity, combinatorics, and logic. Relational data base semantics (functional, multivalued and generalized dependencies; normal forms; equivalence of algebraic and calculus-based languages; expressibility of domain-independent constraints). Query processing (tableaux and tableau equivalence; theory of joins; combinatorial optimization problems related to distributed query processing). Concurrency control (correctness of concurrently accessed data bases; serializability; schedulers; locking and locking policies; distributed schedulers). (A previous data base course useful but not required. Alternate years. ***Not offered 1981-82.***)
C. H. Papadimitriou

6.851J Algorithms (A)

(Same subject as 18.437J)
Prereq.: 18.061 or 18.063; 6.045J
Year: G (1)
3-0-9

Design and analysis of fast and optimal algorithms for sorting and manipulating families of sets, searching graphs, finding patterns in strings, manipulating polynomials, matrices and integers, performing geometric constructions, and solving linear inequalities. Random and probabilistic algorithms. The class of NP-complete problems.
V. R. Pratt, G. L. Miller

6.853J Computation by Automata (A)

(Same subject as 18.428J)
Prereq.: 6.045J or 6.840J
Year: G (2)
3-0-9

Time and space-bounded Turing machines. Simulation, diagonalization, information-theoretic and overlap arguments. Contrast between nondeterminism and determinism in logarithmic space, linear space, and polynomial time; polynomial hierarchy, alternation of quantifiers, and games. Equivalence of pushdown tape-bounded automata and time-bounded computers, time-space trade-offs, and a pebbling game. Time and space bounds for parsing context-free languages. Circuit and formula complexity of finite functions. (Alternate years. ***Not offered 1981-82.***)
A. R. Meyer, M. Sipser

6.854J Advanced Algorithms (A)

(Same subject as 18.438J)
Prereq.: 6.851J or 18.437J
Year: G (2)
3-0-9

Exploration in greater depth of some topics from 6.851J/18.437J. New topics include network and matroid algorithms, advanced graph algorithms, and problems from logic. Greater emphasis on the underlying models of computation and on precise mathematical analysis. (Alternate years. ***Offered 1981-82.***)
R. L. Rivest, R. Kannan

6.856 Algebraic Manipulation (A) (New)

Prereq.: 6.821, 6.822
Year: G (2)
3-0-9

Algorithmic and systemic issues arising in the design of an algebraic manipulation system. Overview of systemic issues arising in the MACSYMA system with special emphasis on data abstraction techniques useful in the representation of mathematical expressions. Algorithms for computing the Greatest Common Divisor of two polynomials, factorization of polynomials, and computation of determinants. Algorithms for simplification and integration of elementary functions. (Alternate years. ***Offered 1981-82.***)
J. Moses, R. E. Zippel

6.863 Natural Language and the Computer Representation of Knowledge (A)

Prereq.: 6.034
Year: G (2)
3-0-9

Relationship between computer representation of knowledge and the structure of natural language. Models for the semantics of English that are relevant to symbolic computation. State of the art in computer representation of knowledge. Utilization and augmentation of knowledge; parsing, question answering, and computer acquisition of knowledge. (***Not offered 1981-82.)***
W. A. Martin

6.865 Introduction to Machine Vision and Manipulation (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Intensive introduction to the intelligent interaction of machines with their environment. Students are expected to attend 6.088 lectures as well as additional seminar meetings on special topics. Material presented in 6.088 is supplemented by reading from literature. Students required to prepare a paper analyzing research in one selected area.
B. K. P. Horn

6.868 Topics in Artificial Intelligence (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Seminar on selected, currently active research topics in artificial intelligence. One or two topics covered in depth each term. Subject intended primarily for advanced students in artificial intelligence but open to students with backgrounds in areas related to the topics discussed.
M. L. Minsky

6.871 Knowledge-Based Applications Systems (A)

Prereq.: 6.035; 6.034 or 6.860
Year: G (1)
3-0-9

Focus on the development of programming systems which contain a significant amount of knowledge about a particular domain of interest. Major issues considered include: 1) theories of human problem solving insofar as they suggest means to augment the ability of people to make effective decisions, 2) the identification, representation, and dissemination of expert knowledge, and 3) technological problems arising from attempts to mechanize expertise (including applications program architecture, human-machine dialogue through natural language, and automatic programming). These issues presented and discussed within the context of selected domains such as applied mathematics, management decision systems, inventory control systems, medicine, and automatic programming. Included will be case studies and use of existing systems by the students. ***(Not offered 1981-82.)***
P. Szolovits

6.875J Cryptography and Cryptanalysis (A)

(Same subject as 18.419J)
Prereq.: 18.061 or 18.063; 6.045J, 18.05
Year: G (2)
3-0-9

Mathematical history of cryptographic systems. Principles of design and usage that enhance security. Standard cryptanalytic attacks and statistical weaknesses. Modern cryptographic systems: DES, public key systems. Protocols for secure communication in networks. Key distribution, physical security of devices. Relationship of cryptography and cryptanalysis to complexity theory, information theory, and theory of random numbers. ***(Not offered 1981-82.)***
R. L. Rivest, Staff

6.880 Perspectives on Computers and Society (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Seminar on selected topics on the interface between computers and society. Among topics discussed are: the influence of ideas derived from computers and computation on the individual's reconstruction of reality; modern society's dependence on computers; what the general public believes about computers and what computer scientists' role in creating beliefs about computers is and ought to be; questions of responsibility raised by large, possibly incomprehensible computer-based systems; ethical issues confronting computer scientists and engineers. Extensive readings. A number of very short papers and a long final paper are required. Papers judged for their clarity and precision of language as well as for substantive content, i.e., papers written in correct English are a precondition to passing the subject.
J. Weizenbaum

6.891-6.899 Special Topics in the Computer Sciences (A)

Prereq.: Permission of Instructor
Year: G (1, 2)
Arr.

A seminar-type discussion of special topics in the computer sciences. Opportunity for graduate students and instructors to investigate a topic of common interest. Topic and staff announced each term. These subjects given independently or sequentially, as circumstances require.
J. Moses

Special Subjects

6.901 Inventions and Patents

Prereq.: 14.02
Year: U (1)
3-0-6

History of private and public rights in scientific discoveries and applied engineering leading to the development of worldwide patent systems. The classes of invention protectable under the patent laws of the US, including the procedures in protecting inventions in the Patent Office and in the courts. Review of past cases involving inventions and patents in a) the chemical process industry and medical field, b) devices in the mechanical, ocean exploration, civil, and/or aeronautical fields, c) the electrical and electronic areas including key radio, solid state, and computer inventions. This subject is an Engineering School-Wide Elective.
R. H. Rines

6.910 Special Studies in Electrical Engineering and Computer Science

Prereq.: —
Year: U (1, 2, S)
Arr.

Opportunity for individual study at the undergraduate level related to electrical engineering and computer science not covered by other subjects offered by the Department. Responsibility of students for initiation of arrangements and filing of proposal. (Permission of instructor required.)
L. A. Gould

6.911-6.919 Special Subjects in Electrical Engineering and Computer Science

Prereq.: —
Year: U (1, 2)
Arr.

Opportunity for group study of undergraduate subjects related to electrical engineering and computer science not otherwise included in curriculum. (Programs subject to approval of professor in charge.)
L. A. Gould

6.921 Industrial Practice

Prereq.: —
Year: U (1, S)
0-12-0

Provides academic credit for the first two Company Assignments of VI-A students at companies affiliated with the Department's VI-A Program. Students register for this subject twice. The grade of "J" is given following completion of the first Assignment. Students must complete the second Assignment in order to receive the full academic credit of 24 units for this subject. (Enrollment limited to students participating in the VI-A Program.)
J. A. Tucker

6.922 Advanced Industrial Practice

Prereq.: 6.921
Year: U (2, S)
0-12-0

Provides academic credit for the third Company Assignment of VI-A students at companies affiliated with the Department's VI-A Program. (Enrollment limited to students participating in the VI-A Program.)
J. A. Tucker

6.925 Engineering Internship

Prereq.: —
Year: U (1, 2, S)
0-6-0

Provides academic credit for the first two Work Assignments of Electrical Engineering and Computer Science students participating in the Engineering Internship Program. Students register for the subject twice. The grade of "J" is given following completion of the first Work Assignment. Students must complete the second Work Assignment in order to receive the full academic credit of 12 units for this subject. (Enrollment limited to Course VI students participating in the Engineering Internship Program.)
J. K. Roberge

6.929 Undergraduate Thesis Presentation

Prereq.: —
Year: U (1, 2, S)
0-3-0

Registration for written and oral presentation of the undergraduate thesis when the thesis work is an extension of a project laboratory or is carried out as part of a VI-A Assignment.
D. Adler

6.930 Management in Engineering

Prereq.: —
Year: U (1)
3-0-9

Introduction to the concepts of management of the engineering function, as found in a variety of industrial and non-industrial settings. Aim is to help the student acquire: 1) recognition of role of engineering and its relationship to other functions in getting a job done, 2) familiarity with some managerial tools and concepts employed in engineering organizations, 3) practice in dealing with both short- and long-term managerial problems in a range of real-life circumstances, and 4) incentive to develop a career strategy relevant to engineering training. Topics: financial principles; management of innovation; engineering project planning, scheduling and control; human factors; career planning; contracts; patents; and technical strategy for firms. Taught, in part, by case method, which emphasizes student participation in discussion. (Intended for juniors, seniors, or graduate students; others should consult the instructor in charge.) This subject is an Engineering School-Wide Elective.
R. T. Lund, D. P. Hoult, H. S. Marcus

6.931 Development of Inventions and Creative Ideas (A)

Prereq.: 14.002
Year: G (2)
3-0-9

Role of the engineer as patent expert and as technical witness in court and patent interference and related proceedings, with emphasis on actual experiences in the field of electrical and electronic engineering. Rights and obligations of engineers in connection with various types of employment contracts and employers, including educational institutions, government, and large and small businesses. Various manners of transplanting inventions into business operations, including development of New England electronics industry and its different types of institutions. American systems of incentive to creativity apart from the patent laws, including provisions relating to inventions and ideas in the atomic energy and space fields. (For graduate students only; others see 6.901.)
R. H. Rines

6.932J The Technology and Politics of Nuclear Weapons and Arms Control (A)

(Same subject as 17.486J)
Prereq.: Permission of Instructor
Year: G (2)
4-0-8

Review of nuclear weapons systems developments and efforts at arms control. Focus on the interaction of technological factors with strategic concepts, intelligence assessments, and political judgments. Topics: nuclear weapons technology and effects, nuclear weapons proliferation, and analysis of current strategic arms programs. To the extent possible, experts who have played key roles in the topics covered are invited to give guest lectures.
J. P. Ruina, G. W. Rathjens

6.933 Product Development Workshop (A)

Prereq.: Permission of Instructor
Year: G (1, 2)
3-6-3

A working model of the real-world systems and methods employed to create useful new products and processes in industry. Development problems furnished by industrial companies are solved by teams of students. Lectures on new product development in small to medium size technological companies including group dynamics, management, economic, engineering, and systems aspects. Corporate decisions criteria in development of new products. Specific development requirements such as technical and economic specifications, drawings and bills of material, quality control, government regulations, and productivity. Team functions include information acquisition, quantitative engineering understanding of each problem, actual development, construction, and product testing. Test reports, disclosures, and a final detailed documentation package required.
S. R. Rich, W. F. Schreiber

6.935J Invention

(Same subject as 2.941J, 10.802J, 13.77J, 16.671J)
Prereq.: —
Year: G (1)
3-0-6

Process of invention is analyzed with the intention of enhancing skill of the student inventor. Instructions will include the following phases of the process: a) technology observation to increase technology background of the potential inventory; b) need analysis to define clearly the requirements and limitations of needed inventions; c) parameter analysis, to focus attention of the inventor on the important parameters of the problem and on the potential solutions; d) creative steps, to develop techniques for providing innovative solutions. Students are encouraged to provide innovative solutions to invention needs of their own choice.
G. C. Newton, Jr., D. G. Jansson, A. D. Carmichael, W. C. Flowers, J. B. Howard

6.936 Entrepreneurship

Prereq.: —
Year: G (2)
4-0-5

This class is an introduction to the various issues faced by technical innovators who are interested in becoming entrepreneurs. Lectures and discussions are held on concept evaluation, patents, licensing, contract negotiation, marketing, business planning, financing, accounting and small business management. Students are encouraged to use their own innovative ideas as the object of study topics. This subject is an Engineering School-Wide elective (open to undergraduates by permission of instructor).
D. G. Jansson

6.938 Engineering Risk-Benefit Analysis (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Risk evaluation and cost-benefit analysis techniques for the assessment of engineering projects involving risks. Emphasis on public sector. Balancing risks and benefits with concern for financial uncertainties, environmental risks, and especially, issues of human safety. Introduction to decision analysis, the value of information, problems with multiple goals, and issues related to collective decisions. Issues of public policy and regulation. Case studies with attention to the nature of public discussion. Cases drawn from dam safety, safety of nuclear reactors, transport and storage of liquefied natural gas, seismic risk problems, and offshore oil exploration. Some background in elementary probability is assumed. (This subject is intended mainly for graduate and upperclass students in the School of Engineering, and is an Engineering School-Wide Elective subject.)
M. E. Paté, A. W. Drake

6.941J Current Issues in Engineering

(Same subject as 1.491J, 3.562J, 13.682J, 22.87J)
Prereq.:—
Year: G (S)
3-0-6

Review of a selection of technological developments of great significance to industrialized societies, choosing from current areas such as electronic materials and microprocessors, conventional and new energy technology, and practical aspects of cell manipulation. Key features of the technologies, and their relationships to social, economic and managerial issues that their development implies.
T. H. Lee

6.942J Cases and Projects in Engineering Management (A) (New)

(Same subject as 1.492J, 3.563J, 13.683J, 22.88J)
Prereq.; 6.941J
Year: G (1)
3-1-5

Continuation of 6.941J with a shift from macro-level of technologies toward micro-level of projects. Case studies of and student projects involving several real engineering and scientific programs in industrial firms and government agencies. Cases chosen from new ventures as well as mature firms, in both product and process development. All aspects of projects assessed.
T. H. Lee

6.951 Graduate Industrial Practice

Prereq.: 6.922
Year: G (1, 2, S)
0-12-0

Provides academic credit for the final Graduate Company Assignment of graduate students at companies affiliated with the Department's VI-A Program. (Enrollment limited to graduate students participating in the VI-A Program.)
J. A. Tucker

6.952 Graduate Industrial Practice

Prereq.: 6.951
Year: G (1, 2, S)
0-12-0

Provides academic credit for graduate students who require an additional term at the plant to complete the Graduate Company Assignment of the Department's VI-A Program. This academic credit is for registration purposes only and cannot be used toward fulfilling the requirements of any degree program. (Enrollment limited to graduate students participating in the VI-A Program.)
J. A. Tucker

6.955 Advanced Engineering Internship

Prereq.: 6.925
Year: G (1, 2, S)
0-6-0

Provides academic credit for the third Work Assignment of Electrical Engineering and Computer Science graduate students participating in the Engineering Internship Program. Students register for the subject twice. The grade of "J" is given following completion of the first term of the Work Assignment. Students must complete the second term of the Work Assignment in order to receive the full academic credit of 12 units for this subject. (Enrollment limited to Course VI graduate students participating in the Engineering Internship Program.)
J. K. Roberge

6.961 Introduction to Research in Electrical Engineering and Computer Science

Prereq.: —
Year: G (1, 2)
Arr.

Opportunity to become involved in graduate research, under guidance of a staff member, on a problem of mutual interest to student and supervisor. Recommended for all entering full-time graduate students in the Department of Electrical Engineering and Computer Science. Individual programs subject to approval of professor in charge. (Enrollment restricted to regular graduate students in Electrical Engineering and Computer Science.)
D. J. Epstein

6.962-6.969 Special Studies in Electrical Engineering and Computer Science

Prereq.: —
Year: G (1, 2)
Arr.

Opportunity for study of graduate level topics related to electrical engineering and computer science but not included elsewhere in the curriculum. Registration under this subject normally used for situations involving individual study, under supervision of a faculty member, of topics of mutual interest to student and supervisor, but may, when appropriate, be used for small study groups. Normal registration is for 12 units. (Registration subject to approval of professor in charge.)
D. J. Epstein

6.971-6.979 Special Subjects in Electrical Engineering and Computer Science (A)

Prereq.: —
Year: G (1, 2)
Arr.

Opportunity for group study of advanced subjects related to electrical engineering and computer science not otherwise included in curriculum. (Programs subject to approval of professor in charge.)
D. J. Epstein

6.980 Teaching Electrical Engineering and Computer Science

Prereq.: —
Year: G (1, 2, S)
Arr.

For qualified students interested in gaining teaching experience. Classroom, tutorial, or laboratory teaching under the supervision of a faculty member. (Enrollment limited by availability of suitable teaching assignments. Students selected by interview.)
F. C. Hennie

6.981-6.989 Teaching Electrical Engineering and Computer Science

Prereq.: —
Year: G (1, 2, S)
Arr.

For Teaching Assistants in Electrical Engineering and Computer Science in cases where teaching assignment is approved for academic credit by the Department.
F. C. Hennie

6.991-6.999 Research in Electrical Engineering and Computer Science

Prereq.: —
Year: G (1, 2, S)
Arr.

For Research Assistants in Electrical Engineering and Computer Science in cases where the assigned research is approved for academic credit by the Department. (Hours arranged with research supervisor.)
A. C. Smith

6.UR Undergraduate Research in Electrical Engineering and Computer Science

Prereq.: —
Year: U (1, 2, S)
Arr.

Extended participation in the work of a faculty member or research group, including activities such as independent study of the literature, direct involvement in the group's research, and project work under an individual faculty member. The research is arranged by mutual agreement between the student and a member of the faculty of the Department of Electrical Engineering and Computer Science, and may continue over several terms. Registration requires submission of a written proposal, signed by the faculty supervisor, to Professor Thornton (Room 36-361). In addition, a summary report must be submitted at the end of each term.
R. D. Thornton

6.ThU Undergraduate Thesis

Prereq.: —
Year: U (1, 2, S)
Arr.

Program of undergraduate research leading to the writing of an S.B. thesis; to be arranged by the student and an appropriate MIT faculty member.
D. Adler

6.ThG Graduate Thesis (A)

Prereq.: —
Year: G (1, 2, S)
Arr.

Program of graduate research leading to the writing of an S.M., E.E., Ph.D. or Sc.D. thesis, to be arranged by the student and an appropriate MIT faculty member.
A. C. Smith

7 Biology

7.UR Undergraduate Research

Prereq.: —
Year: U (1, 2)
Arr.

Undergraduate research opportunities in the Department of Biology. For further information consult the Departmental Coordinator: D. E. Housman. A written report is required. (Permission of Department required.)
Staff

7.00 Current Concepts in Biology

Prereq.: —
Year: U (1)
3-0-6

Introductory examination of several topics in Biology of current interest, including: genetic engineering, gene organization, recombinant DNA, fetal development and experimentation, antibody synthesis and the immune response, cancer, storage and utilization of biological energy, and organization and structure of cell membranes. Considers impact of discoveries in these areas on contemporary society.
D. Baltimore, H. F. Lodish

7.01 General Biology

Prereq.: —
Year: U (1, 2) SD
4-0-8

Introduction to biology — lectures and demonstrations. Part 1: Molecular biology using examples from work done with bacteria and viruses; introduction to synthesis of small molecules and macromolecules, to enzymes and various aspects of cellular control systems, biochemical energetics, and genetics. Part 2: Evolution of more complicated processes in simple multicellular organisms; evolution and classification of plants and animals. Part 3: Higher organism physiology; interactions of organisms with their unfriendly environment. Emphasis on detectors and effectors which enable the organism to respond to both predictable and non-predictable changes in environment.
Term 1: *C. E. Holt*
Term 2: *S. E. Luria, D. E. Housman*

7.011 Introduction to Experimental Biology

Prereq.: 7.01 or 7.05
Year: U (1, 2) LAB
2-8-4

Application of experimental techniques in biochemistry, microbiology, and cell biology. Emphasis on integrating factual knowledge with understanding the design of experiments and data analysis to prepare the students for research projects.
A. Torriani-Gorini, Staff

7.021 Experimental Immunology

Prereq.: *7.73*
Year: U (1) LAB
2-16-6

Laboratory project in immunology. (Enrollment limited. Alternate years. ***Not offered 1981-82.***)
M. J. Bevan, M. L. Gefter

7.03 Genetics

Prereq.: —
Year: U (1)
4-0-8

Continuity and variation in the multiplication of living organisms. Mutation and selection as a mechanism for biological change. Principles of formal genetics. Physical and chemical basis of heredity. Structure and function of the hereditary material. Molecular basis for mutation, genetic function, and recombination in microorganisms.
H. R. Horvitz, E. R. Signer

7.031 Experimental Microbial Genetics

Prereq.: 7.011
Year: U (2) LAB
2-16-6

Laboratory project in microbiology and genetics. (Enrollment limited. Alternate years. ***Offered 1981-82.***)
G. C. Walker

7.04 Cell and Developmental Biology

Prereq.: 7.03 or 7.05
Year: U (2)
4-0-8

Basic properties of cells and their relationship to development: biochemical and structural differentiation of cells. Principles of embryology and development: determination, pattern formation, and cell-cell interaction. Analysis of development by techniques of cell biology, genetics, and biochemistry.
M. L. Pardue, R. O. Hynes

7.041 Experimental Cell Biology

Prereq.: 7.011
Year: U (1) LAB
2-16-6

Laboratory investigation dealing with animal cells. (Enrollment limited. Alternate years. ***Offered 1981-82.***)
D. E. Housman

7.05 General Biochemistry

Prereq.: 5.41
Year: U (1, 2) SD
5-0-7

Contributions of biochemistry toward an understanding of the structure and functioning of organisms, tissues, and cells. Chemistry and functions of constituents of cells and tissues and the chemical and physical-chemical basis for the structures of nucleic acids, proteins, and carbohydrates. General metabolism of carbohydrates, fats, and nitrogen-containing materials such as amino acids, proteins, and related compounds.
Term 1: *G. M. Brown, U. L. RajBhandary*
Term 2: *F. E. Solomon, P. R. Schimmel*

7.051 Experimental Biochemistry

Prereq.: 7.011, 7.05
Year: U (2) LAB
2-16-6

Laboratory project in biochemistry. (Enrollment limited. Alternate years. ***Not offered 1981-82.***)
P. W. Robbins

7.06 Metazoan Cell Biology

Prereq.: 7.01 or 7.05
Year: U (2)
3-0-9

Molecular and structural biology of cells and higher organisms. Macromolecular biochemistry including RNA synthesis and processing and protein synthesis. Structure, function, and formation of subcellular components and organelles. Structural networks in cells and their relation to tissue. Emphasis on biochemistry and electron microscopic anatomy.
S. Penman

7.09 Biology, Medicine and Social Policy

Prereq.: 7.01
Year: U (1)
3-0-6

Analysis of the interplay between social and economic factors and the development of biological and medical science, with a focus on the question of the origin of human disease. Among the issues covered are social darwinism, cholera, the eugenics movement, occupa-

tional lung disease (black lung, brown lung), industrial carcinogens (asbestos, aniline dyes, vinyl chloride), environmental pollutants (dioxins, PCBs, PBBs), genetic engineering, and human experimentation. A case study approach is combined with historical and technical analysis. ***(Not offered 1981-82.)***
J. A. King

7.11 Biology Teaching

Prereq.: —
Year: U (1, 2)
Arr.

For qualified undergraduate students interested in gaining some experience in teaching. Laboratory, tutorial, or classroom teaching under the supervision of a faculty member. Students selected by interview.
Staff

7.13 The Biosphere

Prereq.: —
Year: U (2)
2-0-6

The natural services: what they do for the world ecosystem and the requirements for maintaining them. Pressures imposed on the biosphere by human populations and technology in the framework of present political and economic structures. Land, water, food, and energy needs; use priorities; preservation of resources. Analysis of the limits to the growth of populations, food supply, and pollution. Catastrophes.
E. Bell

7.21 Microbial Physiology

Prereq.: 7.05
Year: U (1)
4-0-8

Biochemical properties of bacteria and other microorganisms that enable them to grow under a variety of conditions. Interaction between bacteria and bacteriophages. Genetic and metabolic regulation of enzyme action and enzyme formation.
B. Magasanik, S. E. Luria

7.24 Topics in Bacteriology (A)

Prereq.: 7.21
Year: G (1)
2-0-6

Recent developments in bacteriology: regulatory mechanisms and membrane phenomena. (Permission of instructor required.)
Staff

7.25 Topics in Bacterial Viruses

Prereq.: 7.21, 7.27
Year: G (2)
2-0-6

Biological and molecular properties of bacteriophages as model systems for the study of viruses and as prototypes of noncellular organisms are presented and discussed on the basis of specific examples from current literature.
Staff

7.26 Animal Virology

Prereq.: 7.21
Year: G (1)
3-0-9

General survey of animal virology including studies of their genome organization, virion structure, genetics; virus interaction with the infected cell and the immune system. The virus is viewed as a model system of the macromolecular metabolism of the cell. The pathogenesis of medically important virus diseases is discussed.
R. A. Weinberg

7.27 Molecular Biology of Bacteria and Bacterial Viruses (A)

Prereq.: 7.03, 7.05
Year: G (2)
4-0-8

Detailed biochemical and genetic study of nucleic acid and protein synthesis in bacterial cells. The mechanism of protein and RNA synthesis, especially initiation and termination. Regulation of gene expression; replication, recombination and repair of DNA; physiology of bacteriophage development and its regulation.
B. Magasanik, M. S. Fox

7.30 Method and Logic in Molecular Biology (A)

Prereq.: Permission of Instructor
Year: G (1)
4-0-8

Logic and experimental design: an in-depth discussion and assessment of biochemical, physical, and genetic methods employed in testing hypotheses. (Limited to Course VII graduate students.)
D. Botstein, R. O. Hynes

7.32 Analysis of Differentiation and Development

Prereq.: 7.05
Year: G (2)
2-0-4

Graduate discussion seminar which examines in depth fundamental aspects of development and differentiation. In addition, particular attention paid to the critical appraisal of current published research in important areas of the field. ***(Not offered 1981-82.)***
V. M. Ingram

7.36 Advanced Neurophysiology (A)

Prereq.: 7.06
Year: G (1)
3-0-6

A series of lectures, with student participation, on some aspects of the nervous system. Foundation for work on the structure and function of the nervous system.
J. Y. Lettvin

7.411-7.419 Seminars in Biological Oceanography (A)

Prereq.: —
Year: G (1, 2)
Arr.

Selected topics in biological oceanography. (Permission of instructor required.)
Woods Hole Staff

7.421 Special Problems in Biological Oceanography (A)

Prereq.: —
Year: G (1, 2)
Arr.

Advanced problems in biological oceanography with assigned reading and consultation.
Woods Hole Staff

7.43 Phytoplankton Ecology (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-6

Distribution and speciation of phytoplankton in the open ocean, coastal waters, and estuaries. Phytoplankton classes and their characteristics. Physiology and biochemistry of major groups. Interaction of environmental parameters — nutrients, temperature, light, predation, sinking, etc., on phytoplankton growth and population size. Consideration given to the role of phytoplankton in the sea-nutrient cy-

cling, uptake kinetics, models of phytoplankton growth. Laboratory studies — continuous and batch cultures. (Alternate years. ***Offered 1981-82.***)
D. M. Anderson (Woods Hole Staff)

7.44 Ecology of Oceanic Zooplankton

Prereq.: 7.43
Year: G (2)
3-0-6

Provides a general context for understanding current problem areas in oceanic zooplankton ecology. Major topics for lectures and demonstrations include zoogeography, behavioral and morphological adaptation to pelagic existence, secondary production and zooplankton energetics, and field and laboratory problems involved in their study. (There is opportunity for student participation in presenting material and in structuring portions of the course. Permission of instructor required. Alternate years. ***Not offered 1981-82.***)
(Woods Hole Staff): T. J. Cowles, P. H. Wiebe

7.45 Benthos and Fish (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-6

Aspects of the ecology of marine fishes and benthic invertebrates. Emphasis on communities, with consideration of sampling, life histories, population dynamics, biotic interrelationships, zoogeography, diversity, stability, and evolution. Emphasis on recent literature including some historical perspective. Environments considered are shallow and deep-sea soft bottoms, sandy beaches, rocky shores, coral reefs, estuaries, and salt marshes. (Alternate years. ***Offered 1981-82.***)
J. F. Grassle (Woods Hole Staff)

7.46 Topics in Physiology and Biochemistry of Marine Animals (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Features aspects of the metabolism, biochemistry, and physiology of marine animals. Particular emphasis on perception of, response and adaptation to, changing and varied conditions of the physical and chemical environment in the sea. Respiration and anaerobic metabolism, food and nutrition, osmoregulation, thermal and pressure adaptation, chemoreception and foreign compound metabolism, and other topics considered. Special topics include light in the sea, locomotion and diving, cycles and migration. (Alternate years. ***Not offered 1981-82.***)
(Woods Hole Staff): J. J. Stegeman, J. M. Capuzzo

7.491 Research in Biological Oceanography (A)

Prereq.: —
Year: G (1, 2)
Arr.

Directed research in biological oceanography not leading to graduate thesis and generally done before the qualifying examination. Possible areas include: population dynamics, physiology and cytology of marine microorganisms, physiology, nutrition, and productivity of phytoplankton, influence of organisms on the compositon of seawater, systematics, physiology and ecology of pelagic larvae, zooplankton, benthos, and mesopelagic fishes, physiology and migration of large fishes, diving physiology and use of sound by marine mammals.
Woods Hole Staff

7.51J General Physiology

(Same subject as 6.524J)
Prereq.: —
Year: U (2) SD
3-0-9

Form-function relations. How local actions determine global geometry in development. Strategies of growth. Special problems in respiration, circulation, excretion, and animal movement illustrating how function and form direct each other. Structure and action of muscle. Physiology of perception. How the senses of predators affect the evolution of their prey. Mimesis and protective coloration of prey as guides to the nature of vision in predator. Tactics of color vision and form vision. Introduction to the physiology of nerve membrane and to the action of nervous tissue.
J. Y. Lettvin, E. R. Gruberg

7.53 Laboratory in Biological Electron Microscopy

Prereq.: Permission of Instructor
Year: G (2)
1-2-6

Introduction to the use of visualization techniques for studying biological problems. Operation of the transmission electron microscope. Biological sample preparation including negative staining, shadowing, Kleinschmidt technique for nucleic acids, embedding and sectioning, autoradiography, and specific antibody staining. Interpretation of ultrastructure from micrographs, including image processing techniques. (Limited to 16 students.)
J. A. King, E. R. Hartwieg

7.60 Cell Biology (A)

Prereq.: 7.06
Year: G (1)
4-0-8

Advanced subject covering the structure and function of eucaryotic cells, with emphasis on the major experimental techniques and approaches on which this knowledge is based. Readings from literature and outside speakers used extensively. Topics: sub-cellular structure; macromolecular biosynthesis; specialized cells and differentiation. (7.06 or graduate standing required.)
H. F. Lodish, M. L. Pardue

7.61 The Mammalian Cell in Differentiation

Prereq.: 7.05, 7.27
Year: G (1)
3-0-9

Lectures and student reports. Problems in development and differentiation with emphasis on cell culture systems. Consideration of mesenchymal and epithelial cell types, cytoplasmic dominance in differentiation, the problem of transdifferentiation, determination in early development, and the study of teratomas. ***(Not offered 1981-82.)***
Staff

7.62 Tumor Biology (A)

Prereq.: 7.05
Year: G (2)
3-0-9

Broadly concerned with the natural history and causal mechanisms of cancer in humans and animals. Subjects include: differences between normal and tumor cells, viral and chemical carcinogenesis in cultured cells and in animals, activation of chemical carcinogens, chromosomal and genetic influences, monoclonal vs. polyclonal tumors, malignant-normal cell hybrids, host-tumor interactions, tumor immunology, reversibility of malignant phenotype, causes and treatment of human cancer. Lectures and student papers.
D. Baltimore, H. N. Eisen

7.63 Immunogenetics and Cellular Immunology

Prereq.: 7.73
Year: G (2)
4-0-8

Mammalian immune system discussed with special emphasis on cellular interactions and genes which control immune responsiveness. Topics include lymphoid anatomy and lymphocyte recirculation, lymphocyte ontogeny, helper T cells, supressor T cells, cell interactions in antibody synthesis, role of the major histocompatibility complex in cellular interactions, genetics and serology of the major histocompatibility complex, genetics of immunoglobulin H and L chains, control of idiotype expression. Lectures and discussions of current papers.
M. L. Gefter, M. J. Bevan

7.65 Cell Motility and Cell Form

Prereq.: 7.05
Year: G (2)
2-0-4

Roles of filamentous elements, cell membranes, other cell organelles, and relevent structural and regulatory molecules in cell motility are analyzed. Their contribution to the establishment, maintenance, and change of cell form considered.
E. Bell

7.66 Cell Surfaces (A)

Prereq.: 5.58, 7.05
Year: G (2)
2-0-4

Consideration of selected topics in: molecular biology of membranes and cell surfaces, interrelationships between membrane structure and function, role of surface molecules in control of cellular behavior and growth, cellular interactions, cell surfaces in development. Lectures and discussion of literature. (Alternate years. ***Not offered 1981-82.***)
R. O. Hynes

7.71J Biophysical Chemistry

(Same subject as 5.64J)
Prereq.: 5.60, 7.05
Year: U (1)
4-0-8

Forces which determine protein conformation; water structure; prediction of protein structure from amino acid sequence. Helix-coil transitions; statistical thermodynamics and partition functions. Chemical equilibria. Enzyme kinetics; control mechanisms and allosteric systems. DNA physical chemistry; superhelical conformations; reaction kinetics of nucleic acids; protein-nucleic acid interactions. Membrane structure and function.
P. R. Schimmel, P. A. Sharp, R. A. Alberty

7.72J Enzymatic Reaction Mechanisms (A)

(Same subject as 5.50J)
Prereq.: 5.42
Year: G (2)
4-0-8

Study of the chemical mechanisms of enzyme-catalyzed reactions. Analysis of transformations of substrates to product molecules made with reference to stereochemistry and prosthetic group reactivity. Structural and spectroscopic data are incorporated with chemical studies to depict events in catalytic sites. Major reaction types analyzed include hydrolases, coenzyme-catalyzed reactions, group transfer reactions, biological oxidation, eliminations, racemizations, and aldol cleavage reactions.
C. T. Walsh, W. H. Orme-Johnson

7.73 General Immunology

Prereq.: 7.05
Year: G (1)
4-0-8

Lectures on basic concepts in immunology (10 weeks) followed by discussions of papers prepared by students on material of current research interest (4 weeks). Topics include: antigens and immunogenicity, structure and heterogeneity of immunoglobulins, antigen-antibody reactions, biological activities of immunoglobulins, cells and tissues of the immune system, antibody formation, cellular immunity, complement, ontogeny, and phylogeny of the immune response, tolerance, immune surveillance, theories on the origins of antibody diversity.
L. A. Steiner, H. N. Eisen, M. L. Gefter

7.74J Seminar in Biochemistry (A)

(Same subject as 5.981J)
Prereq.: —
Year: G (2)
1-0-2

Presentation by visiting scientists of critical reviews of recent publications in chemistry and biochemistry with application to selected biochemical problems. Discussions by staff and students.
J. M. Buchanan, P. R. Schimmel, C. T. Walsh

7.75 Advanced Biochemistry (A)

Prereq.: 7.05
Year: G (2)
3-0-9

Major metabolic pathways involved in the synthesis and degradation of amino acids, purines, pyrimidines, vitamins, steroids, and coenzymes with emphasis on the mechanisms of individual enzymatic reactions and problems of regulation. Photosynthesis and oxidative phosphorylation.
G. M. Brown

7.77 Structure, Function, and Assembly of Biological Macromolecules (A)

Prereq.: 7.03, 7.05
Year: G (2)
3-0-9

Studies of proteins, nucleic acids, their interactions, and their assembly into macromolecular complexes. Chemical and physical principles underlying methods of isolation and structural analysis of proteins and nucleic acids; the use of chemical, enzymatic, and genetic methods in the study of tertiary and quaternary interactions. Above methods and principles applied to the following: protein folding, nucleic acid chemistry and three-dimensional organization, protein-DNA recognition, general symmetry principles in macromolecular organization, collagen and the contractile proteins, flagella and cilia, and the structure and assembly of viruses, ribosomes, and other organelles. Throughout subject the relationship between structure and biological function emphasized.
J. A. King, U. L. RajBhandary, R. T. Sauer

7.78 Seminar in Lipid and Carbohydrate Biochemistry (A)

Prereq.: 7.05
Year: G (2)
2-0-4

Discussion of recent research in the area of complex lipids and carbohydrates. Lipid topics include phospholipids, prostaglandins, and steroids. In the carbohydrate area emphasis is on membrane and cell surface components of bacteria, yeast, and animal cells. Format includes lectures, discussions of recent literature, and student reports.
P. W. Robbins

7.86 Molecular Genetics (A)

Prereq.: 7.05, 7.27
Year: G (2)
3-0-9

Examination in depth of selected topics by study and discussion of the literature in seminar format. Special emphasis on experimental details supporting current ideas about replication of nucleic acids and control of gene expression as developed in microbial and applied to mammalian and other eukaryotic systems. Subject designed to establish familiarity with literature and patterns of thought in the field and to develop ability of critically evaluating papers. (Undergraduates who have taken 7.03 and 7.21 admitted with permission of instructor.)
E. R. Signer

7.90 Special Problems in Biology for Undergraduates

Prereq.: —
Year: U (1, 2)
Arr.

Program of study or research to be arranged with a department faculty member. Written report required. (Permission of Department required.)
Staff

7.93 Selected Topics in Biology (A)

Prereq.: —
Year: G (1 or 2)
Arr.

Class work in various fields of biology not covered by the regular subjects of instruction.
Staff

7.941 Research Problems (A)

Prereq.: —
Year: G (1)
Arr.

7.942 Research Problems (A)

Prereq.: —
Year: G (2)
Arr.

Directed research in a field of biological science, but not contributory to graduate thesis.
Staff

7.99 Molecular Configuration in Biological Systems Seminar (A)

Prereq.: 7.05
Year: G (2)
2-0-4

Properties conferred on biochemical substances by assumption of specific physical configurations. Optical methods (emphasizing X-ray diffraction) for determining configuration in macromolecular systems. Special emphasis on molecular structure of crystalline proteins and nucleic acids.
A. Rich

8 Physics

General Undergraduate Subjects

8.UR Undergraduate Research

Prereq.: —
Year: U (1, 2)
Arr.

Undergraduate research opportunities in physics. For further information contact the Departmental UROP Coordinator.
Staff

8.01 Physics I

Prereq.: —
Year: U (1, 2)
5-1-6

An introduction to classical mechanics. Space and time: straight line kinematics; motion in a plane; forces and equilibrium; experimental basis of Newton's laws; particle dynamics; universal gravitation; collisions and conservation laws; work and potential energy; vibrational motion; conservative forces; inertial forces and non-inertial frames; central force motions; rigid bodies and rotational dynamics.
Staff

8.012 Physics I

Prereq.: —
Year: U (1)
5-1-6

Covers much the same material as 8.01, but particularly suited for students with a strong preparation in mathematics. Elementary calculus used, and concurrent registration in 18.02 recommended.
Staff

8.013J Physics I

(Same subject as HST 500J)
Prereq.: —
Year: U (1)
5-1-6

The sequence 8.013J-8.023J is designed for students interested in medicine and the life sciences. Elementary kinematics and vector algebra. Newton's laws of motion. The conditions of static equilibrium; forces acting on the human body. Elasticity and strength of materials. Momentum conservation; application to ballistocardiography and to fracture and concussion during impacts. Work, kinetic and potential energy, and the law of energy conservation; the first law of thermodynamics; applications to metabolism and work done by various organs of the body. Harmonic motion; damped and driven oscillators; resonance. Angular momentum and torque. Introduction to the principles of feedback and control systems with examples in physiology.
Staff

8.02 Physics II

Prereq.: 8.01 or 8.012 or 8.013J; 18.01
Year: U (1, 2)
5-1-6

Electromagnetism: electrostatics and field concepts; electric currents and magnetic fields; induction laws; field energies; Maxwell's equations; circuit electricity; electromagnetism and relativity.
Staff

8.021 Physics II

Prereq.: 8.01 or 8.012 or 8.013J; 18.01
Year: U (2)
5-1-6

Intended for students who wish a broader view of physics in their second semester, with more emphasis on conceptual understanding and less on mathematical details. Electrostatics, electric currents, magnetic fields, Maxwell's equations and light, elements of the quantum theory, the Bohr atom, introduction to nuclear and particle physics. May be followed by 8.03 without too much difficulty.
J. L. Matthews

8.022 Physics II

Prereq.: 8.012
Year: U (2)
5-1-6

Parallel to 8.02, but at a mathematically more advanced level. Some knowledge of vector calculus assumed.
Staff

8.023J Physics II

(Same subject as HST 501J)
Prereq.: 8.01 or 8.012 or 8.013J; 18.01
Year: U (2)
5-1-6

Electrostatics: Coulomb's Law, electric fields; Gauss' Law; the electrostatic potential, Laplace's equation. Capacitors, work and energy. Dielectrics, molecular dipoles. Currents, Ohm's Law; R-C circuits; flow of charge in three dimensions; electrocardiography. Nernst-Planck equation; diffusion potentials; Debye shielding; electrophoresis of cells and proteins. Electrodes, electrochemical cells; pH measurements. Bioelectricity: cell membrane potentials; the Hodgkin-Huxley axon. Magnetic fields; Lorentz force, Ampere's and Biot-Savart's laws. Faraday's law of induction; self- and mutual inductance, LC circuits and transformers. Maxwell's equations; electromagnetic waves.
Staff

Undergraduate Laboratory and Special Project Subjects

8.03 Physics III

Prereq.: 8.02 or 8.021 or 8.022 or 8.023J; 18.02
Year: U (1, 2) SD
5-0-7

Mechanical vibrations and waves; simple harmonic motion, superposition, forced vibrations and resonance, coupled oscillations and normal modes; vibrations of continuous systems; reflexion and refraction; phase and group velocity. Optics; plane wave solutions to Maxwell's equations; polarization; Snell's Law, interference, Huygens' principle, Fraunhofer diffraction, gratings, Fresnel zone plates.
Staff

8.04 Quantum Physics I (Revised Content)

Prereq.: 8.03 or 6.014, 18.03
Year: U (1, 2) SD
5-0-7

Experimental basis of quantum physics: Photoelectric effect, Franck-Hertz experiment, the Bohr atom, electron diffraction, Compton scattering, photons, deBroglie waves, wave-particle duality of matter and light. Introduction to Wave Mechanics: Schroedinger's equation, wave functions, wave packets, probability amplitudes, stationary states, the Heisenberg uncertainty principle and zero-point energies. Solutions to Schroedinger's equation in one dimension: transmission and reflection at a barrier, barrier penetration, potential wells, the simple harmonic oscillator. Simple three-dimensional cases: particle in a box, spherically symmetric solutions for a central force (the hydrogen atom).
Staff

8.05 Quantum Physics II (Revised Content)

Prereq.: 8.04 or 8.211
Year: U (1, 2)
5-0-7

Review of the postulates of wave mechanics. Wave mechanics in two and three dimensions: the hydrogen atom. General formalism of Quantum Mechanics: state space, Dirac notation, representations, and matrix mechanics. Angular momentum, magnetic moments. Identical particles and the exclusion principle: many-electron atoms, the periodic table, simple molecules, Fermi and Bose gases. Perturbation theory: time independent theory, variational principle, adiabatic and sudden approximations, time dependent theory. Real physical examples discussed at each stage. It is recommended that students have a background in linear algebra (particularly eigenvalues of matrices). Recommended course: 18.085.
T. J. Greytak

8.06 Mechanics II

Prereq.: 8.03
Year: U (2)
4-0-8

Basic concepts of mechanics: inertial frames of reference; space, time, mass, force. Types of forces. Equations of motion; non-inertial frames of reference. Conservation laws for closed systems. Planetary motion. Harmonic oscillator. Macroscopic objects: constraints; Hamilton's principle and Lagrange's equations. Rigid body dynamics. Coupled oscillators, Green's functions. Normal modes; continuum limit; elastic strings, solids. Canonical variables, Hamilton's equations.
Staff

8.07 Electromagnetism II

Prereq.: 8.06
Year: U (1)
4-0-8

Survey of electrodynamics: basic phenomena, systems of units. Electrostatics: potential theory, Laplace's and Poisson's equations, Green's functions, methods of images and eigenfunctions. Magnetostatics. Electromagnetic properties of media. Relativity: relativistic mechanics and electrodynamics. Radiation: plane waves, polarization; propagation in media: refraction, dispersion; Lienard-Wiechert potentials, bremsstrahlung, synchrotron radiation, multipole radiation.
Staff

8.08 Statistical and Quantum Physics

Prereq.: 8.05
Year: U (2)
4-0-8

Introduction to statistical methods: random walk, central limit theorem. Statistical description of systems of many particles: quantum and classical microstates, ensembles. Statistical thermodynamics: equilibrium, interacting systems, three laws, applications to ideal gas, photon gas, magnetic systems. Canonical ensemble: kinetic theory, paramagnetism. Grand canonical ensemble: equilibrium between phases, Fermi gas, Bose gas, application to electrons in metals, phonons in solids. Interacting particles: Van de Waals gas, ferromagnetism. Transport theory: Boltzmann equation and applications. Irreversible processes and fluctuations: Brownian motion, Nyquist theorem.
M. A. Kastner

8.11 Physics Project Laboratory I

Prereq.: —
Year: U (1) LAB
1-6-5

8.12 Physics Project Laboratory II

Prereq.: —
Year: U (2) LAB
1-6-5

A project laboratory in which students develop experiments of their own selection, by themselves, with close faculty guidance. Instruments and associated facilities available to construct and run experiments in many areas of physics: atomic electron and ion physics; mechanics; optics and spectroscopy; acoustics; physical and circuit electronics; and some areas of nuclear and cosmic ray physics. Glass blowing, high vacuum facilities. Modern electronic instrumentation, and machine shop facilities available.
J. S. Whitaker

8.13 Experimental Atomic Physics I

Prereq.: 8.04 or 8.211
Year: U (1)
0-6-9

Laboratory experiments fundamental to the development of modern physics, illustrative of basic experimental techniques and giving data challenging to analyze. About seven experiments, including some of: hydrogenic atomic spectra; 21 cm Hydrogen emission in the galaxy; low temperature phenomena: superconductivity, Josephson Effect and superfluidity; motional EMF in solids (Hall); scattering of alpha particles by nuclei (Rutherford); excitation by (Franck-Hertz) and scattering of (Ramsauer) electrons in gases; lifetime of the u meson; plasma physics. Machine shop, vacuum and electronic practice as parts of the experiments. (Limited primarily to juniors in Course VIII.)
L. Grodzins

8.14 Experimental Atomic Physics II

Prereq.: 8.13
Year: U (2)
0-6-9

Continuation of 8.13. Experiments include: Optical spectra of homopolar and heteropolar diatomic molecules; solar rotation (Doppler Effect in Fraunhofer Lines); speeds of cosmic rays and of light; optical rotation (Faraday); optical pumping; e/m for highly relativistic electrons; nuclear magnetic resonance; coher-

Undergraduate Elective Subjects

ent scattering of gammas by nuclei (Mossbauer); scattering of gammas by electrons (Compton) and positron annihilation; magnetic splitting of a molecular beam (Stern-Gerlach).
D. E. Pritchard

8.18 Special Problems in Undergraduate Physics

Prereq.: —
Year: U (1, 2)
Arr.

Opportunity for undergraduates to engage in experimental or theoretical research under the supervision of a staff member. Specific approval of Academic Officer required in each case.
A. P. French

8.19 Readings in Physics

Prereq.: —
Year: U (1, 2)
Arr.

Supervised reading and library work. Choice of material and allotment of time according to individual needs. For students finding it desirable to do work not provided for in the regular subjects. Specific approval of Academic Officer required in each case.
A. P. French

8.20 Introduction to Special Relativity

Prereq.: 8.01, 18.01
Year: U (2) SD
2-0-7

Galilean relativity and Newtonian mechanics. Lorentz-Einstein transformations. Space-time diagrams, point events and world lines. Proper time, length and mass-energy. Relativistic kinematics and dynamics, conservation laws and invariants. Relativity and electric and magnetic fields. Point interactions, collisions and particle creation. Four-vectors and the laws of mechanics. (Primarily for first- and second-year students.)
Staff

8.201J Statistical and Biological Physics

(Same subject as HST 505J)
Prereq.: 8.02 or 8.021 or 8.022 or 8.023J; 18.02
Year: U (1) SD
5-0-7

Elements of probability theory. Random walk, Brownian motion, and diffusion. Diffusion equation and Fick's Law. Permeability of capillary walls; artificial kidney. Equilibrium and diffusion in external fields; ultracentrifugation. Osmotic pressure; coupled flow of solute and solvents across membranes. Poisson statistics and fundamental limits on detection of light by the eye; the Delbruck-Luria experiment. Thermal motion; molecular distribution of energy in crystals and gases; definition of temperature and the Boltzmann factor. Statistical characterization of thermal equilibrium; entropy. Entropy and heat; second law of thermodynamics. Open systems and free energy minimum principles. Vapor pressure and freezing points; chemical equilibrium; hemoglobin oxygenation. (Subject not routinely offered but can be given when sufficient interest is indicated.)
Staff

8.206J Public Controversies on the Control of Technology

(Same subject as STS 413J)
Prereq.: —
Year: U (2)
2-0-7

Role of scientists and engineers in controlling the damaging side effects of technologies on which industrialized nations are now dependent. Presentations by professionals who have played major roles in such issues. Historical cases and contemporary problems studied through readings, discussions, lectures, and student reports. Topics: dangers of the nuclear arms race; environmental and health hazards; responsibilities of scientists and engineers as advisors and outside critics; means of involvement and opportunities for action. (Not usable as a restricted elective by physics majors.)
B. T. Feld, H. W. Kendall, C. Weiner

8.211 Introduction to Quantum Physics

Prereq.: 8.03 or 6.014
Year: U (1) SD
5-0-7

One-term introduction to quantum physics designed to lay the groundwork for understanding the application to atoms, molecules, and solids. Emphasis placed on failures of classical physics, experimental basis for quantum mechanics, and development of an understanding of the Uncertainty Principle. Schroedinger's theory of quantum mechanics developed, and the free particle, tunneling, the harmonic oscillator, and the hydrogen atom solved quantitatively. Pauli Exclusion Principle, many-electron atoms, and quantum theory of ionic and covalent bonding discussed. (Not usable as a restricted elective for physics majors.)
D. Adler

8.231J Physics of Solids I

(Same subject as 6.731J)
Prereq.: 6.018, 8.211 or 8.05
Year: U (1)
4-0-8

First term of a two-term sequence presenting the basic concepts of the quantum theory of solids. Emphasis on physical models which provide a quantitative description of solids. Topics: periodic structure and symmetry of crystals; diffraction; reciprocal lattice; chemical bonding in simple molecules and solids; lattice dynamics, phonons, thermal properties; free electron gas; nearly free electron approximation; tight binding approximation; semiconductors: electrons, holes, impurities; materials with s, p, d, and f electrons. (The second half of this sequence, 8.500J, is listed among the graduate subjects.)
R. J. Birgeneau, M. S. Dresselhaus

8.236 Topics in Quantum Theory of Matter

Prereq.: 8.05
Year: U (2)
3-0-9

Introduction to group theory and the quantum mechanics of atoms, molecules, and crystals. Group representations. The full rotation group and angular momentum. Addition of angular momentum and the Clebsch-Gordan coefficients. Approximate atomic wave functions, spin-orbit interaction, and hyperfine structure.

Molecular electronic wave functions. Normal modes of vibration. Molecular rotation. Symmetry properties of crystals and the group of the k-vector; Crystalline electric fields.
M. W. P. Strandberg

8.242 Quantum Electronics

Prereq.: 8.05 or 8.211
Year: U (2)
4-0-8

Fundamental processes in lasers and masers. Classical dipole radiation; susceptibility, and bulk properties of matter. Interaction of a quantum-mechanical two-level system with electromagnetic radiation. Laseroscillators. Excitation mechanisms in gaseous and solid-state lasers. Raman effect and nonlinear optics. Laboratory demonstrations. Familiarity with Maxwell's equations and the Schroedinger equation required.
M. S. Feld, A. Javan

8.243 Modern Optics

Prereq.: 8.03
Year: U (1) SD
3-0-9

Propagation of light, laws of reflection and refraction, lenses and mirrors, optical imaging devices such as telescopes and microscopes. Polarization of light. Optics of solids, propagation of light in anisotropic solids, optical activity, electro-optic and magneto-optic effects. Coherence and interference, Michelson and Fabry-Perot interferometers, multilayer interference filters, Fourier Transform Spectroscopy. Fraunhofer and Fresnel diffraction, diffraction gratings. Theory of laser cavities, laser applications in spectroscopy, fusion, photochemistry, holography. Introduction to nonlinear optics, fiber optics, integrated optics. Spontaneous and stimulated light scattering.
R. L. Aggarwal

8.251 Physics of Noise and Fluctuations

Prereq.: 8.04
Year: U (1)
3-0-9

Mathematical description of random processes: joint probability distributions, correlation functions and power spectra. Fluctuations in discrete systems: shot noise, photon counting. Fluctuations about thermal equilibrium: space-time correlations of fluctuations of density, pressure, entropy, etc., and their relation to transport coefficients and dissipation constants. Discussion of modern experimental techniques for the study of thermal fluctuations. Quantum effects. Information theory. Fluctuations in living systems. (Alternate years. ***Not offered 1981-82.***)
T. J. Greytak

8.263 Physics of Fluids

Prereq.: 8.03
Year: U (1) SD
3-0-9

Introduction to the physics of fluids for students who have had little or no previous training in thermodynamics and statistical mechanics. Required material in these fields developed as needed. Emphasis on phenomena rather than mathematics. Topics include: physical properties of liquids, gases, and plasmas. Continuum dynamics. Wave motions. Acoustic waves and shock waves. Statistical theory of the dynamics of gases and plasmas. Transport phenomena. Basic principles illuminated throughout with examples from a variety of fields: geophysics, biophysics, aeronautics, acoustics, and astrophysics.
K. U. Ingard

8.271 Introduction to Nuclear Physics

Prereq.: 8.05 or 8.211
Year: U (1)
4-0-8

Properties of atomic nuclei, from the deuteron to the superheavy. Strong, electromagnetic, and weak interactions. Radioactive decay, scattering and reaction processes, interactions of photons and mesons with nuclei. Theoretical models of nuclear structure. Discussion of modern experimental techniques and research in progress at MIT.
S. G. Steadman

8.274 Introduction to Particle Physics

Prereq.: 8.05
Year: U (2)
4-0-8

Orders of magnitude. Accelerators. Fermions, bosons, leptons, mesons and baryons. Scattering and cross-sections. Quarks. Four classes of fundamental forces and the carriers of the forces. Symmetries and conserved quantities. Discovery of the new particles with charm or beauty quantum numbers and current effort to search for "truth" and the weak bosons.
M. Chen

8.282 Introduction to Astrophysics and Astronomy

Prereq.: 8.01
Year: U (2) SD
3-0-9

Quantitative introduction to physics of the Galaxy and the universe as determined from astronomical observations at radio, infrared, visible, ultraviolet, X-ray and y-ray wavelengths, and from cosmic ray and neutrino experiments. Topics: the sun and "normal" stars, supernovae, pulsars, globular clusters, compact objects (white dwarfs, neutron stars, black holes), optical and X-ray stellar binary systems, interstellar medium and star formation, galaxies, quasars, and cosmology. Includes research now being carried out by MIT observers at radio and optical observatories and with earth-orbiting X-ray astronomy satellites. Guest lectures given by the astrophysics staff. (Not usable as a restricted elective by physics majors.)
H. V. D. Bradt

8.285 Topics in Astrophysics

Prereq.: *8.05,* 8.282
Year: U (1)
3-0-9

Astrophysics of the Galaxy and universe as determined from observations of particle and photon fluxes, e.g., cosmic rays, radio waves, visible light, X rays. The theory of fundamental processes which occur in celestial objects and in the interstellar medium, e.g., synchrotron radiation, thermal bremsstrahlung, inverse Compton effect. These processes applied to specific astrophysical systems, e.g.: the Galaxy, main sequence stars, neutron stars, radio galaxies, supernovae, pulsars, the "big bang" universe. Observational data discussed. Stresses topics to which elementary electromagnetic and atomic theory can bring fundamental understanding.
H. V. D. Bradt

8.287J Observational Techniques of Optical Astronomy (Revised Unit)

(Same subject as 12.117J)
Prereq.: 8.282 or 12.113
Year: U (1) LAB
3-4-5

Fundamental physical and optical principles used for astronomical measurements at visible wavelengths and practical methods of astronomical observations. Topics: astronomical coordinates, time, geometrical optics, telescopes, photomultipliers, and other detectors, photon counting, signal-to-noise ratios, limita-

Graduate Subjects

tions imposed by the earth's atmosphere on optical observations, photography, photometry, spectroscopy and time variability. Project at Wallace Astrophysical Observatory.
J. L. Elliot

8.291J Planetary Physics and Chemistry I

(Same subject as 12.131J)
Prereq.: 8.02, 18.02
Year: U (1) SD
3-0-9

8.292J Planetary Physics and Chemistry II

(Same subject as 12.132J)
Prereq.: 8.02, 18.02
Year: U (2) SD
3-0-9

Study of the planetary system: evolution, composition, present configuration, dynamics, interiors, surfaces, atmospheres, and magnetospheres of the planets and, where appropriate, similar aspects of the satellites, asteroids, and comets. Theoretical interpretations of the existing data stressed. First term: a general description of the solar system and its origin and a comprehensive discussion of the outer planets. Second term: solar system dynamics, the interplanetary medium; and the interiors, surfaces, and atmospheres of the inner planets.
I. I. Shapiro, J. S. Lewis

8.293J Dynamical Astronomy

(Same subject as 12.115J)
Prereq.: 18.03
Year: U (2) SD
3-0-9

Kepler's laws and the law of gravitation. One- and two-body motion: orbits in space and time. General and special cases of the n-body problem. Disturbed motion of two bodies; variation of orbital elements; planetary and satellite theory; periodic and secular effects; orbital resonance. Astronomical coordinate systems and time. Numerical integration of orbits. Maximum-likelihood estimation of orbital initial conditions and astronomical constants. Emphasis throughout on applications to actual problems, both historical and current, rather than on mathematical theory *per se*. Demonstrations using a real-time computer and display.
I. I. Shapiro, C. C. Counselman

8.299 Physics Teaching

Prereq.: —
Year: U (1, 2)
Arr.

For qualified undergraduate students interested in gaining some experience in teaching. Laboratory, tutorial, or classroom teaching under the supervision of a faculty member. Students selected by interview.
Staff

8.ThU Undergraduate Physics Thesis

Prereq.: —
Year: U (1, 2, S)
Arr.

Program of undergraduate research leading to the writing of an S.B. thesis; to be arranged by the student under approved supervision.
E. R. Cosman

An asterisk (*) denotes subjects not routinely offered but that can be given when sufficient interest is indicated.

General and Mathematical Physics

8.312 Electromagnetic Theory (A)

Prereq.: 8.07
Year: G (2)
4-0-8

Review of basic principles of electromagnetic theory: Maxwell's equations; vector and scalar potentials; conservation laws, methods in electro- and magnetostatics. Propagation of electromagnetic waves in various media (conductive, dispersive, etc.). Dispersion theory. Scattering and diffraction of electromagnetic waves. Theory of special relativity; covariant formulation of Maxwell's equations. Motion of relativistic particle in electric and magnetic fields. Collisions and energy loss. Cerenkov radiation. Radiation by moving charges; synchrotron radiation. Bremsstrahlung. Radiation damping; self-fields of a particle.
Staff

8.321 Quantum Theory I (A)

Prereq.: 8.07
Year: G (1)
4-0-8

8.322 Quantum Theory II (A)

Prereq.: 8.321
Year: G (2)
4-0-8

A two-semester subject on quantum theory. Review of elementary wave mechanics. Principles of quantum mechanics, including uncertainty principle, observables, eigenstates, eigenvalues, probabilities of the results of measurement, transformation theory, equations of motion, constants of motion. Symmetry in quantum mechanics, representations of symmetry groups. Theory of angular momentum, spin, addition of angular momenta. Symmetry in particle physics. Variational and perturbation approximations. Systems of identical particles and applications. Time-dependent perturbation theory. Scattering theory: phase shifts, Born approximation, diffraction, resonances. The quantum theory of radiation. Second quantization and many-body theory. Relativistic quantum mechanics of one electron: the Dirac equation.
M. Baranger

8.323 Relativistic Quantum Field Theory (A)

Prereq.: 8.322
Year: G (1)
3-0-9

Classical field theory, canonical quantization, Dirac field. Interacting fields, perturbation theory, Feynman graphs. Functional methods, non-perturbative properties. Renormalization. Calculations in quantum electrodynamics.
R. L. Jaffe

8.333 Statistical Mechanics I (A)

Prereq.: 8.321
Year: G (1)
4-0-8

Quantum mechanics of macroscopic systems. Counting of quantum states. Density of states ω (E, V, N): extensive property of ln ω. Basic postulate of quantum statistical mechanics; classical limit; phase space volume. The microcanonical distribution. The microcanonical entropy S(E, V, N). Statistical interpretation of the entropy maximum principle; equilibrium conditions for composite systems in contact; thermodynamic temperature, pressure and chemical potentials. Work and heat. Open systems; canonical and grand canonical distributions and free energy minimum principle. Elements of chemical thermodynamics; Legendre transformations; reaction and phase equilibria; Gibbs phase rule. Applications to real and model systems: Ising models, Fermi and Bose gases, photon gas, lattice vibrations, dilute molecular gases. Interacting systems, Mayer cluster expansion, Van der Waals gas, mean field theories and their limitations. Systems at very low temperatures; spin waves in ferro-magnets; liquid helium.
F. M. H. Villars

8.334 Statistical Mechanics II (A)

Prereq.: 8.333
Year: G (2)
4-0-8

Continuation of 8.333. Contents varying from year to year, but generally including one or more of the following topics: 1) Boltzmann and Vlasov equations, H-theorem and transport processes. 2) Non-equilibrium statistical mechanics; linear response theory, correlation functions, fluctuation dissipation theorem. Relaxation to equilibrium, density matrix techniques. 3) Magnetism; ferro- and antiferromagnetism, soluble models. 4) Critical phenomena; scaling laws and the renormalization group method. 5) Statistical mechanics of low temperature systems: elementary excitations in interacting Bose and Fermi systems.
P. A. Wolff

8.341 Mathematical Methods of Physics I (A)

Prereq.: 18.076
Year: G (1)
3-0-9

8.342 Mathematical Methods of Physics II (A)

Prereq.: 8.341
Year: G (2)
3-0-9

A subject in the methods of mathematical physics for first-year graduate students. Topics: the equations of mathematical physics, linear spaces, electrostatics and complex variables, integral transforms, differential equations, separability and symmetry properties, orthogonal polynomials. Group theory: rotation group, Poincare group, and permutation group. Green's functions and integral equations. Approximation methods. Scattering theory, including dispersion theory, and analytic properties of scattering amplitudes.
R. C. Giles

8.361 Quantum Theory of Many-Particle Systems (A)

Prereq.: 8.322, 8.333
Year: G (1)
3-0-9

Introduction to general many-body theory applicable to low temperature, nuclear, and solid-state physics. Review of occupation number representation and classical Mayer expansion. Perturbation theory: diagrammatic expansions and linked cluster theorem for zero or finite temperature systems of fermions or bosons. Green's functions: analytic properties, equations of motion, relation to observables, approximations, linear response theory, random phase approximation. Superconductivity: electron-phonon interaction, instability of normal state, BCS ground state, perturbation theory. (Alternate years. ***Not offered 1981-82.***)
Staff

8.381, 8.382 Selected Topics in Theoretical Physics (A)*

Prereq.: —
Year: G (1, 2)
3-0-9

Topics of current interest in theoretical physics, varying from year to year.
Staff

8.391, 8.392 Special Problems in Theoretical Physics (A)

Prereq.: —
Year: G (1, 2)
Arr.

Reading, consultation, and original investigation on a problem in theoretical physics.
Staff

8.399 Physics Teaching (A)

Prereq.: —
Year: G (1, 2)
Arr.

For qualified graduate students interested in gaining some experience in teaching. Laboratory, tutorial, or classroom teaching under the supervision of a faculty member. Students selected by interview.
Staff

Physics of Atoms, Radiation, Solids, Fluids, and Plasmas

8.411 Advanced Atomic Physics (A)*

Prereq.: 8.05
Year: G (1)
3-0-9

Theory of spectroscopy, including atomic and solid-state spectroscopy in optical and microwave regions. Angular momentum through use of Racah formalism. One-electron and many-electron atoms. Atoms in crystal lattices; the Stark and Zeeman effects; the effects of strain on crystal spectra.
G. F. Koster

8.421 Atomic and Molecular Physics (A)

Prereq.: 8.05
Year: G (1, 2)
3-0-9

Modern topics in atom-field interactions including momentum exchange with the field, multiphoton processes (including 4-wave mixing), and effects of coherence of field and radiators. Survey of methods of laser spectroscopy. Interatomic forces, diatomic molecules, and atom-atom collisions (both elastic and inelastic). Atom-molecule collisions, energy transfer. Particular emphasis placed on semi-classical methods and models, and on the relationship of continuum and bound behavior in two-particle systems. Complementary to 8.422. ***(Not offered 1981-82).***
D. E. Pritchard

8.422 Survey of Atomic Physics (A)

Prereq.: 8.05
Year: G (2)
3-0-9

Structure of atoms and simple molecules and their interactions with electromagnetic radiation. Resonance in two-level and multi-level systems; spontaneous and stimulated emission. Spectroscopy of hydrogen including optical, fine, and hyperfine structure. Lamb shift, anomalous moment of the electron, and other fundamental studies in atomic physics. Highly excited one- and two-electron atoms, quantum defect theory, photo-ionization, auto-ionization, behavior of atoms in strong fields. (Complementary to 8.421.)
D. Kleppner

8.442 Statistical Optics and Spectroscopy (A)*

Prereq.: 8.05, *8.08*
Year: G (2)
3-0-9

Discussion of light as a statistical process and description of its spectrum by the modern concept of correlation functions. Interaction of light with photodetectors, modern techniques of spectral analysis: photon counting, heterodyne beating, digital auto-correlation, Brown-Twiss experiment. Principles of interference and spatial coherence. Applications to Fabry-Perot interferometers and Fourier transform spectroscopy. Theory of diffraction, and grating spectrometers. Spectrum of light scattered by thermal fluctuations in transparent media.
J. D. Litster

8.451 Physics of Optical and Infrared Lasers (A)

Prereq.: 8.07, 8.321
Year: G (1)
3-0-9

Subject to develop theoretical background of the physics of lasers and quantum electronics required for laboratory research with optical and infrared lasers: classical treatment of the interaction of radiation with matter, with emphasis on radiation reaction and self-force in free space and inside a resonant cavity. Optical resonators and normal modes. Quantum theory of dipolar interaction; density matrix representation of atomic states. Stimulated emission of radiation, Raman effect, nonlinear optics, and parametric interactions. (Alternate years. ***Offered 1981-82.***)
M. S. Feld, A. Javan

8.452 Seminar in Optical and Infrared Lasers (A)

Prereq.: 8.451
Year: G (2)
3-0-9

Current advanced topics in the physics of quantum electronics and lasers. Topics: gas laser theory, laser-induced line-narrowing effects, and short pulse propagation through optically thick media. (Alternate years. ***Offered 1981-82.***)
M. S. Feld, A. Javan

8.481, 8.482 Selected Topics in Physics of Atoms and Radiation (A)*

Prereq.: 8.321
Year: G (1, 2)
3-0-9

Presentation of topics of current interest with content varying from year to year.
Staff

8.491, 8.492 Special Problems in Physics of Atoms and Radiation (A)

Prereq.: —
Year: G (1, 2)
Arr.

Advanced problems in atomic, optical, microwave and radiofrequency physics, with assigned reading and consultation.
Staff

8.500J Physics of Solids II (A)

(Same subject as 6.732J)
Prereq.: 6.731J or 8.231J
Year: G (2)
4-0-8

Second term of a two-term sequence presenting the basic concepts of the quantum theory of solids. Emphasis on physical models which provide a quantitative description of solids. Topics: dynamics of electrons in solids, Fermi surfaces, transport phenomena, such as electrical and thermal conductivity, with applications to metals and semiconductors; optical properties of solids with applications to metals, semiconductors, and insulators; magnetic phenomena in solids such as paramagnetism, diamagnetism, ferromagnetism, resonance studies in a magnetic field; superconductivity. The first half of this sequence is the undergraduate physics elective subject 8.231J, Physics of Solids I.
R. J. Birgeneau, M. S. Dresselhaus

8.511J Theory of Solids I (A)

(Same subject as 6.741J)
Prereq.: 8.231J
Year: G (1)
3-0-9

First term of a theoretical treatment of the physics of solids. Theory of electron motion in crystal lattices: separation of electron and nuclear motion; Hartree-Fock approximations; one electron states in periodic potentials; energy bands; OPW pseudopotential and APW approximations; survey of electronic properties of crystals. Lattice dynamics: Normal modes; quantization; phonon excitation; thermal properties of solids.
J. D. Joannopoulos, D. Adler

8.512J Theory of Solids II (A)

(Same subject as 6.742J)
Prereq.: 8.511J
Year: G (2)
3-0-9

Second term of a theoretical treatment of the physics of solids. Semiconductors: survey of band structures; effective mass theory; effective g-factor; transport; optical properties. Metals: band structures; electron dynamics; transport; magnetic properties; optical properties. Many-body theory: the random phase approximation; collective effects in normal metals; Fermi liquid theory; superconductivity.
J. D. Joannopoulos, D. Adler

8.513J Application of Group Theory to the Physics of Solids (A)

(Same subject as 6.734J)
Prereq.: 8.500J
Year: G (1)
3-0-9

Group theory techniques: mathematical background, representation theory, character tables, basis functions, double groups, time reversal symmetry. Applications: crystal field structure, selection rules, directed valence and bonds, molecular vibrations, group of the wave vector with application to energy bands, lattice modes. Application of double groups to crystal field theory and energy band structure. (Alternate years. ***Not offered 1981-82.***)
G. F. Koster, M. S. Dresselhaus

8.522 Topics in Biological Physics (A)

Prereq.: 8.07, 8.05
Year: G (2)
3-0-9

Topics include statistical mechanics and thermodynamics of micelles, theory of polymer solutions and the sol-gel transition. Thermodynamics of enzyme function with particular applications to allosteric enzymes and the oxygen binding proteins: myoglobin and hemoglobin. Elements of immunology and the kinetics of agglutination reactions involving antigens and antibodies. Physiologic topics include the theory of transparency of the cornea and lens and statistical features of the detention of light by the eye.
G. B. Benedek

8.561 Correlations and Critical Behavior in Condensed Matter (A)

Prereq.: 3.511J, 8.333
Year: G (1)
3-0-9

Presents Condensed Matter Physics from point of view of space- and time-dependent correlation functions as measured via scattering spectroscopy. Emphasis on underlying unifying concepts of hydrodynamics, conservation laws, broken symmetry and the fluctuation-dissipation theorem. Consequent interconnection between apparently diverse physical systems is elucidated. Detailed discussions are given of classical and quantum liquids, ferro- and antiferromagnets, liquid crystals, superconductors, unstable solids and the electron gas. Where appropriate, special attention is given to the behavior near critical points. Experimental techniques of X-ray, light, electron and neutron scattering are treated in detail. Theoretical development is strongly phenomenological in style in order to elucidate the underlying physics with minimal mathematical complexity. (Alternate years. ***Not offered 1981-82.***)
J. D. Litster

8.581, 8.582 Selected Topics in the Theory of Solids (A)*

Prereq.: 8.512J
Year: G (1, 2)
3-0-9

Topics in solid-state theory varying from year to year.
Staff

8.591, 8.592 Special Problems in Solid-State Physics (A)

Prereq.: —
Year: G (1, 2)
Arr.

Advanced problems in the physics of the solid state, with assigned reading and consultation.
Staff

8.613J Introduction of Plasma Physics I (A)

(Same subject as 6.651J, 22.611J)
Prereq.: 6.014 or 8.07; 6.018 or 8.04; 18.04 or 18.075
Year: G (1)
3-0-9

Introduction to plasma phenomena relevant to energy generation by controlled thermonuclear fusion and to astrophysics. Coulomb collisions and transport processes. Motion of charged particles in magnetic fields; plasma confinement schemes. Low-frequency plasma dynamics; MHD models; simple equilibrium and stability analysis. Two fluid hydrodynamic plasma models; wave propagation in a magnetic field. Introduction to kinetic theory; Vlasov plasma model; electron plasma waves and Landau damping; ion-acoustic waves; streaming instabilities; derivation of the collision operator; Spitzer conductivity.
A. Bers, K. Molvig, M. Porkolab

8.614J Introduction to Plasma Physics II (A) (New)

(Same subject as 6.652J, 16.59J, 22.612J)
Prereq.: 6.651J or 8.613J or 22.611J; 18.075
Year: G (2)
3-0-9

Linear Waves and instabilities in magnetized plasmas; solutions of Vlasov-Maxwell equations in homogeneous and inhomogeneous plasmas; conservation principles for energy and momentum; negative energy waves; absolute and convective instabilities. Quasi-linear theory and conservation principles; evolution of unstable particle distribution functions. Collisional transport theory; Fokker-Planck equations; particle diffusion, thermal conductivity, and viscosity in magnetized plasmas.
R. C. Davidson, A. Bers, K. Molvig, J. E. McCune

8.621J Plasma Kinetic Theory (A)

(Same subject as 22.64J)
Prereq.: 8.613J
Year: G (1)
3-0-9

Content varying from year to year. Typical subjects: the linearized Vlasov equation, Fokker-Planck and diffusion approximations for the average distribution function, autocorrelation functions, resonant and nonresonant diffusion, free energy, energy and momentum conservation, resonant wave coupling, nonlinear Landau damping, strong turbulence theories. Selected applications to enhanced diffusion, stochastic acceleration, turbulent resistivity, shock waves, radio emission.
T. H. Dupree

8.622J Advanced Topics in Plasma Kinetic Theory (A)

(Same subject as 22.65J)
Prereq.: 8.621J or 22.64J
Year: G (2)
3-0-9

Varying content, including topics of current interest. Typical subjects: theories of collective phenomena such as linear instability and nonlinear saturation mechanisms in plasma, particularly in regimes described by the Vlasov-Maxwell equations. Effects of wave-particle resonance; trapping and scattering of particles by waves. Linear theory of instabilities in inhomogeneous plasmas. Reflection and eigenmode problems in bounded systems. Diffusion phenomena and anomalous resistivity associated with wave-particle interaction. Discussion of experiments.
T. H. Dupree

8.624 Waves, Instabilities, and Nonlinear Effects in Plasmas (A)

Prereq.: 8.613J
Year: G (2)
3-0-9

Comprehensive treatment of the linear theory of electromagnetic waves in a cold magnetized plasma; effects of finite temperature; linear mode-conversion. Vlasov theory of waves and instabilities in a hot, magnetized plasma. Bernstein waves, drift waves, gravitational modes, and loss-cone modes. Electromagnetic waves in a hot plasma. Applications to radio-frequency heating of fusion plasmas: ECRH, ICRH. Introduction to nonlinear plasma physics: parametric instabilities, solitons; weak turbulence theory: quasi-linear effects, resonant mode-mode coupling, nonlinear Landau damping, explosive instabilities, plasma wave echoes, large amplitude waves and particle trapping, renormalization theories. Time allow-

ing, additional selected topics, such as ion acoustic shocks and anomalous resistivity, discussed. Experimental evidence of these phenomena also presented and discussed. (May be taken in sequence to 8.613J.)
M. Porkolab

8.641 Physics of High Temperature Plasmas I (A)

Prereq.: 8.613J
Year: G (1)
3-0-9

8.642 Physics of High Temperature Plasmas II (A)

Prereq.: 8.613J
Year: G (1)
3-0-9

Basic physics of thermonuclear plasmas with applications to controlled fusion research and astrophysics. Main theoretical descriptions (MHD approximation, moment equations for particles and guiding centers including finite Larmor radius and transport coefficients, drift approximation of Vlasov equation, significant solutions of complete kinetic equations.) Effects of (discrete) collisions on main transport coefficients (electrical resistivity, thermal conductivities, viscosity, etc.) and comparison with effects of collective modes (e.g., micro-instabilities). Resistive and collisionless reconnecting modes (tearing and gravitational instabilities), formation of magnetic islands, destruction of skin currents. Role of singular perturbations in plasma theory. Convective micro-instabilities in geometry and velocity space. Electron runaway problem and anomalous electrical resistivity. Positive and negative energy modes, nonlinear instabilities (resonant mode coupling, nonlinear Landau damping and quantum-mechanical models). Equilibrium theory of significant confinement configuration (e.g., multipoles, stellarators, tokamaks) and relevant transport coefficients in strongly collisional regimes. Trapped particle regimes and collisional transport. Similarity between effects of impurity ions and of trapped particles. Impurity driven modes. Trapped particle instabilities, characteristic integral equations, relevant nonlinear scattering processes and transport. Radiation emission processes from inhomogeneous plasmas. Physics of thermonuclear ignition. (Each subject is so organized that it can be taken independently of the other. ***8.642 offered 1981-82.***)
B. Coppi

8.681, 8.682 Selected Topics in Fluid and Plasma Physics (A)*

Prereq.: 8.613J
Year: G (1, 2)
3-0-9

Presentation of topics of current interest, with content varying from year to year.
Staff

8.691, 8.692 Special Problems in Fluid and Plasma Physics (A)

Prereq.: —
Year: G (1, 2)
Arr.

Advanced problems in fluid or plasma physics with assigned reading and consultation.
Staff

Nuclear and Particle Physics

8.711 Nuclear Physics I (A)

Prereq.: 8.05
Year: G (1)
3-0-9

Introduction to nuclear physics, stressing experimental results and correlating the data with current theory and nuclear models. Nucleon-nucleon interaction. Static properties of nuclei, the shell model, the Hartree-Fock method. Models of nuclear collective motion: rotations, vibrations, and giant resonances.
R. P. Redwine

8.712 Nuclear Physics II (A)

Prereq.: 8.711
Year: G (2)
3-0-9

Electromagnetic and weak interactions of nuclei: electron scattering; beta decay and muon capture. Study of nuclear structure through nuclear reactions; optical models; resonance reactions; heavy ion collisions; nucleon transfer reactions; high energy scattering from nuclei; meson-nucleus interactions.
R. P. Redwine

8.721 High Energy Nuclear Physics (A)*

Prereq.: 8.712
Year: G (1)
3-0-9

Studies of nuclear structure using high energy probes: Elastic and inelastic scattering of high energy electrons, nucleons and mesons; photodisintegration. Compton scattering and coherent meson production. Born approximation, phase shift analyses and multiple scattering approximations. Distribution of charge, matter and magnetization. Transition densities. Sum rules. Mesonic atoms. Nuclear momentum distributions from (N, 2N) and (e, e N) studies. Nucleon-nucleon correlations (π, 2N), (γ, 2N) and other reactions.
W. Bertozzi

8.751 Theory of Nuclear Structure (A)

Prereq.: 8.322
Year: G (1)
3-0-9

Nature of internuclear forces. The nuclear many-body problem: Brueckner-Bethe-Goldstone theory and its application to nuclear matter and finite nuclei; the Hartree-Fock approximation; the nuclear shell model. Collective models of the nucleus; rotational states in deformed nuclei. Particle-hole formalism for excited states; random phase approximation. Nuclear pairing theory. Unified theory of nuclear reactions; theory of the optical potential. (Alternate years. ***Not offered 1981-82.***)
E. L. Lomon

8.781, 8.782 Selected Topics in Nuclear Theory (A)*

Prereq.: 8.751
Year: G (1, 2)
3-0-9

Presentation of topics of current interest in nuclear structure and reaction theory, with content varying from year to year.
Staff

8.791, 8.792 Special Problems in Nuclear Physics (A)

Prereq.: —
Year: G (1, 2)
Arr.

Research and reading with consultation in the general area of experimental or theoretical nuclear physics.
Staff

8.810 Particle Physics I (A)

Prereq.: 8.05, 8.321
Year: G (2)
4-0-8

Introduction to phenomenology of particle properties and interactions, stressing experimental results. Classification by quantum numbers. Experimental determination. Isospin concept, symmetries; conservation laws and experimental limits of validity. Particle detectors and techniques. Accelerators, relativistic kinematics, phase space, invariants. Characteristics of interactions: strong: elementary S-Matrix theory; electromagnetic: Dirac-

Feynman, experimental validity limits; weak: V-A theory, empirical rules, Conservation-Violation: Parity, etc. experiments. K-mesons, associated production, puzzles, mixing, regeneration, CP-violation. Formfactors.
L. S. Osborne

8.811 Particle Physics II (A)

Prereq.: 8.810
Year: G (1)
3-0-9

Resonances and partial wave analysis. Regge and optical models compared to data. Elementary symmetries SU (3)-SU (6), Quark model, predictions. Photoproduction, inelastic ep scattering-scaling, electroproduction. Simple parton models and possible tests. Current research on pp and ee storage rings, neutrino-physics and extreme high energy phenomena.
L. S. Osborne

8.871, 8.872 Selected Topics in Theoretical Particle Physics (A)*

Prereq.: 8.323
Year: G (1, 2)
3-0-9

Presentation of topics of current interest in theoretical particle physics, with content varying from year to year.
Staff

8.881, 8.882 Selected Topics in Experimental Particle Physics (A)*

Prereq.: 8.811
Year: G (1, 2)
3-0-9

Presentation of topics of current interest in experimental particle physics, with content varying from year to year.
Staff

8.891, 8.892 Special Problems in Particle Physics (A)

Prereq.: —
Year: G (1, 2)
Arr.

Advanced problems in the general area of experimental or theoretical particle physics with assigned reading and consultation.
Staff

Space- and Astro-physics

8.910 Astrophysics I (A)

Prereq.: 8.05, 8.08
Year: G (2)
3-0-9

Sizes and time scales in astrophysics. Dynamics in phase space: distribution function and Boltzmann equation; applications to interplanetary and interstellar media, distribution of stars in the galaxy. Radiative transfer; line formation; spectroscopy of interstellar medium; H-R diagrams and fundamentals of stellar structure and evolution; planetary nebulae, novae, and supernovae; degenerate matter.
Staff

8.911 Astrophysics II (A)

Prereq.: 8.910
Year: G (1)
3-0-9

Relativistic electrodynamics, with applications to pulsars, X-ray sources, radio galaxies, and quasars. Cosmic ray acceleration, diffusion and radiation mechanisms. Properties of collapsed objects (white dwarfs, neutron stars, black holes). Introduction to cosmology: dynamical and physical evolution of the "universe."
Staff

8.912 Intermediate Theoretical Plasma Physics (A)

Prereq.: 8.613J
Year: G (1)
3-0-9

Designed to provide a connection between the material covered in Physics 8.613J and that taught in 8.621J, 8.641, 8.642, 8.913, and 8.914. Main topics concern the basic fluid and kinetic description of plasmas as represented by the ideal MHD approximation and the Vlasov equation, respectively. Special examples of applications of this theory drawn from topics described under Cosmic Electrodynamics (8.913 and 8.914) and under Physics of High Temperature Plasmas I and II (8.641 and 8.642). Among these are: theory of equilibria of magnetically confined plasmas such as toroidal and mirror configurations, the plasmasphere of a collapsed (neutron) star, Chapman-Ferraro sheet, various methods of integration of the Vlasov equation, role of Landau-damping in collisionless transport processes and collisionless shock waves. (Alternate years. ***Not offered 1981-82.***)
B. Coppi

8.913 Cosmic Electrodynamics I (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

8.914 Cosmic Electrodynamics II (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

For students interested in astrophysics, space physics, and plasmas. Physics of closed and open magnetospheres. Single particle and fluid descriptions. Magnetic trapping and Van Allen belts. Magnetic configurations and particle acceleration processes produced by strongly magnetized rotating neutron stars and relevant pulsar models. Electron runaway distributions; collisional and turbulent electrical resistivity; relevant thermal instability and current driven modes. Transport coefficents due to (discrete) collisions in magnetized plasmas. Wave-particle interactions and resulting diffusion processes; applications to cosmic ray modulation in the solar system. MHD discontinuities and shock waves. Microscopic theory of collisional and collisionless shock fronts. Solitons. Theory and observations of the solar wind; stellar winds in general. Reconnection of magnetic lines and conversion of magnetic energy to particle energy. Neutral line and sheet configurations. Collisional and collisionless tearing modes. Solar flare models. Collective modes in the Earth magnetotail and auroral substorms. Relationship between the theory of gravitational (galactic) plasmas and that of magnetically confined plasmas. Accretion processes and applications to X-ray stars. Each subject is so organized that it can be taken independently of the other. ***(8.914 offered 1981-82.)***
B. Coppi

8.921 Stellar Structure and Evolution (A)

Prereq.: 8.910
Year: G (1)
3-0-9

Observable stellar characteristics and an overview of observational information. The physical principles underlying calculations of stellar structure and evolution. Estimates of conditions in stellar interiors as suggested by the observations. Examination of physical processes in stellar interiors: properties of matter and radiation; radiative, conductive, and convective heat transport; nuclear energy generation and nucleosynthesis; neutrino emission. Applications to stars and to other observational data: pre-stellar nebulae and protostars; the main sequence and the problem of the solar neutrino flux; red giants and other advanced evolutionary stages; variable stars;

mass-loss phenomena, including planetary nebulae, novae, and supernovae; final stages of stellar evolution, including white dwarfs and neutron stars; evolution of close binary systems; abundances of the chemical elements. (Alternate years. ***Offered 1981-82.***)
P. C. Joss

8.942 Cosmology (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Cosmic ages, Hubble law and Olbers paradoxes. Thermal backgrounds in space. Cosmological principle and its consequences: Newtonian cosmology and types of "universes;" survey of relativistic cosmology; horizons. Overview of evolution in cosmology; radiation and element synthesis; physical models of the "early stages." Formation of large-scale structure. Variability of physical laws. First and last states.
P. Morrison

8.952J Radio Interferometry (A)

(Same subject as 6.664J, 12.626J)
Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Principles, techniques, and applications of radio interferometry, emphasizing current research using very long baselines. Techniques applicable to natural continuum, as well as artificial sources. Synthesized wide band group-delay interferometry, continuous phase-delay interferometry, and differential interferometry. Inference of astronomical and geophysical parameters from interferometric observations: tests of relativity theory; source angular brightness distributions, positions, and proper motions; propagation-medium effects; geodesy; solid earth tides; polar motion and spin rate; tracking of artificial satellites, lunar and planetary probes. (Knowledge of electronic signals, systems, and noise theory required. Alternate years. ***Offered 1981-82.***)
C. C. Counselman, D. H. Staelin, I. I. Shapiro

8.962 General Relativity and Gravitation (A)*

Prereq.: 8.312
Year: G (2)
3-0-9

Experimental basis for gravitational theories. Development of mathematical techniques: vector spaces, Euclidian point spaces, tensor algebra, Riemannian geometry, and the absolute differential calculus, special relativistic treatment of electromagnetism, gravitation, and hydrodynamics. Geometrization of gravitation, Einstein field equations, linearization of the field equations, rigorous solutions — Schwarzchild exterior and interior solutions. Approximately half of the subject dedicated to applications: solar system tests of relativistic gravitation, generation, and detection of gravitational radiation, cosmological models and observables.
R. Weiss

8.981, 8.982 Selected Topics in Astrophysics (A)*

Prereq.: —
Year: G (1, 2)
3-0-9

Topics of current interest, varying from year to year.
Staff

8.991, 8.992 Special Problems in Astrophysics (A)

Prereq.: —
Year: G (1, 2)
Arr.

Advanced problems in astrophysics with assigned reading and consultation. (Permission of instructor required.)
Staff

8.ThG Graduate Physics Thesis (A)

Prereq.: —
Year: G (1, 2, S)
Arr.

Program of graduate research leading to the writing of an S.M., Ph.D. or Sc.D. thesis, to be arranged by the student and an appropriate MIT faculty member.
G. F. Koster

9 Psychology

9.UR Undergraduate Research

Prereq.: —
Year: U (1, 2, S)
Arr.

Individual participation in an ongoing research project in brain science, experimental psychology, and cognition. (For students in the Undergraduate Research Opportunities Program.)
A. Hein

9.00 Introduction to Psychology

Prereq.: —
Year: U (1)
3-0-6

Introduces students to current fields of research and controversy in psychology. Topics include structure and function of the brain and nervous system, sensation, perception, learning, memory, language, personality, social relations, and deviance. How does the body interact with the brain and mind? How do we come to perceive the world, to learn from what we perceive, and to act upon what we have learned? How do these processes change during development? How do our theories about human nature shape our understanding of human nature? Arguments about such diverse topics as IQ tests, mental illness, political dissent, riots, and welfare are often psychological arguments. How does psychology interact with society?
S. L. Chorover

9.01 Neuroscience and Behavior (Revised Unit)

Prereq.: 9.00
Year: U (1)
3-0-6

Relation of structure and function at various levels of neuronal integration. Topics include: functional neuroanatomy and neurophysiology, motor systems, centrally programmed behavior, sensory systems, arousal, sleep and dreaming, motivation and reward, emotional displays of various types, "higher functions" and the neocortex, and neural processes in learning and memory. (May be counted toward Humanities Requirement *only* by students concentrating in Psychology; see Department for details. Permission of instructor required.)
G. E. Schneider, P. H. Schiller

9.014J The Neurosciences I (A)

(Same subject as 20.511J)
Prereq.: 7.05
Year: G (2)
6-0-9

First of a two-semester sequence designed to expose graduate students to the broad range of contemporary topics in the Neurosciences. Topics: 1) mammalian neuroanatomy; 2) basic neurochemistry (protein, fat, energy metabolism in the brain, blood-brain-barrier transport); 3) cellular neurophysiology (excitation and conduction properties of nerves, synaptic transmission); 4) neuroendocrinology (reproductive neuroendocrinology, anterior and posterior pituitary function, pineal gland, adrenal medulla); 5) feeding and hunger, drinking, sleep.
M. J. Baum, J. D. Fernstrom, A. M. Graybiel, M. A. Moskowitz, W. J. H. Nauta, T. F. Weiss

9.015J The Neurosciences II (A)

(Same subject as 20.512J)
Prereq.: 9.014J
Year: G (1)
6-0-9

Second semester subject of a two-semester sequence designed to expose graduate students to the broad range of contemporary topics in the Neurosciences. Topics:
1) neurotransmitter biochemistry and pharmacology, 2) sensory physiology (somatosensory, chemosensory, auditory, visual systems);
3) motor system (central control of movement, muscle dynamics, and reflex spinal and supraspinal mechanisms governing movement);
4) development and plasticity of the nervous system; 5) neuropsychology (cortical functions, language, cognitive function, sensorimotor functions); 6) clinical neuroscience (pharmacology and anatomy of pain, mental diseases, neurological diseases).
E. Bizzi, S. Corkin, R. M. Held, P. H. Schiller, G. E. Schneider, R. J. Wurtman

9.016J The Human Nervous System (A)

(Same subject as 20.514J, HST 130J)
Prereq.: Permission of Instructor
Year: G (1)
6-3-6

This subject encompasses a) the gross anatomy, internal organization, and fine structure (light- and electron-microscopic) of the mammalian nervous system with particular emphasis, wherever possible, on the human nervous system and its functional disorders; b) neurophysiology from the level of the single cell to that of complex neural organizations, in particular, perceptual, motor and associative systems; c) neuropharmacology and neuroendocrinology. (Enrollment limited.)
W. J. H. Nauta, E. Bizzi, A. M. Graybiel, R. J. Wurtman

9.018J Pathophysiology of the Nervous System (A)

(Same subject as HST 131J)
Prereq.: 9.016J
Year: G (2)
3-0-6

Discussion of the physiological and biochemical mechanisms underlying diseases of the peripheral and central nervous systems. Emphasizes recent advances in the basic sciences as they apply to the following phenomena and representative disease states: muscle contraction and relaxation (muscular dystrophy), neuromuscular transmission (myasthenia and related syndromes), peripheral nerve conduction (peripheral neuropathies), pain and nociception, suprasegmental control of movement (tremor and Parkinson's disease), myelin formation and breakdown (multiple sclerosis), sleep and other biological rhythms (narcolepsy), cortico-cortical interactions (behavior and language disorders), neuronal excitability (epilepsy), cerebral circulation (stroke). (Enrollment limited. Permission of instructor required.)
N. Geschwind, M. A. Moskowitz

9.019 Topics in Neuropsychology (A)

Prereq.: Permission of Instructor
Year: G (2)
2-3-7

Weekly lectures by neuropsychologists and neurologists on the effects of brain disease on human behavior. Weekly laboratory sessions with demonstrations of behavioral testing methods and occasional clinical demonstrations. Review of current issues in the study of brain and behavior relationships, emphasizing the search for underlying neural mechanisms. (Alternate years. ***Not offered 1981-82.***).
S. Corkin, Guest Lecturers

9.02 Nature, Nurture, and the Individual Brain

Prereq.: 9.01
Year: U (2)
3-0-6

Individual differences in brain structure and correlated physiology and behavior. The nature of genetic and environmental influences on the developing nervous system. The phenomena of plasticity in neonatal and adult brains. (Alternate years. ***Not offered 1981-82.***)
G. E. Schneider, P. H. Schiller, N. Geschwind

9.021 Topics in Brain and Behavior (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Detailed discussion of the neuroanatomy, neurochemistry, neurophysiology, and neuropsychology of selected regions of the forebrain. Seminar sessions in which participants take turns leading class discussions on the readings and presenting reports on special topics. Occasional clinical demonstrations during the term and a one-hour quiz during the last class. (Alternate years. ***Offered 1981-82.***)
S. Corkin, A. M. Graybiel

9.022 Topics in Neuroanatomy (A) (Revised Content and Unit)

Prereq.: 9.014J, 9.016J
Year: G (2)
3-0-6

Recent findings and functional concepts dealing with internal organization of mammalian central nervous system. Emphasis on the forebrain. Seminar sessions in which participants take turns leading class discussions on the readings and presenting reports on special topics. (Permission of instructor required.)
A. M. Graybiel

9.05 Psychotechnology: Scientific and Ethical Issues in Behavior Control

Prereq.: —
Year: U (2)
3-0-6

The behavior of animals — including human beings — can be altered in various ways through the use of physical methods and chemical agents. New techniques of electrical brain stimulation and psychosurgery also contribute to the growing power of psychotechnology. Development and deployment of psychotechnology traced by considering case studies drawn from contemporary social problem areas. Topics considered include mental testing (I.Q.), identification and regulation of social deviance, biological orientation toward social inequalities ("social darwinism"). Biomedical and psychotechnological approaches to delinquency, drug addiction, and other social problems discussed in terms of their alleged scientific bases, scope, power and limitations. Evaluation of the use of psychotechnology in such areas as the diagnosis and treatment of neuropsychiatric disorders, detection and control of drug abuse and/or narcotic addiction, modulation of emotional reactivity and aggressive behavior, enhancement and/or retardation of learning, intelligence and memory, normalization of disturbing social behavior and control of social deviance. Emphasis throughout upon questions that bridge the traditional gaps between science and technology, and social policy planning. ***(Not offered 1981-82.)***
S. L. Chorover

9.051 Human Nature and Sociobiology (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Critical survey of attempts to account for human social behavior in terms of evolutionary and psychobiological mechanisms. Review of the traditional "nature vs. nurture" controversy and its influence on ideas about human society from ancient times to the present. Particular emphasis on uses and abuses of psychological, genetic, and ethological concepts in sociology, politics, and economics. Analysis of current knowledge about the genetic and environmental bases of human behavior (including motivation, territoriality, aggression, competition, cooperation, etc.) and alleged implications for society (including laissez-faire and planned economic systems, conformity and deviance, social stability and social change). Readings in scholarly and popular sources from Hobbes, Malthus, Spencer, and Darwin to Lorenz, Ardrey, Skinner, and Wilson. ***(Not offered 1981-82.)***
S. L. Chorover

9.30 Animal Behavior (Revised Content)

Prereq.: 9.00
Year: U (1)
3-0-6

Review of basic concepts in the study of animal behavior. Examination of the natural history of selected species (e.g., felids, canids, and cephalopods). Contributions of environment and heredity to the shaping of behavior. Inquiry into the contribution of behavior to meeting requirements for individual and species survival. Analysis of selected problems including animal communication, navigation, sexual behavior, aggression, defense, perception and learning.
A. Hein

9.340 Control of Movement in Biological and Robotic Systems (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Synthesizes recent approaches toward motor control in the fields of neurophysiology, artificial intelligence, and systems theory. Topics: understanding the physical plant in biological and artificial systems. Kinematics, statics, dynamics. Actuators and effectors. Control of unconstrained movements: open loop control and trajectory determination. Feedback control and reflexes. Control of constrained movements: handwriting, manipulation, and locomotion. (Alternate years. ***Offered 1981-82.***)
E. Bizzi, J. Hollerbach, T. L. Johnson

9.342 Movement: Mechanisms and Models (A)

Prereq.: Permission of Instructor
Year: G (1, 2)
3-0-6

Survey of basic concepts and methods in the study of motion behavior.
E. Bizzi

9.35 Perception: Mechanisms and Models

Prereq.: 9.00
Year: U (2)
3-0-6

Survey of current knowledge of sensory processes and neural systems underlying perception in humans and other animals. Basic properties of vision, hearing, smell, touch, and taste discussed. Vision covered most extensively. Topics include: sensory transduction; neural encoding and feature extraction; perception of color, form, motion, and depth; development and transformation of space perception. (May be counted toward Humanities Requirement *only* by students concentrating in Psychology; see Department for details.)
R. M. Held, Staff

9.351 Seminar on Sensation and Perception

Prereq.: Permission of Instructor
Year: G (2)
4-0-8

Reading, discussion, and criticism of current theory and experiments bearing on topics selected according to interests of participants. Topics: perception of form, motion, and space; sensorimotor interaction; relevant neural processes; theoretical models, comparisons among species; and developmental approaches. ***(Not offered 1981-82.)***
R. M. Held, Staff

9.36 Natural Computation and Control

Prereq.: 18.02
Year: U (1)
3-0-6

Animate and inanimate objects differ widely from each other as well as among themselves in terms of their appearance and behavior in a natural environment. These differences and variations are limited, however, by the natural and physical properties of the world. By understanding these constraints imposed by nature, we can begin to understand how different objects may be represented, for object identification can then be viewed as the exploitation of a code that is subject to highly constraining biological, optical, mechanical, and tactile laws. Emphasis on computing representations of various aspects of visual scenes; treatment of communication by speech sounds included, as well as natural design constraints on manipulators for tactile shape recognition and control. (May *not* be counted toward Humanities Requirement.)
W. A. Richards, P. H. Winston, C. L. Searle

9.361 Neurophysiology of the Visual System (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-6

Review of the current neurophysiological and neuroanatomical research literature on the mammalian visual system. ***(Not offered 1981-82.)***
P. H. Schiller

9.365 Dissection by Psychophysics (A) (Revised Unit)

Prereq.: 9.35 or 9.36
Year: G (2)
Arr.

Non-invasive techniques for analyzing the flow and processing of information by the brain. Illustration of dissection methods include isolation of receptors, first and second neural levels, thalamus, mid-brain, and at least two hierarchical levels to cortex. Inclusion of feedback as well as feed-forward or shunting mechanisms. Although major examples are visual, some consideration given to auditory and somatosensory systems. Students elect one of the following topics for tutorial study to apply dissection techniques: color vision, texture perception, movement perception, space perception, or cognitive information processing. (Permission of instructor required.)
W. A. Richards

9.366 Vision Algorithms and Psychophysics (A)

Prereq.: 9.36
Year: G (2)
3-0-6

Seminar in the application of algorithmic techniques to vision by humans or machines. Theoretical and empirical problems in representing the various aspects of a visual scene. Topics include brightness, color, texture, stereo vision, motion, surface orientation, the primal sketch, the 2 1/2D sketch (cyclopean retina), and object-centered representation of 3D shape. (Permission of instructor required.)
W. A. Richards, T. Poggio, S. Ullman

9.401 Survey of Cognition and Perception (New)

Prereq.: Permission of Instructor
Year: G (2)
6-0-12

Topics include visual and auditory perception, concentrating on higher-order processing and computational approaches, information processing, memory and attention, psycholinguistics, organization and control of action, and conceptual development. The fundamental question addressed is that of how representations of objects and events, and of the actions taken upon them, are constrained by the structure of mind and of the environment. (Consult M. C. Potter.)
Staff

9.50 Research in Psychology

Prereq.: 9.00 or 9.55 or 9.90J; and one other subject in Psychology
Year: U (1, 2, S) LAB
2-8-2

Laboratory research in the areas of perception, learning, memory, and development. Each student carries out an experimental study in one of these areas. Written presentation of results is required. (Consult P. H. Schiller.)
Staff

9.55 Introduction to Language and Cognition

Prereq.: —
Year: U (2)
3-0-6

It traditionally has been held that the examination of languages is among the best ways to discover the workings of the human mind. This subject is an introduction to current work on linguistic and cognitive phenomena. Topics include some or all of the following: What is a language? Do other species have language? Relation of language to thought. Information processing in perception and memory. Imagery and other forms of mental representation. Cognitive development.
Staff

9.59 Psychology of Language and Communication

Prereq.: 9.55 or 24.951
Year: U (1)
3-0-6

Study of language processes in light of contemporary linguistic theory; examination of problems of language production and perception. Methodological implications of psycholinguistic experiments and theory stressed. ***(Not offered 1981-82.)***
M. F. Garrett

9.590J Serial and Temporal Factors in Language Processing (A)

(Same subject as 24.985J)
Prereq.: 24.901J or 9.55
Year: G (2)
3-0-9

Examination of recent linguistic and psycholinguistic evidence for serial effects in the processing of language for comprehension and production. (Permission of instructor required. ***Not offered 1981-82.***)
M. F. Garrett, J. R. Ross

9.591 Seminar in Psychology of Language and Communication I (A)

Prereq.: 9.59 or 9.901
Year: G (1)
3-0-6

Reading, discussion, and criticism of selected topics. Emphasis on one or more of the following themes in a particular term: theories of language, speech perception, communication in sub-human species, aphasia, language acquisition, language and thought, interaction between grammatical structure and verbal performance.
J. A. Fodor

9.592 Seminar in Psychology of Language and Communication II (A)

Prereq.: 9.591
Year: G (2)
3-0-6

Advanced topics in psycholinguistics. (A research paper required as part of this subject.)
M. F. Garrett

9.62J Introduction to Cognitive Science (New)

(Same subject as 24.116J, SRE 108J)
Prereq.: —
Year: U (1)
3-0-9

Survey of major issues that occupy contemporary cognitive science. Topics: induction and inductive logics as psychological theories; formal learning theory in linguistics; Is English a finite state language?; deduction and deductive logics as psychological theories; concepts and conceptual composition; the problem of natural concepts; images and percepts. Emphasis on clear formulation of questions and theoretical criteria of adequacy. Examination of specific proposals in response to these questions.
D. N. Osherson

9.630J Natural Concepts (A)

(Same subject as SRE 228J)
Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Psychological theorizing requires an account of what concepts humans find natural, i.e., readily understandable and easily encoded in natural language. The problem of stating a non-question-begging distinction between natural and unnatural concepts occupies this subject. Several formal theories of conceptual naturalness are examined that attempt to link the distinction to independently motivated theories of simplicity, deductive validity, ontology, induction, and syntactic well-formedness. (Restricted enrollment. ***Not offered 1981-82.***)
D. N. Osherson

9.631J The Psychology of Reasoning (A)

(Same subject as SRE 234J)
Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Over the past 50 years a variety of logical formalisms has been developed to systematize the deductive validity and inductive strength of arguments. Often, such systems provide incompatible accounts of logical truth or probability. Treats logical systems as theories of human reasoning. General criteria of empirical adequacy are formulated and discussed and psychological data brought to bear on proposed logics.
D. N. Osherson

9.65J Cognitive Processes

(Same subject as SRE 245J)
Prereq.: —
Year: U (1)
3-0-6

An introduction to human information processing and learning; topics include memory, problem solving, concept formation, complex perceptual processes, and related issues.
M. C. Potter, S. Carey

9.651 Cognitive Processes (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Focus on one or more special topics in the fields of human information processing, representation, relation of pictorial and linguistic knowledge; episodic vs semantic memory; concept learning.
M. C. Potter

9.652J Seminar in Cognitive Development (A)

(Same subject as SRE 231J)
Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Critical survey of selected topics. Emphasis on one or more of the following: growth of logic; relation between conceptual change in the history of science and in the individual child; cognitive development from an information processing point of view. (Open only to graduates or undergraduates who have taken a subject in either cognitive psychology, developmental psychology, or artificial intelligence.)
S. Carey

9.653J Cognitive Theories (A)

(Same subject as 24.517J)
Prereq.: Permission of Instructors
Year: G (1)
3-0-9

Problems and topics in contemporary and historical approaches to higher cognitive processes. Material from the history of philosophy and from current work in psychology, philosophy, and linguistics examined from the point of view of its bearing on such issues as: what is the nature of the conceptual systems which internally represent knowledge and belief? How are such systems acquired and how are they employed in action, perception, and recall? To what extent is the nature of such systems discoverable from the examination of semantic and syntactic phenomena of natural languages? ***(Not offered 1981-82.)***
J. A. Fodor, N. A. Chomsky

9.68 Affect: Biological, Psychological, and Social Aspects of "Feelings"

Prereq.: 9.00
Year: U (2)
3-0-6

What is affect: This seminar addresses this question in an effort to make an important aspect of human experience comprehensible. Considers the nature of affect and traces both its development within the individual human being and its connections with various cognitive and behavioral variables. Reviews some relevant features of brain organization. Examines some familiar aspects of human culture to determine the extent to which they may properly be regarded as socially organized counterparts of individual feelings.
S. L. Chorover

9.70 Social Psychology

Prereq.: —
Year: U (2)
3-0-6

Examination of the basic processes by which people interact, perceive and make judgments of others, influence each other, and develop social beliefs and values, in the context of small and large groups and societies.
S. L. Chorover

9.88 Development of Behavior (Revised Content)

Prereq.: 9.00
Year: U (2)
3-0-6

History of the changing concepts of infancy, childhood and development. Interaction of innate and experiential factors in the development of learning capacities, perception, social behavior and motor patterns in both animals and humans. Implications of evolution, genetics, embryology and early experience for the ontogeny of behavior. (Alternate years. ***Offered 1981-82.***)
A. Hein

9.881 Seminar in the Development of Behavior (A) (Revised Content)

Prereq.: Permission of Instructor
Year: G (2)
3-0-6

History of the changing concepts of infancy, childhood and development. Interaction of innate and experiential factors in the development of learning capacities, perception, social behavior and motor patterns in both animals and humans. Implications of evolution, genetics, embryology and early experience for the ontogeny of behavior. (Alternate years. ***Not offered 1981-82.***)
A. Hein

9.90J Human Development: Individual and Social Perspectives

(Same subject as SRE 107J)
Prereq.: —
Year: U (2)
3-0-6

Psychological processes and structures examined from a developmental perspective. The evolution of individual personality and social awareness treated first, followed by an overview of leading theories of cognitive growth. The perceptual, cognitive, and affectional systems operative in the human infant given special attention; the organization of these immature systems linked to the theoretical problem of the role of childhood experience in mature intellectual and emotional organization.
D. N. Osherson

9.901 Proseminar in Psychology (A) (Revised Unit)

Prereq.: Permission of Instructor
Year: G (1)
6-0-6

General introduction to graduate work in psychology and brain science, to be taken in conjunction with other, more specialized subjects depending upon student's background and interests. (Restricted to Course IX graduate students.)
Staff

9.91-9.92 Topics in Psychology

Prereq.: 9.00; and any other two subjects in Psychology
Year: U (1, 2)
Arr.

Critical survey of contemporary problems in psychology. (Consult P. H. Schiller.)
Staff

9.911-9.916 Special Topics in Psychology (A)

Prereq.: Permission of Instructor
Year: G (1, 2, S)
Arr.

Opportunity for graduate study of advanced subjects in psychology not included in other subject listings. (Programs subject to approval of professor in charge. Consult W. A. Richards.)
Staff

9.921 Research in Psychology (A)

Prereq.: 9.901
Year: G (1)
Arr.

9.922 Research in Psychology (A)

Prereq.: 9.901
Year: G (2)
Arr.

9.923 Research in Psychology (A)

Prereq.: 9.901
Year: G (S)
Arr.

Guided research under the sponsorship of individual members of the faculty. Ordinarily restricted to candidates for the doctoral degree in psychology.
Staff

9.924 Basic Research Strategy, Experiment Planning, and Data Manipulation

Prereq.: —
Year: G (2)
3-3-3

Introduction to basic concepts of planning, conducting, and evaluating the results of experiments in the behavior sciences. Published research and experiments conducted in class are used as examples of the research process. Includes laboratory experience in generating and collecting data, as well as in computer-aided data analysis.
R. M. Held, Staff

10 Chemical Engineering

10.UR Undergraduate Research

Prereq.: —
Year: U (1, 2)
Arr.

Opportunity for participation in the work of a research group or for special investigation in a particular field. Topic and hours to fit individual requirements.
C. M. Mohr

10.10 Process Synthesis

Prereq.: —
Year: U (2) SD
3-0-6

An introduction to the invention of processes for the large-scale, low-cost processing of materials such as water, chemicals, petroleum products, food, drugs, and wastes. Open to students in any field desiring a practical introduction to process engineering. (Open to freshmen.)
C. M. Mohr

10.11 Computer Models of Physical and Engineering Systems (Revised Unit)

Prereq.: 18.02, 8.01
Year: U (1) SD
3-0-9

Reduction of physical and engineering systems to simplified physical and mathematical models; representation using networks; graphs and finite element methods. Process simulations using random variables (Monte-Carlo techniques) and Linear and Dynamic Programming. Manipulation of the resulting models using algorithms on digital computers. Examples drawn from fields primarily of interest to scientists and engineers, with some attention to styles of problem solving. Extensive "hands-on" computing experience. (Working knowledge of FORTRAN expected.) This subject is an Engineering School-Wide Elective.
B. Schumacker, R. Kaplow, K. J. Bathe

10.13 Mass and Energy Processing

Prereq.: *18.02*
Year: U (1) SD
4-0-8

Basic concepts and chemical applications of the material balance. Theoretical development of classical thermodynamics: concepts of energy, equilibrium, and reversibility; the Fundamental Equation of simple systems; properties of pure materials. Introduction to the properties of mixture, phase equilibrium, and chemical equilibrium. Recitation section emphasizes applications in mass and energy conversion with closed and open systems, and analysis of industrial chemical process technology.
C. M. Mohr

10.14 Chemical Engineering Thermodynamics

Prereq.: 10.13
Year: U (2)
3-0-6

Extension of 10.13, intended primarily for chemical engineering majors. Thermodynamics of multicomponent systems, criteria of equilibrium and stability, phase equilibrium, chemical equilibrium in homogeneous and heterogeneous systems, electrochemical systems.
F. A. Putnam

10.17 Air Pollution Fundamentals

Prereq.: 5.41, 18.02
Year: U (2) SD
2-0-4

Introduction to the causes, effects, and control of air pollution with emphasis on combustion generated pollution and industrial process sources; origin and fate of air pollutants; air pollution meterology; combustion processes and the formation of gaseous and particulate pollutants; air pollution control principles; measurement methods for gaseous air pollutants and for particulates, sampling and analytical techniques.
G. C. Williams

10.18 Industrial Chemistry

Prereq.: 5.41, 10.14, 10.302
Year: U (2)
3-0-6

Study of processes for making industrial chemicals as systems. Exploration of those factors which determine the flow sheet and apparatus required for carrying out the reactions and associated operations. Extensive problem work on the influence of stoichiometry, energy requirements, equilibria, kinetics and the transfer processes on overall design and operation.
R. F. Baddour

10.19 Experimental Methods in Combustion and Heat Transfer

Prereq.: 10.302, 10.37
Year: U (2)
2-8-2

Study of modern diagnostic methods in combustion and high temperature heat transfer processes. Themes selected to cover problems of topical interest such as coal-oil slurry combustion, combustion of fuels derived from coal or shale. Students receive instructions on methods of measurements of temperatures and radiative heat transfer, in high temperature reacting systems, on collection and analyses of representative gas and solid samples, measurement of gas and particulate velocities and in general, the characterization of particulate clouds and fuel sprays. Students working in small teams are assigned projects preferably relating to ongoing research programs involving the pilot plant size Combustion Research Facility and the Fluidized Bed Combustor. (Enrollment limited. Permission of instructor required.)
J. M. Beér, A. F. Sarofim

10.21 Structures and Properties of Matter

Prereq.: 5.41, 5.62
Year: U (1)
3-0-6

Atomic and molecular interactions and their importance in determining physical and chemical properties of matter. Dielectric properties of materials. Description of physical and specific chemical intermolecular forces, including hydrogen bonds. Bulk and interfacial properties of pure and mixed gases and liquids. Techniques for characterizing molecular structure and for predicting properties of matter.
C. K. Colton

10.25 Industrial Chemistry (A)

Prereq.: 5.41, 10.14, 10.302
Year: G (1, 2)
3-0-6

Study of the factors determining the flow sheets, equipment design, and interrelations in plants for producing industrial chemicals. Many examples drawn from the inorganic and organic industries both quantitatively and qualitatively.
M. P. Manning, P. S. Virk

10.26 Chemical Engineering Laboratory

Prereq.: 5.41, 10.14, 10.302
Year: U (1)
2-8-2

Laboratory projects in the areas of applied chemical research and unit operations. Emphasis on applications of engineering concepts and fundamentals to solution of practical and research problems. Training in planning research projects, execution of experimental work, and articulation (both oral and written) of the research plan and results in the areas of applied chemical technology and engineering operations related to mass, momentum, and heat transfer.
R. F. Baddour, M. P. Manning, J. E. Vivian

10.301 Fluid Mechanics

Prereq.: 18.03
Year: U (1)
3-0-6

Introduction to the mechanical principles governing fluid flow. Stress in a fluid. Conservation of mass and momentum using differential and integral balances. Elementary constitutive equations for fluids. Hydrostatics. Exact solutions of the Navier-Stokes equations. Approximate solutions using control volume analysis. Mechanical energy balances and Bernoulli's equation. Dimensional analysis and dynamic similarity. Introduction to boundary layer theory.
R. A. Brown, J. F. Brady, H. H. Sawin

10.302 Transport Processes

Prereq.: 10.13, 10.301
Year: U (2)
3-0-6

Principles of heat and mass transfer. Steady and transient conduction and diffusion. Convective transport of heat and mass in both laminar and turbulent flows. Natural convection. Condensation and boiling. Application to design of heat exchangers. Radiative heat transfer.
A. F. Sarofim, F. M. Gelbard

10.311 Continuum Mechanics

Prereq.: 10.301
Year: U (1)
4-0-8

A sound foundation for extensive work. Kinematics of continua; forces and stresses in continua; fluid statics; flow of an ideal fluid; rheology of real fluids; simple laminar flows.
K. A. Smith

10.312 Transport Phenomena

Prereq.: 10.311
Year: U (2)
4-0-8

Convective heat and mass transfer. Boundary layer flows, turbulence, the analogies, flow past bluff bodies, condensation, natural convection.
K. A. Smith

10.32 Separation Processes

Prereq.: 10.14, 10.302
Year: U (1)
3-0-6

General principles of separation by equilibrium and non-equilibrium processes. Graphical and analytical treatment of binary cascades with emphasis on binary distillation; ideal cascade theory as applied to isotope separation. Solvent extraction, absorption, and humidification in plate and packed towers. Approximate and tridiagonal matrix techniques for treating multicomponent distillation. Thermodynamic efficiency of separation processes and study of other selected separation processes.
J. P. Longwell, S. M. Senkan

10.33 Analytical Treatment of Chemical Engineering Processes (A)

Prereq.: 10.301, 18.03
Year: G (1)
3-0-6

Mathematical techniques for handling rate problems with diffusion, heat transfer, and chemical reactions basic to most chemical engineering operations. Formulation of problems corresponding to specific physical situations in terms of ordinary differential, partial differential, and finite-difference equations. Solution of these equations by appropriate analytical and numerical methods.
R. C. Armstrong

10.34 Numerical Methods Applied to Chemical Engineering (A)

Prereq.: 10.33
Year: G (2)
3-0-6

Numerical methods for solving problems arising in heat and mass transfer, fluid mechanics, and chemical reaction engineering. Topics: numerical linear algebra, solution of nonlinear algebraic equations and ordinary differential equations, and finite-difference and finite-element methods for elliptic and parabolic partial differential equations. All methods presented in context of problems arising in transport phenomena. Lectures and assignments assume knowledge of FORTRAN.
R. A. Brown

10.341 Finite Element Methods for Problems in Transport Phenomena (A)

Prereq.: 10.34
Year: G (2)
3-0-6

Advanced methods for solving problems in fluid mechanics and heat and mass transfer. Emphasis on efficient techniques for handling highly irregular boundaries, nonlinearities, complicated boundary conditions, and singularities. Variational, Galerkin, and collocation schemes discussed.
R. A. Brown

10.35 Chemical Process Dynamics and Control (A)

Prereq.: 10.37, 18.03
Year: G (2)
3-0-6

Optimum steady-state design and control. Dynamical behavior of chemical process units such as chemical reactors, separation units, and heat exchangers. Examination of linear, linearized, and nonlinear process models. Stability analysis. Design of simple PID controllers. Bode diagrams and root locus techniques. Introduction to multivariable control systems. Cascade, modal, and feedforward control. Selection of control and measurement variables. (Open to qualified undergraduates.)
C. Georgakis

10.351 Advances in Process Control (A)

Prereq.: 10.35 or 6.231 or 2.14 or 6.302 or 16.20
Year: G (2)
3-0-9

Detailed exposure to areas of multivariable control theory of importance to process control applications. Emphasis is on distributed parameter and large finite-dimensional systems. Examples are drawn from industrial flow processes with emphasis on chemical engineering systems such as chemical reactors, distillation columns, multiple effect evaporators.
C. Georgakis

Engineering Operations

10.36 Process Design

Prereq.: 10.302, 10.32
Year: U (2)
3-0-6

Presentation and discussion of real process design problems, with case studies in chemical processing and petrochemicals. Emphasis on conception and invention of processes, as well as analysis and economic balances, to specify optimum design and operating conditions. Discussion of a variety of cases throughout the term.
C. M. Mohr

10.37 Chemical Kinetics and Reactor Design

Prereq.: 5.41, 10.301
Year: U (2)
3-0-6

Fundamentals of chemical kinetics. Analysis of batch, plug flow, and continuous stirred tank reactors for single, multiple, and series-type reactions. Introduction to concepts of residence time distribution and chain reactions. Consideration of some real reactors and typical reactor design problems.
P. S. Virk

10.371 Chemical Reactor Analysis (A)

Prereq.: 10.37, 10.33
Year: G (1)
3-0-9

Analysis of the interplay of chemical kinetics, fluid mechanics, heat and mass transfer in the design of chemical reactors. Development and analysis of lumped or distributed parameter models for batch or continuous flow isothermal, adiabatic or non-adiabatic reactors. Parametric analysis. Uniqueness and multiplicity of operating points. Stability criteria. Hot spots and runaway conditions. Numerical techniques. Optimal design. Estimation of model parameters from experimental data.
C. Georgakis

10.38 Analysis and Simulation of Chemical Processing Systems (A)

Prereq.: 10.302, 18.03
Year: G (2)
2-2-4

Introduction to techniques for computer-aided analysis of chemical processing systems. Development of mathematical models to describe dynamic and steady-state process behavior. Representation of the structure of complex, interconnected chemical processes with arbitrary recycle stream. Numerical methods for solving resulting systems of nonlinear differential and algebraic equations. Application of various mathematical optimization techniques. Survey of recent developments in comprehensive problem-oriented computing systems to assist in chemical process design. A knowledge of FORTRAN programming assumed.
L. B. Evans

10.39 Energy Technology (A)

Prereq.: 10.13, 10.14
Year: G (2)
3-0-6

Study of the factors determining the choice of energy technologies and their individual design and performance features. Consideration of energy supply-demand patterns, economics, efficiency of resource utilization, and environmental and social effects. Special emphasis given to synthetic fuel systems and to utilization-related energy technologies. Special subjects such as fuel cells, solar energy, and geothermal energy can be studied and presented as term paper topics. (Open to undergraduates by permission of instructor.)
J. B. Howard, J. P. Longwell

10.40 Chemical Engineering Thermodynamics (A)

Prereq.: 10.13
Year: G (1, 2)
4-0-8

Basic postulates of classical thermodynamics. Application to transient open and closed systems. Criteria of stability and equilibria. Thermodynamic properties of pure materials and mixtures with some discussion of estimation and correlating techniques. Phase and chemical equilibria. Applications emphasized through extensive problem work relating to practical cases.
R. C. Reid

10.41 Distillation (A)

Prereq.: 10.13, 10.32
Year: G (2)
3-0-6

General principles of staged contacting with major emphasis on the distillation of binary and multicomponent mixtures. Vapor-liquid equilibria of high pressure and non-ideal multicomponent systems. Cascade configurations. Graphical, analytical, and computer techniques for binary and multicomponents systems. Vapor-liquid contacting theory from transport fundamentals.
J. E. Vivian

10.42 Advanced Thermodynamics (A)

Prereq.: 10.40
Year: G (2)
2-0-6

Equilibrium and stability concepts examined in depth. Surface thermodynamics, equilibrium in body force fields, irreversible thermodynamics comprise other topics.
R. C. Reid

10.47 Ion Exchange (A)

Prereq.: 10.13, 10.301
Year: G (2)
2-0-4

Preparation and properties of synthetic organic exchangers. Industrial applications of the general ion exchange process; equilibrium and rate studies for fixed and moving beds; ion exchange chromatography.
R. F. Baddour

10.48J Gas-Solid Reactions (A)

(Same subject as 3.551J)
Prereq.: 3.55, 10.50
Year: G (2)
3-0-6

Elements of Gas-Solid Reactions, involving single particles, including chemical kinetics, heat and mass transfer pore diffusion effects, and structural changes. Reaction of porous and non-porous particles, reactions between solids, proceeding through gaseous intermediates. Review of experimental techniques used for study of gas-solid reactions, including physical characterization of solid specimens. Behavior of multi-particle systems, such as packed beds, fluidized beds, and rotary kilns. Gas-solid reactions of industrial importance, including coal gasification, iron oxide reduction, roasting of sulfide ores, reaction of SO_2 with limestone, and incineration of urban wastes. Text: J. Szekely, J. W. Evans, and H. Y. Sohn, *Gas-Solid Reactions*, Academic Press, 1976.
C. Georgakis, J. Szekely

10.49J Biomedical Transport Phenomena (A)

(Same subject as HST 521J)
Prereq.: 10.301, 10.302
Year: G (2)
2-0-5

Application of the principles of transport phenomena to the analysis of selected physiological processes and the design of artificial internal organs and extracorporeal devices. Review of pertinent physiological principles. Rheology of blood. Convective and diffusive mass transport in blood and tissues. Mass transport characteristics of biological and synthetic membrane processes. Clinical application of artificial internal organs, with emphasis on artificial kidneys and cardiopulmonary assist devices.
C. K. Colton, W. M. Deen

10.50 Heat and Mass Transfer (A)

Prereq.: 10.302 or 10.312
Year: G (1, 2)
3-0-6

Fundamentals of diffusive and convective transport of heat and mass. Analytical and numerical solutions to steady-state and transient diffusion problems. Superposition techniques. Forced convection of heat and mass in laminar flow. Turbulent diffusion. Mass, heat, and momentum transfer from a phase boundary to a turbulent fluid. Simultaneous heat and mass transfer.
F. M. Gelbard, S. M. Senkan, J. W. Tester

10.51 Macromolecular Hydrodynamics (A)

Prereq.: 10.301
Year: G (2)
3-0-6

Observed phenomena in polymeric flow systems. Techniques of viscometry and viscoelastic measurements for polymeric fluids. Rheological models. Continuum theories. Molecular theories of polymeric fluids. Analytical solutions to flow problems; non-Newtonian viscosity, linear viscoelasticity, normal stresses, recoil, stress relaxation, etc. Unit operations of the polymer industry; extrusion, blow molding, injection molding, mixing. (Alternate years. ***Offered 1981-82.***)
R. C. Armstrong

10.52 Mechanics of Fluids (A)

Prereq.: 10.302 or 10.312
Year: G (1)
3-0-6

Content varying each year; material drawn from topics such as boundary layer theory, turbulence, rheology, hydrodynamic stability, compressible flow, and continuum mechanics.
R. A. Brown

10.53 Chemical Engineering Design (A)

Prereq.: 10.302 or 10.312, 10.32
Year: G (2)
3-0-6

Design of a complete plant. Plant size, location, and selected process based on market analysis and technical and economic evaluation of alternate processes and of sources of raw material.
C. M. Mohr

10.54 Advanced Topics in Mass Transfer (A)

Prereq.: 10.50
Year: G (1)
3-0-6

Advanced treatment of molecular and eddy diffusion and mass transfer between phases. Theories of mass transfer with simultaneous chemical reactions. Process design cases involving gas absorption.
K. A. Smith

10.55 Advanced Topics in Heat Transfer (A)

Prereq.: 10.50
Year: G (1)
3-0-6

Advanced treatment of selected problems in heat transfer of current concern to the chemical engineer. Choice of problems in conduction, simultaneous heat transfer and chemical reaction, condensation, natural convection, and radiation. Emphasis on such analytical methods as superposition, perturbation, asymptotic methods, integral equations.
K. A. Smith

10.56 Chemical Engineering in Medicine (A)

Prereq.: 5.62, 10.301
Year: G (2)
2-0-4

Seminar on application of chemical engineering principles to understanding of biological phenomena, in particular human physiology, and to solution of medical problems. Selected topics of current interest, such as membrane transport and artificial organ technology. Visits to local hospitals; discussions with physicians, surgeons, and life scientists on problems of mutual interest.
C. K. Colton

10.57J Polymer Processing (A)

(Same subject as 2.820J)
Prereq.: 10.301
Year: G (2)
3-0-9

Review of physicochemical properties, and mechanical and rheological behavior of polymers. Uses of polymers as adhesives, foams, coatings, engineered rigid plastics, and elastomers. Survey of processing techniques. Modeling, analysis, and scale-up of extrusion, molding, thermoforming, calendering, and mixing. Chemical aspects of polymer processing, e.g., degradative reactions, synthesis for separations, methods for cross-linking. Case studies in process syntheses. Relationship between selected processing techniques and properties of end products. Limitations of the present state of the art. Assigned projects. (Alternate years. ***Not offered 1981-82.***)
R. C. Armstrong, E. W. Merrill, L. Erwin, N. P. Suh

Applied Chemistry

10.58J Artificial Internal Organs (A)

(Same subject as HST 520J)
Prereq.: Permission of Instructor
Year: G (2)
2-0-6

Theory and clinical application of artificial internal organs, particularly artificial kidneys and cardiopulmonary assistance devices. Review of pertinent engineering principles of mass transfer, fluid mechanics, and membrane transport. Problems posed by interaction of blood components and biomaterials. Design and performance of devices. Examples of artificial organ therapy for treatment of severe clinical disorders examined in detail to reveal limitations of the current state of the art. Previous exposure to mammalian physiology, calculus, and physical chemistry desirable.
C. K. Colton, W. M. Zapol, E.G. Lowrie

10.59 Properties of Gases and Liquids (A)

Prereq.: 5.62
Year: G (2)
3-0-6

Intermolecular forces including dipole, multipole, induced dipole, and London-type forces. Application of intermolecular force theories to the problems of predicting equilibrium and transport properties of gases and liquids. Modern theories of liquid structure are reviewed.
R. C. Reid

10.60 Heterogeneous Catalysis and Catalytic Processes (A)

Prereq.: 5.62 or 10.37
Year: G (1)
3-0-6

Relationships of activity and selectivity to physical and chemical properties of a solid catalyst. Physical adsorption, chemisorption. Kinetic models and correlation of rate data. Components and preparation of catalysts. Physical characterization and examination of catalyst structures. Supported metal catalysts, acid catalysts and molecular sieve catalysts, catalytic oxidation. Processing of petroleum and hydrocarbons. Synthesis gas and associated processes. Experimental methods.
C. N. Satterfield

10.61J Surface and Colloid Chemistry (A)

(Same subject as 3.24J)
Prereq.: 5.62 or 3.20
Year: G (1)
3-0-6

Thermodynamic, kinetic, and chemical factors underlying surface and interfacial phenomena. Intermolecular forces and origins of surface tension. Capillarity and effects of surface curvature on bulk phase properties. Thermodynamics of adsorption at interfaces; the Gibbs adsorption isotherm. Electrical phenomena at interfaces: origins of surface potential, structure of the diffuse double layer. Surface active agents and orientation at interfaces. Contact angles, spreading and wetting phenomena. Properties of colloidal electrolytes, micelle formation, solubilization phenomena. Classical theory of charge stabilization in colloidal systems, macromolecular stabilization, stability in emulsions and nonaqueous media, flocculation. Electrokinetic phenomena. Applications of these fundamentals in understanding: emulsification, foaming, flotation, detergency, adhesion, lubrication, ceramics, polymers, metallurgy.
F. A. Putnam, A. Bleier

10.613J Solid-State Surface Science (A)

(Same subject as 3.22J)
Prereq.: 10.40 or 3.20
Year: G (2)
3-0-6

Structural, chemical, and electronic properties of solid surfaces in ionic crystals, metals, and ceramics. Surface analytical tools for characterizing the structure and composition of solid surfaces in ultra-high vacuum, with emphasis on Auger and photoelectron spectroscopies, and electron diffraction techniques. Surface thermodynamics and kinetics. Phase transitions at surfaces. Effects of interactions of surfaces with crystalline defects. Applications, including heterogeneous catalysis, oxidation, crystal growth, and tribology.
F. A. Putnam, R. M. Latanision

10.615 Integrated Circuit Processing (A) (New)

Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Introduction to the basic process techniques used in semiconductor device fabrication with particular emphasis on silicon monolithic integrated circuits. Review of fundamental solid-state chemistry and physics. Introduction to basic semiconductor device physics. Prime emphasis on application of transport phenomena, thermodynamics, chemical kinetics, process design, and process control to integrated circuit processing. Topics include crystal growth, chemical vapor deposition, oxidation, etching, lithography, dopant diffusion, metalization.
H. H. Sawin

10.62 Electrochemistry (A) (New)

Prereq.: 10.14, 10.302
Year: G (1)
3-0-6

Principles of thermodynamics, kinetics, and transport processes applicable to electrochemical systems. The electric potential, potentials of reference electrodes and of cells with junctions. Debye-Huckel and other models for activity coefficients of ionic solutions. Structure of the electric double layer. Electrode kinetics. Transport in electrolyte solutions by convection, diffusion, and ion migration. Electrokinetic phenomena. Current distribution and mass transfer in electrochemical systems. Applications, including fuel cells and electrogenerative processes.
W. M. Deen, C. G. Vayenas

10.63 Adsorption and Catalysis (A)

Prereq.: 5.62
Year: G (2)
3-0-6

Adsorption and catalysis from a fundamental viewpoint. Adsorption thermodynamics and consideration of adsorbed layers as a thermodynamically distinct phase. Adsorbate-adsorbate interactions, formation of ordered surface structures and effects of surface morphology. Dynamic processes among surface atoms and kinetics of surface reactions. General theories of chemisorption and heterogeneous catalysis. Examples of experimentally observed phenomena and discussion of recent clean surface studies and methods.
F. A. Putnam

10.641 Structure and Properties of Polymers (A)

Prereq.: 5.42; 5.60 or 5.62
Year: G (1)
3-0-6

Introduction to properties of polymers with particular reference to molecular structure. Microstructure of chain molecules. Molecular weight distributions — effect on properties. Crystallinity and crystallization. The glassy state and glass transitions. Rubber elasticity. Steady-

state polymer rheology. Introduction to viscoelasticity. Survey of principal mechanical properties. Diffusion and permeation in polymeric substance.
R. E. Cohen

10.642 Molecular and Phenomenological Interpretation of Polymer Viscoelasticity (A)

Prereq.: 5.60 or 5.62
Year: G (2)
2-0-7

Theory and phenomenological aspects of linear viscoelastic behavior in polymers. Material functions and their interconversion, model representation and time-temperature equivalence. Review of molecular theories of polymer behavior. Introduction to nonlinear viscoelasticity. (Alternate years. ***Offered 1981-82.***)
R. E. Cohen

10.65 Chemical Reactor Engineering (A)

Prereq.: 10.37
Year: G (2)
3-0-6

Application of chemical kinetics to development and improvement of industrial processes. Theories of chemical kinetics, complex kinetics, homogeneous liquid phase kinetics, chain reactions. Non-ideal reactor analysis, including residence time distributions, concepts of mixedness and segregation dispersion and CSTR models. Mass and energy transfer limitations in heterogeneous non-catalytic, catalytic and electrocatalytic reaction systems. Reactor stability and sensitivity to operating parameters. Choice and design of reactors for heterogeneous reactions. Emphasis on interpretation and correlation of experimental data and application to kinetic and reactor design problems.
C. G. Vayenas, J. Wei

10.651J Fluidization (A)

(Same subject as 2.65J)
Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Regimes of fluidizations, slugging, spouted and particulately fluidized beds. Motion of a single bubble in fluidized beds. Bubble behavior and growth in a multi-bubble bed. Properties of emulsion phase in dense bubbling beds. Heat and mass transfer in fluidized beds. Gas-solid reactions. Treatment of particle ensembles. Conversion of gas in bubbling systems. Analysis of non-catalytic gas-solid reactions. Applications to heat exchangers and fluidized-bed combustors. (Alternate years. ***Offered 1981-82.***)
A. F. Sarofim, L. R. Glicksman

10.655 Multiphase Chemical Reactors (A)

Prereq.: 10.37
Year: G (2)
3-0-6

Mass transfer with simultaneous chemical reaction in gas-solid, gas-liquid, and gas-liquid-solid systems. Analysis of contacting patterns and of mass and energy effects in multiphase chemical reactors, including slurry-type reactors, trickle beds, fluidized beds and reactors for homogeneously catalyzed reactions. Emphasis on interpretation of phenomena, application of theory, and use of experimental data for scale-up and mathematical modeling. Attention directed primarily to reactions catalyzed heterogeneously or homogeneously, and to applications in fossil fuel processing and new synfuel processes.
C. N. Satterfield

10.66 Polymer Rheology Laboratory (A)

Prereq.: 10.301
Year: G (2)
1-5-6

Experimental methods for characterizing polymeric fluids. Shear flow properties including non-Newtonian viscosity, normal stress differences, linear viscoelastic properties, and transient nonlinear properties. Elongational flow properties. Effects of concentration, molecular weight distribution, molecular structure. Theory for analysis of experimental results. (Permission of instructor required. Alternate years. ***Offered 1981-82.***)
R. E. Cohen, R. C. Armstrong

10.67 Polymer Science Laboratory (A)

Prereq.: 5.62
Year: G (2)
1-5-6

Acquaints students with a selection of techniques employed in the synthesis and characterization of polymeric materials. Experiments chosen for their practical importance and instructional value. A study of free radical polymerization kinetics, condensation polymerization, thermodynamic and viscometric molecular weight determinations, thermal analysis, nuclear magnetic resonance and mechanical properties testing. (Enrollment limited. Qualified undergraduates admitted by permission of instructor. Alternate years. ***Not offered 1981-82.***)
R. E. Cohen, Staff

10.681 Physical Chemistry of Polymers (A)

Prereq.: 5.60 or 10.14 or 10.40
Year: G (2)
3-0-6

Polymer chains conformation statistics. Elements of rubber elasticity theory. Statistical thermodynamics of polymer-solvent mixtures. Applications of thermodynamics to separation of polymers from solvents, fractionation, domain formation in block copolymers, swelling of cross-linked polymers, "fringed" micelle crystallization, melting point depression by plasticizers, and methods of molecular weight determination (osmotic pressure, viscometry, light scattering, gel permeation chromatography).
E. W. Merrill

10.682 Chain Structure, Conformation and Morphology of Synthetic Polymers (A)

Prereq.: 5.42, 5.62
Year: G (2)
3-0-6

Introduction to microstructure and conformation of synthetic polymer chains. Spectroscopic observation and fundamentals of vibrational and nuclear magnetic resonance spectroscopy as applied to macromolecules. Stereochemical configuration and its relationship to polymerization mechanisms. Geometrical isomerism. Head-to-tail, head-to-head isomerisms. Spectroscopic determination of copolymer structure. Branches and defeat structures. Chain conformation: its theoretical treatment and experimental observation in solution and in crystalline and amorphous solid states. Polymer crystallization and crystal morphology.
F. A. Bovey

10.691 Synthetic Chemistry of Polymers (A)

Prereq.: 5.42
Year: G (1)
3-0-6

Condensation, ring opening, and chain polymerizations illustrating the interrelationships of chemical kinetics, competitive reactions, thermodynamic and equilibrium considerations, and diffusion control. Specific topics include radical polymerization and copolymerization by bulk, solution, emulsion, and suspension routes; ionic polymerizations and block copolymerizations; and Ziegler-Natta heterogeneous polymerizations. Chain configuration (cistrans,

syndio-, iso- and a-tactic, etc.) as determined by the method of synthesis. Molecular weight distributions-theory and experimental results. Brief survey of: "errors" in chain polymers, branching, reactions on polymers, cross-linking, degradation, and network formation.
E. W. Merrill

10.70 Principles of Combustion (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-6

Basic concepts and applications of combustion; flame propagation in premixed gas mixtures; ignition, minimum ignition energy, quenching distance; laminar diffusion flames, premixed laminar flame stabilization; turbulence; turbulent flame propagation in premixed gaseous mixtures; combustion noise; turbulent diffusion flames, free turbulent jets, compound jets; recirculating flows, bluff body flame stabilization, enclosed jets; swirling flows, swirling jet flames, turbulent flames in rotating flow environment; modeling and flame lengths; droplet and particle burning, heterogeneous combustion reactions; homogeneous chemical kinetics of combustion reactions; pollutant formation and destruction in combustion processes; combustion systems, gaseous combustion, principles of burner design, liquid fuel combustion, atomization, droplet-flow interaction, coal preparation, grinding-drying, pulverized coal combustion, fluidized combustion of coal.
J. M. Beer, A. F. Sarofim

10.72 Seminar in Air Pollution Control (A)

Prereq.: 10.302 or 10.312
Year: G (1)
2-0-4

Review of combustion sources of pollution and of criteria and legislation for maximum allowable emission rates. Methods for reduction of SO_2, particulate, and NO_x formation by modifications of the combustion process. Absorption systems for SO_2 and NO_x removal. Methods for reduction of particulate emission. Stack dispersion. Survey of above topics by faculty and guest lecturers. Term projects for detailed studies of promising new techniques of pollution control.
G. C. Williams

10.73 Seminar in Fuel Conversion and Utilization (A)

Prereq.: Permission of Instructor
Year: G (1, 2)
2-0-4

Seminar covering topics in combustion and fuel conversion related to current research interests.
Fuels Laboratory Faculty

10.74 Radiative Transfer (A)

Prereq.: 10.302
Year: G (1)
3-0-6

Heat transmission in high temperature operations and use of optical diagnostic techniques for measurement of temperature, concentration, and particle size. Analysis of radiation in enclosures, including consideration of radiation geometry and matrix methods for solving the governing integral equations. Thermal radiation characteristics of surfaces, gases, and particle clouds. Case studies of furnace heat transfer and current optical diagnostic methods. (Alternate years. ***Not offered 1981-82.***)
A. F. Sarofim

10.75 Principles of Chemical Waste Management (A) (New)

Prereq.: 10.13, 10.37
Year: G (2)
3-0-6

Basic concepts involved in the treatment and disposal of industrial and municipal wastes with special emphasis on toxic chemical wastes. Examination of physical, physicochemical, and biological methods such as solidification, incineration, composting, adsorption, freezing, liquid-oxidation, etc., as applied to the treatment and disposal of various waste streams. Students assigned to examine the applicability and limitations of specific processes and their findings discussed in class.
S. M. Senkan

10.76 Oral Technical Presentation

Prereq.: —
Year: G (1)
2-0-4

Workshop using audio and visual aids to develop abilities to deliver lucid, succinct oral talks in a variety of simulated situations. (Registration limited to 10 students.)
R. C. Reid

10.77 Commercial Development of New Technology (A) (Revised Unit)

Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Methods for commercial development of technology within the framework of the present day American economic system. Special problems associated with development of chemical-based technology are considered.
R. F. Baddour, S. W. Bodman

10.771 Seminar in Wastewater Treatment Processes (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Intended for non-chemical engineering majors. First third of term devoted to fundamentals of thermodynamics, heat and mass transfer, kinetics, and process design. Remainder of term identical to 10.772. (Combined enrollment of 10.771 and 10.772 limited to 20 students.)
M. Modell

10.772 Seminar in Wastewater Treatment Processes (A)

Prereq.: 10.13, 10.18, 10.37
Year: G (2)
2-0-4

Intended for chemical engineering majors. Subject meets three hours per week for last two-thirds of the term. Examination of methods of treating wastewater for removal of suspended solids and dissolved inorganic and organic contaminants. Each student required to analyze applicability and limitations of a specific treatment process (e.g., adsorption, oxidation, flocculation, ultrafiltration, reverse osmosis, foam fractionation, freezing, extraction, activated sludge, anaerobic digestion). Presentation and discussion of student term papers. (Combined enrollment of 10.771 and 10.772 limited to 20 students.)
M. Modell

10.78 The Structure of the Chemical Processing Industries: Function and Economics (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Concerned with quantitative description and analysis of the production of chemicals and related products by firms in the chemical processing industries; organization and of manpower, capital, plant and equipment, technology, and innovation; financial driving

forces of market demand and competition; sociopolitical restraining forces of governments and public opinion; and future prospects.
R. F. Baddour, J. Wei

10.79J Introduction to Nuclear Chemical Engineering (A)

(Same subject as 22.76J)
Prereq.: 10.302 or 22.311
Year: G (1)
3-0-9

Applications of chemical engineering to processing of materials for and from nuclear reactors. Fuel cycles for nuclear reactors; chemistry of uranium, thorium, zirconium, plutonium and fission products; extraction and purification of uranium and thorium from their ores; processing of irradiated nuclear fuel; solvent extraction and ion exchange as applied to nuclear materials; management of radioactive wastes; principles of and processes for isotope separation. (Open to qualified undergraduates. Alternative years. ***Offered 1981-82.***)
Staff

10.801 Entrepreneurship

Prereq.: —
Year: G (2)
4-0-5

This class is an introduction to the various issues faced by technical innovators interested in becoming entrepreneurs. Lectures and discussions held on concept evaluation, patents, licensing, contract negotiation, marketing, business planning, financing, accounting and small business management. Students encouraged to use their own innovative ideas as the object of study topics. This subject is an Engineering School-Wide Elective (open to undergraduates).
D. G. Jansson

10.802J Invention

(Same subject as 2.941J, 6.935J, 13.77J, 16.671J)
Prereq.: —
Year: G (1)
3-0-6

The process of invention is analyzed with the intention of enhancing the skill of the student inventor. Instructions include the following phases of the process: a) technology observation to increase the technology background of the potential inventor; b) need analysis to define clearly the requirements and limitations of needed inventions; c) parameter analysis, to focus attention of the inventor on important parameters of the problem and on potential solutions; d) creative step, to develop techniques for providing innovative solutions. Students are encouraged to provide innovative solutions to invention needs of their own choice.
J. B. Howard, A. D. Carmichael, D. G. Jansson, W. C. Flowers

10.803 Introduction to Technology and Law

Prereq.: —
Year: U (1)
3-0-9

Introduction to the basic principles and functions of law, using legal cases and materials arising from scientific and technical issues. Provides an understanding of the law and legal processes as they impact upon the work of engineers and scientists. Study of judicial law making focuses on elementary civil procedure and how change in legal doctrine takes place. Examination of statutory law making shows how Federal and state power to govern grows as technology grows. Administrative law making focuses on the regulatory agencies' role in controlling and supporting technology as well as the extent and curbs on their power. Study of law cases, using so-called "Socratic method," and of legal processes and doctrines provides insight into the lawyer's working methods. Law's task of resolving conflicts found in scientific and engineering alternatives sensitizes students to choice of values questions. This subject is an Engineering School-Wide Elective. ***(Not offered 1981-82.)***
J. D. Nyhart

10.804 Government and the Chemical Process Industries (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Analysis and understanding of processes and principal mechanisms by which society, through government policies and programs, affects the invention, development, design, and operation of chemical process technologies and products. Topics: policy process; mechanisms of government support for R & D and innovation; rationales for, function of, and alternatives to environmental, health, safety, and energy regulation; and responsibilities of the individual professional. Case studies from various industries including organic chemicals, petroleum refining, primary metals, pharmaceuticals, and food processing. Seminar format. (Open to seniors and students from other departments by permission of the instructor.)
C. T. Hill

10.805J Technology, Law and the Working Environment

(Same subject as TPP 35J)
Prereq.: Permission of Instructor
Year: G (1)
3-0-6

Addresses relationship between technology-related problems and the law applicable to work environment. National Labor Relations Act, Occupational Safety and Health Act of 1970, Toxic Substances Control Act, and state worker's compensation examined. Suits by workers in the courts discussed. Problems related to occupational health and safety, collective bargaining as a mechanism for altering technology in the workplace, job alienation, productivity, and the organization of work addressed. (Prior courses or experience in the environmental, public health, or law-related areas.)
N. A. Ashford

10.806 Management in Engineering

Prereq.: —
Year: U (1)
3-0-9

Introduction to the concepts of management of the engineering function, as found in a variety of industrial and non-industrial settings. Aim is to help the student acquire: 1) recognition of role of engineering and its relationship to other functions in getting a job done, 2) familiarity with some of the managerial tools and concepts employed in engineering organizations, 3) practice in dealing with both short- and long-term managerial problems in a range of real-life circumstances, and 4) incentive to develop a career strategy relevant to engineering training. Topics: financial principles; management of innovation; engineering project planning, scheduling, and control; human factors; career planning; contracts; patents; and technical strategy for firms. Uses case method, which emphasizes student participation in discussion. (Intended for juniors, seniors, or graduate students; others should consult the instructor in charge.) This subject is an Engineering School-Wide Elective.
R. T. Lund, D. P. Hoult, H. S. Marcus

School of Chemical Engineering Practice

10.808J Thermoeconomics (A) (Revised Unit)

(Same subject as 2.454J)
Prereq.: Permission of Instructor
Year: G (1)
3-0-6

Thermoeconomics is a new method for the optimum design of a thermodynamic system. According to the method, a plant (power, chemical process, etc.) is divided into separate zones and a miniature economy is erected which governs the buying and selling of generalized availability from one zone to another. The proper transfer prices for interzonal trading are found from the Lagrangian of the system which guarantees that local optima coincide with plant optimum. Lectures cover generalized availability analysis, Lagrangian prices and their determination, methods of calculation for real systems, and computational techniques in thermodynamic analysis. ***(Not offered 1981-82.)***
J. B. Howard, W. M. Rohsenow, M. Tribus

10.816 Engineering Risk-Benefit Analysis (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Risk evaluation and cost-benefit analysis techniques for assessment of engineering projects involving risks. Emphasis on public sector. Balancing risks and benefits with concern for financial uncertainties, environmental risks, and especially, issues of human safety. Introduction to decision analysis, the value of information, problems with multiple goals and issues related to collective decisions. Issues of public policy and regulation. Case studies with attention to the nature of public discussion. Cases drawn from dam safety, safety of nuclear reactors, transport and storage of liquefied natural gas, seismic risk problems, and offshore oil exploration. Some background in elementary probability assumed. (Intended mainly for graduate and upperclass students in the School of Engineering.) This is an Engineering School-Wide Elective.
M. E. Paté, A. W. Drake

10.82 School of Chemical Engineering Practice — Industrial Station (A)

Prereq.: —
Year: G (1, 2)
0-12-0

Conducted under Institute staff supervision at the Albany (New York) Station located in the plants of the Plastics Department at Selkirk, NY and the Silicone Products Department at Waterford, NY of the General Electric Company. Group problem assignments conducted at plant sites involving improvement and development of existing polymer manufacturing processes. Exposure to highly diversified unit operations at pilot-scale or production levels, including distillation, extraction, filtration, extrusion, and fixed and fluidized bed reactor systems. Credit granted in lieu of a Master's thesis, see section on School of Chemical Engineering Practice for details. (Application should be made three to four months in advance to allow ample time for routine entry procedures. Enrollment limited and subject to plant availability. Permission of instructor required.)
J. W. Tester

10.83 School of Chemical Engineering Practice — Industrial Station (A)

Prereq.: 10.82
Year: G (1, 2)
0-12-0

Continuation of 10.82.

10.84 School of Chemical Engineering Practice — Industrial Station (A)

Prereq.: 10.83
Year: G (1, 2)
0-12-0

Continuation of 10.83.

10.85 School of Chemical Engineering Practice — Industrial Station (A)

Prereq.: 10.84
Year: G (1, 2)
0-12-0

Continuation of 10.84.

10.86 School of Chemical Engineering Practice — Oak Ridge Station (A)

Prereq.: —
Year: G (1, 2)
0-12-0

Conducted at the Oak Ridge, Tennessee Station located at the Oak Ridge National Laboratory of the Department of Energy, operated by Union Carbide Company, Nuclear Division. Work under direction of Institute staff residing at Oak Ridge with emphasis on the application of engineering principles to the solution of research and development problems arising from the programs of the Oak Ridge National Laboratory. Group problem assignments conducted at the laboratory site involving research on nuclear fuel processing, reactor safety, coal gasification and liquefaction, biochemical engineering, nuclear and bio-waste processing, resource management, and thermonuclear energy conversion. Credit granted in lieu of a Master's thesis, see section on the School of Chemical Engineering Practice for details. (Application should be made three to four months in advance to allow ample time for routine entry procedures. Enrollment limited and subject to laboratory availability. Permission of instructor required.)
J. W. Tester

General

10.87 School of Chemical Engineering Practice — Oak Ridge Station (A)

Prereq.: 10.86
Year: G (1, 2)
0-12-0

Continuation of 10.86.

10.88 School of Chemical Engineering Practice — Oak Ridge Station (A)

Prereq.: 10.87
Year: G (1, 2)
0-12-0

Continuation of 10.87.

10.89 School of Chemical Engineering Practice — Oak Ridge Station (A)

Prereq.: 10.88
Year: G (1, 2)
0-12-0

Continuation of 10.88.

10.90 Experimental Research Problem (A)

Prereq.: Permission of Instructor
Year: G (1, 2)
Arr.

For special and graduate students who wish to carry out some minor investigation in a particular field. Subject and hours to fit individual requirements.
G. C. Williams

10.91 Experimental Research Problem

Prereq.: —
Year: U (1, 2)
Arr.

For undergraduate students who wish to carry out a special investigation in a particular field. Topic and hours to fit individual requirements.
C. M. Mohr

10.93 Teaching Experience in Chemical Engineering (A)

Prereq.: Permission of Instructor
Year: G (1, 2)
2-0-4

For qualified graduate students interested in teaching as a career. Tutorial or classroom teaching under the supervision of a faculty member. Students selected by interview. Total enrollment limited by availability of suitable teaching assignments.
G. C. Williams

10.94 Special Problems in Chemical Engineering

Prereq.: Permission of Instructor
Year: U (1, 2)
Arr.

Problem of current interest, varying from year to year.
C. M. Mohr

10.95 Special Problems in Chemical Engineering (A)

Prereq.: Permission of Instructor
Year: G (1, 2)
Arr.

Directed research and study of special chemical engineering problems.
G. C. Williams

10.96 Selected Topics in Chemical Engineering (A)

Prereq.: Permission of Instructor
Year: G (1, 2)
Arr.

Topics of current interest, varying from year to year.
G. C. Williams

10.991 Seminar in Chemical Engineering (A)

Prereq.: Permission of Instructor
Year: G (1)
2-0-4

10.992 Seminar in Chemical Engineering (A)

Prereq.: Permission of Instructor
Year: G (2)
2-0-4

For students working on doctoral theses.
J. Wei

11 Urban Studies and Planning

Undergraduate Subjects

Introductory Subjects

11.001 Introduction to Urban and Environmental Planning and Development (Revised Content)

Prereq.: —
Year: U (1)
3-0-9

Examines both the structure of the environment and the nature of processes changing it. Class consists of lectures and seminars. Lecture topics: economic processes and urban form, the socio-spatial structure of cities, cities as behavior settings, knowledge and values of urban form, public certainty and environmental regulation, urban ecology, neighborhood change, and urban ideals and futures. In addition, a series of seminars review cases from contemporary practice, current theories of design and theories of form and professional role.
G. A. Hack

11.002 Introduction to Public Policy Analysis and Governmental Action

Prereq.: —
Year: U (1)
3-0-9

Introduction to the field taught through a series of how-to-do-it case exercises. Analyzes differences between public and private policy; describes rationales for government involvement. Presents alternative paradigms for public policy analysis. Reviews examples of contemporary professional practice. Introduces major analytical techniques through exercises in definition of objectives, generation of policy alternatives, implementation, and policy evaluation. Examples from public policy arenas such as housing and community development, health and social welfare, environmental protection, land use growth and development. Subject helps students to build conceptual framework that is the basis for subsequent work in public policy.
S. T. Buckle, L. G. Buckle

11.005 Urban Social Structure and Process

Prereq.: —
Year: U (2) HUM-D
3-0-6

Introduction to sociological analysis dealing primarily with transformations from the turn of the century to the present in the major institutions of urban society. Contemporary structures, changes, and interrelations of ecological and demographical bases; age and sex structures; stratification, economic, political, educational, and religious institutions. Ethnic and racial relationships in the US examined. (May be counted toward Humanities Requirement.)
P. L. Clay

Fundamentals of Applied Social Science

11.007J Politics and Public Policy

(Same subject as 17.201J)
Prereq.: —
Year: U (1, 2) HUM-D
3-0-9

Introduction to political aspects of public policy making. First section considers philosophical rationales for government action and the evolution of government regulation in American history. Second section examines basic strategies of government control: market controls, performance standards, legal instruments, and mass persuasion techniques. Final section introduces ways of analyzing the impacts of public policies — social indicators, cost-benefit analysis, evaluation of distributive equity, and unintended consequences. (May be counted toward Humanities Requirement.)
G. T. Marx, M. Lipsky, D. A. Stone

11.008J Urban Economics

(Same subject as 14.51J)
Prereq.: 14.001
Year: U (1)
3-0-6

Analysis of urban problems in the US using an economic methodology. Metropolitan growth and suburbanization, housing markets, segregation and urban renewal, transportation systems, ghetto economic development, municipal finance, and social service provision. The development of theoretical perspectives primarily through discussion of policy issues. (May be counted toward Humanities Requirement. ***Not offered 1981-82.***)
W. C. Wheaton, J. Rothenberg

11.009 Technology and the City

Prereq.: —
Year: U (2)
3-0-6

Seminar dealing with the impact of technology on the form and function of cities and urban regions. Focus on the "processes" of change, especially institutional adaptation to technological innovation. (May be counted toward Humanities Requirement. ***Not offered 1981-82.***)
D. A. Schon

11.010 Community Sociology

Prereq.: 11.001 or 11.002
Year: U (2)
3-0-6

Introduction to the structure and dynamics of urban community life and institutions. Focuses on development of the modern urban community — from the neighborhood to the regional scale, the social dynamics and institutional dynamics of that development, as well as the tensions and conflicts associated with urban America. Analyzes group behavior and patterns of social interaction. Also looks at issues of race and class and development of interventions to change community structure and dynamics in light of our collective goals and values. Recommended for undergraduate majors in Urban Studies. (May be counted toward Humanities Requirement. ***Not offered 1981-82.***)
P. L. Clay

11.012 Institutions and Communities

Prereq.: 11.005 or 11.007J
Year: U (1)
3-0-6

Fundamental theories of the structure, behavior, and processes of change in communities and formal organizations, with special emphasis on the impact of each on the formulation and implementation of public policies. Background in communities and organizations for students interested in planning or design. Overview of perspectives on communities and organizations as environments for planners, designers, and policy analysts, and as objects of prospective interventions. Applications of organizational and community theories illustrated by extensive use of case study materials drawn from such fields as housing, health, urban design and development, and law. (May be counted toward Humanities Requirement. ***Not offered 1981-82.***)
L. G. Buckle, S. T. Buckle

11.013J American Urban History

(Same subject as 21.412J)
Prereq.: —
Year: U (1) HUM-D
3-0-6

Seminar on institutions and institutional change in urban America from roughly 1890 to the present. Among the institutions considered are political machines, police departments, schools, courts, hospitals, prisons, welfare departments, and universities. Focused around readings and discussions. (May be counted toward Humanities Requirement.)
R. M. Fogelson

11.014J History of the Physical Environment of Urban America

(Same subject as 21.413J)
Prereq.: —
Year: U (2)
3-0-6

Readings and discussions about the history of selected features of the physical environment of urban America. Among the features considered are parks, cemeteries, dumbbell tenements, suburbs, civic centers, superblocks, and shopping centers. (May be counted toward Humanities Requirement.)
R. M. Fogelson

11.015 Models and the Metropolis

Prereq.: 18.01, 18.02
Year: U (1) SD
3-0-9

The science in social science, thinking about complex systems, making of models, their contribution to knowing, their interplay with experiment, their place in deciding policy. Materials usually drawn from problems in urban studies and planning but the local interests of the students can usually be accommodated. ***(Not offered 1981-82.)***
A. Fleisher

11.016 Introduction to Environmental Analysis

Prereq.: —
Year: U (1)
3-0-6

Examination of critical issues underlying current and future environmental problems. Presentation and discussion of current conditions of national and global resources including: air, water, land, population, energy, wildlife, timber, food, recreation, and wilderness. Analysis of conceptual approaches to environmental problem solving including environmental economics, politics, philosophy, and history. Lectures, discussions, case studies, and field trips. (May be counted toward Humanities Requirement.)
S. Marcus

11.017 Introduction to The Political Economy of Urban Poverty

Prereq.: —
Year: U (2)
3-0-6

The measurement of urban poverty; low wages, unemployment, "subemployment." Examination of some possible causes, emphasizing inadequate "human capital," the spatial separation of workers and jobs, and systemic labor market segmentation. Orthodox vs. radical theories of poverty. Antipoverty policy: investment in people vs. investment in "place." Job development programs; public service employment. Urban and ghetto economic development. Some alternative futures. (May be counted toward Humanities Requirement.)
Staff

Specialization in Environmental Planning

11.122 Environmental Policy and Regulation (Revised Content and Unit)

Prereq.: —
Year: U (2)
3-0-9

Analysis of rationales for government intervention to protect the environment. Review of policy instruments available to promote environmental quality including standards, taxes, marketable rights and liability rules. (May be counted toward Humanities Requirement.)
L. S. Bacow

11.123 Environmental Quality Assessment

Prereq.: 18.02 or 8.02; 11.016
Year: U (2) SD
3-2-7

Measurement and estimation of changes in environments, especially changes due to human intervention. Application of basic science to problems of public choice: wind, light and shadow in the city; air and water quality indicators; species diversity and population dynamics; litter; psychometrics of the built environment. Emphasis on relationship of scientific measures to decision making (design regulation, etc.) and on links between "objective" description of phenomena and the human behavior such phenomena cause or encourage.
A. Fleisher

11.124 Workshop in Environmental Planning and Design

Prereq.: 11.122, 11.123
Year: U (2)
4-4-8

Focuses on an actual environmental planning and design problem facing a government or community client. While the topic varies from year to year, issues of energy facility siting, land use planning, environmental impact assessment, pollution control, and the design of more effective regulatory strategies for environmental protection are likely to be emphasized. (Permission of instructor required. ***Not offered 1981-82.***)
G. A. Hack

Specialization in Neighborhood and Community Planning

11.131 The Urban Neighborhood

Prereq.: —
Year: U (1) HUM-D
2-0-7

Covers the relevant theories, methods of study, and policy issues concerning the urban neighborhood. Begins with a review of neighborhood theory from the neighborhood unit to neighborhood territoriality. Then examines extensively the methods for studying neighborhoods, including research design and participant observation. Finally, covers topical issues of policy concern such as municipal decentralization, neighborhood abandonment, and maintaining public safety in the neighborhood. (May be counted toward Humanities Requirement.)
Staff

11.132J Shaping the Urban Environment

(Same subject as 4.742J)
Prereq.: —
Year: U (2)
3-0-6

Analysis of case studies which present a range of design, planning, development, and management issues. Financial, political, sociological, and environmental constraints analyzed along with techniques for professional-client interaction, project management, facilities programming, project evaluation, and environmental impact review. Cases encompass inner city redevelopment, planned unit development, and new town design. (May be counted toward Humanities Requirement. ***Not offered 1981-82.***)
G. A. Hack

11.133 Introduction to Design

Prereq.: 11.001
Year: U (1)
Arr.

Application of urban and environmental planning theory and skills to a real-world project. Class works in teams to produce a professional report for a real or simulated client. Practice in defining problems, stating goals, generating alternative policies, choosing among alternatives, and guiding implementation. Emphasis on both the changes in the

physical environment and interlinked social, political, and economic processes. Instruction in communications skills — written, oral, and graphic presentation. For students specializing in either environmental policy or in urban planning and development. ***(Not offered 1981-82.)***
T. F. Lee

11.139 Introduction to Community Development

Prereq.: —
Year: U (2)
3-0-6

Survey of the basic policy issues surrounding community development. Lectures deal with actual community development activities in both urban and rural settings. Overall strategy of the course to synthesize theories of development through use of actual cases. Material covered is especially relevant for students interested in planning practice. (May be counted toward Humanities Requirement.)
F. S. Jones

11.143 Urban and Regional Planning in Developing Countries

Prereq.: —
Year: U (2)
2-0-7

Problems of cities and regions in developing countries in relation to national economic and social development policies. Case studies and comparative analysis stressed. Paper required. (May be counted toward Humanities Requirement.)
R. Sah

Specialization in Planning for Developing Countries

11.144 Urban and Regional Economic Issues in Developing Countries

Prereq.: 14.74
Year: U (1)
2-0-7

Examination and analysis of a range of urban and regional problems in developing countries with emphasis on public policy. Theoretical and methodological problems associated with the planning of balanced regional development discussed, along with appropriate institutional arrangements for linking national and regional plans. The analysis of urban economic problems focuses on housing, public utilities, social services, transport, land use, and employment.
Staff

11.145 Workshop in Planning for Developing Countries

Prereq.: 11.141, 11.144
Year: U (2)
4-4-8

Focuses on an actual planning problem facing an international planning and development agency or a client group in a developing country. While topic changes from year to year issues of rural development, squatter settlement, site and services policy, growth strategies, agricultural development, transportation investment, and choice of appropriate technologies emphasized. (Permission of instructor required.)
A. M. Strout

Specialization in Public Policy, Urban Management, and the Law

11.164J Urban Politics, Planning and Public Policy (Revised Content)

(Same subject as 17.283J)
Prereq.: —
Year: U (2) HUM-D
3-0-6

Examination of the politics of urban planning, policy development, and policy implementation. Urban policy viewed as a product of the entire American Federal system. Selected policy topics examined in detail. These include land use planning, urban renewal, fiscal policy, transportation, and air pollution control. Special attention paid to the bases for alternative theoretical interpretations, such as Marxist and neoconservative, of the record in each policy arena. (May be counted toward Humanities Requirement.)
A. A. Altshuler

11.165 Law and Public Policy

Prereq.: —
Year: U (2) HUM-D
3-0-9

Introduction to law organized around the theme of how the law shapes, influences, and constrains the design and implementation of policy. Examination of relationship between courts and line agencies. Analysis of how courts differ from other policy-making institutions. Includes basic legal research.
L. S. Bacow

11.166 Legal Institutions and Social Change

Prereq.: —
Year: U (1)
3-0-6

Analysis of unique characteristics and problems of legal institutions, especially police, courts, corrections, and agencies of juvenile justice. Emphasis placed on issues which would most likely affect the process of change in the criminal justice system. Specific topics: the debate concerning the causes of crime, characteristics of prisoners and society behind the walls, nature of the judicial process and its relationship to plea bargaining, conflicting roles of law enforcement, and the nature and nurture of the police. (May be counted toward Humanities Requirement.)
S. T. Buckle, L. G. Buckle

11.167 Seminar on Legal Institutions

Prereq.: 11.166
Year: U (2)
3-0-6

Assessment of contemporary efforts to create organizational change in and through legal institutions. Seminar investigates alternative approaches to reform of the legal system by examining case studies in which change has taken place in formal organizations of law, including courts, correctional agencies, and police departments. Reform strategies including direct community action, unionization, reorganization, "muckraking" social science, deinstitutionalization, diversion, and alternative social service systems examined, and some theories of change in legal institutions developed. (May be counted toward Humanities Requirement. Permission of instructor required.)
S. T. Buckle, L. G. Buckle

11.168 Workshop in Urban Management and Public Policy

Prereq.: 11.164, 11.165, 11.166
Year: U (2)
4-4-8

Focuses on an actual policy analysis or management problem facing a public policy maker or a public agency. While topic changes from year to year, issues of municipal fiscal management, public employee unionism, race relations, intergovernmental relations, uses of information technology, decentralization of city services, and budgeting emphasized. (Permission of instructor required. ***Not offered 1981-82.***)
J. Ferreira, Jr.

Laboratories

11.185J Design with Microclimate

(Same subject as 4.071J)
Prereq.: 8.01, 18.01
Year: U (1) LAB
3-6-3

Introduction to microclimate design that deals with natural phenomena and technical principles, user needs, and policy issues. Study of effects of wind, noise, solar and nocturnal radiation, vegetation and built form on microclimate through lectures, experiments, case studies, and site visits. Modeling methods for testing design alternatives experimentally and measurement techniques for adequate site reconnaissance. Work includes a comprehensive environmental design problem.
T. E. Johnson

11.188 Laboratory in Research Methods

Prereq.: Permission of Instructor
Year: U (2) LAB
2-5-5

Logic, processes and techniques of applying social science to problem solving. Conducted as a laboratory. Students design and run experiments to check out ideas, to test hypotheses, and to generate data. They participate in interplay of model and experiment, in manipulation of numerical and categorical data, in exercise of various modes of inference, and in the measurement of their worth. Several projects are done individually and in groups. (Students must have taken at least one subject in statistics or probability before enrolling. Required of all Course XI majors.)
J. Ferreira, Jr.

11.189 Models in the Policy Process

Prereq.: 18.01, 18.02, or 18.002
Year: U (1)
3-6-3

Introduction to technical and substantive content of mathematical models or urban systems as applied to analysis and synthesis of public policy. Provides competence in the making, proving, and using of models. Treats deterministic models that would optimize (linear and nonlinear programming), or conserve and balance flows (input-output analysis), or describe changes in time (difference and differential dynamics). Focuses on use of models in decision analysis and application of models of system change to the actual testing of public policies.
A. Fleisher, R. C. Larson

Colloquium

11.190 Senior Colloquium

Prereq.: 11.001 or 11.002, 11.188
Year: U (1)
2-0-7

Encourages students to express and refine their own theories and concepts about urban and environmental systems and public policy. Intent of colloquium is to examine different ways of thinking about urban issues rather than to present a substantive body of knowledge. Aims to help students define and structure their senior projects. (Required of all Course XI majors.)
Staff

Tutorials, Fieldwork, and Internships

11.UR Undergraduate Research

Prereq.: —
Year: U (1, 2)
Arr.

Undergraduate research opportunities in Urban Studies and Planning. For further information consult the Departmental Coordinators.
Staff

11.191 Undergraduate Tutorial in Urban Studies

Prereq.: —
Year: U (1)
3-0-6

11.192 Undergraduate Tutorial in Urban Studies

Prereq.: —
Year: U (2)
3-0-6

Reading and discussion of special topics in urban studies. (By arrangement with individual members of the staff.)
Staff

11.193 Preparation for Undergraduate Thesis

Prereq.: —
Year: U (1, 2)
Arr.

Selection of thesis subject, definition of method of approach, and preparation of preliminary thesis outline. Independent study, supplemented by frequent individual conference with staff members.
Staff

11.194 Special Topics in Urban Studies and Planning

Prereq.: —
Year: U (1, 2)
Arr.

11.195 Special Topics in Urban Studies and Planning

Prereq.: —
Year: U (1, 2)
Arr.

Small group study of special topics under staff supervision. For undergraduates wishing to pursue further study or fieldwork in specialized areas of urban studies or city and regional planning not covered in regular subjects of instruction.
Staff

11.196 Urban Fieldwork and Internships

Prereq.: —
Year: U (1, 2)
Arr.

Practical application of city and regional planning techniques to towns, cities, and regions, including problems of replanning, redevelopment, and renewal of existing communities. Includes internships in municipal and state agencies and departments under staff supervision.
Staff

11.197J State and Local Government Internships

(Same subject as 17.351J)
Prereq.: —
Year: U (1, 2)
3-0-9

Internship for each student with a state or local public agency or legislator, supplemented by a seminar of the participants. Instructor assists in arranging internships, which normally run from October to April. Seminar meets every other week during both terms. Students required to write analyses of their work experience. Students receive grade of J at end of first term; they must enroll again for same subject second term. No new students accepted in the second term. (Upon successful completion of two semesters, student petitions for one Humanities Elective credit will be honored.)
M. H. King

Graduate Subjects

Core Subjects and Methods Modules

11.200 The Planning Process

Prereq.: —
Year: G (1)
4-0-8

Basic concepts and theories of planning practice. Evaluation of current developments in the field of planning with special emphasis on implementation strategies. Lectures and gaming exercises explore changing role of the planner and alternative paradigms of the planning process. (Required of all first-year M.C.P. students.)
L. E. Susskind, L. C. Keyes

11.210 Economic Analysis for Planners

Prereq.: —
Year: G (1)
3-3-6

Basic introduction to economic analysis for planners, emphasizing economic institutions and policy analysis. Topics: basic variables and concepts in economics, models of individual and aggregative economic behavior, institutional analysis of economic power, introduction to Marxist political economy, and the relationship between public policy and economic planning. (Required of all first-year M.C.P. students.)
B. Harrison

11.217 Bargaining and Negotiation

Prereq.: —
Year: G (2)
2-1-1

Optional Methods Module. (Counts toward the M.C.P. Methods Requirement.) Introduction to methods and formal theory of bargaining and negotiation. Applications of game theory to two-party and multi-lateral dispute resolution. Analysis of ways in which procedure, structure of bargaining situation, preferences of negotiators and tactics of bargainers can lead to the success or failure of negotiations. Case study and gaming materials used in class. (Permission of instructor required. ***Not offered 1981-82.***)
Staff

11.218 Market Analysis for Housing (New)

Prereq.: —
Year: G (2)
2-1-1

Optional Methods Module (May count toward the M.C.P. requirement). This Module examines various methods for analyzing the feasibility of housing, commercial, and industrial development by studying local real estate markets.
Staff

11.219 Review of Mathematics for Urban Studies and Planning

Prereq.: —
Year: G (1)
2-1-1

Background Methods Module for professional degree candidates. Preparation for the placement exam for 11.220. Review of college level mathematics and mathematical notation including algebraic functions, laws of algebra, exponents, logarithms, fractional exponents and radicals, variables and graphs.
M. Schuster

11.220 Introduction to Statistical Concepts for Planning

Prereq.: 11.219
Year: G (1)
2-1-3

Required Methods Module for professional degree candidates. Introduction to statistical techniques for describing, summarizing, and displaying data, drawing inferences about populations from samples. Focus is on developing a perspective on the use and limitations of statistical techniques for description, observation, and prediction. (Permission of instructor required.)
J. Ferreira, Jr., M. Schuster

11.221 Multivariate Analysis for Planning

Prereq.: 11.220
Year: G (2)
2-1-1

Optional Methods Module. (Counts toward the M.C.P. Requirement.) Module describes the geometric representation of collections of several measurements made simultaneously. We review table making and measures and meanings of association and interaction. Regression is the focus of the module and is discussed as used for curve fitting, explanation, prediction, dimension reduction, and data exploration. (Permission of instructor required.)
A. Fleisher

11.222 Decision Analysis for Planning

Prereq.: 11.220
Year: G (2)
2-1-1

Optional Methods Module. (Counts toward the M.C.P. Methods Requirement.) Introduction to analytical approaches to decision making and policy analysis when uncertainty about outcomes is a central issue. Primary focus on decision tree analysis, attitudes toward risk and uncertainty, and determining an appropriate level of formal analysis. Sampling information, gaming strategies, and social choice problems also discussed. One detailed example considered from several points of view.
J. Ferreira, Jr.

11.223 Communication Techniques for Planning

Prereq.: —
Year: G (1)
2-1-1

Optional Methods Module. (Does not count toward M.C.P. Methods Requirement.) Module covers four basic techniques of visualization: drawing, photography, video, and visual design in print. Aim is to provide planning students with a condensed introduction to visual communication techniques and the issues surrounding their use. Class sessions devoted to presentations, lectures, and instruction.
P. Droege

11.224 Urban and Environmental Impact Assessment

Prereq.: 11.220
Year: G (2)
2-1-1

Optional Methods Module. (Counts toward the M.C.P. Methods Requirement.) Module covers methods for predicting and evaluating impact of development, stressing predictive techniques for use by public officials without formal training in quantitative modeling, and the use of graphic and other non-quantitative techniques as an aid to the scaling and weighting of impacts in evaluation of alternatives. Materials used include traffic, fiscal, employment, and visual impacts. (Permission of instructor required.)
P. B. Herr

11.225 Analysis of Neighborhood and Regional Change

Prereq.: 11.220
Year: G (2)
2-1-1

Optional Methods Module. (Counts toward the M.C.P. Methods Requirement.) Module covers techniques for measuring, explaining, predicting, and displaying changes in population, employment, housing, and land use. Measures of aggregate change, underlying dynamics, basic predictive methods, predictive models, general problems of analyzing neighborhood and regional change are all covered. (Permission of instructor required.)
D. L. Birch

11.226 Cost-Benefit Analysis for Planning

Prereq.: 11.220
Year: G (2)
2-1-1

Optional Methods Module. (Counts toward the M.C.P. Methods Requirement.) Module introduces students to the techniques of project analysis and to the strengths and weaknesses of cost-benefit analysis. Exercises provide practice in discounting, calculating rate of return, and calculating or applying shadow prices. Underlying rationales of various cost-benefit precepts and tools explored. (Permission of instructor required.)
M. Schuster

11.227 Formal Models for Public Policy Analysis

Prereq.: 11.220
Year: G (2)
2-1-1

Optional Methods Module. (Counts toward the M.C.P. Methods Requirement.) Module introduces students to the limitations of formal models for analyzing public policy issues. Emphasis on modeling processes and evaluation of modeling work, not the mathematics involved in "solving" models. Critical issues covered include levels of aggregation, modeling with and without data sources, model verification, and realistic and inane uses of models as management tools. (Permission of instructor required.)
J. Ferreira, Jr.

11.228 Survey Research Methods

Prereq.: 11.220
Year: G (1)
2-1-1

Optional Methods Module. (Does not count toward the M.C.P. Methods Requirement.) Module covers basic techniques of questionnaire design, sample selection, survey distribution, and the practical problems of implementing surveys of citizen attitudes and priorities. Strategies for introducing surveys of different types into public policy debates discussed. (Permission of instructor required. ***Not offered 1981-82.***)
Staff

11.229 Case Study and Field Research Methods

Prereq.: —
Year: G (1)
2-1-1

Optional Methods Module. (Does not count toward the M.C.P. Methods Requirement.) Module covers basic techniques of field studies and interviewing as they relate to the preparation of case studies for program evaluation or policy analysis. Emphasis on when and how to frame case studies, case study selection, generalizing from a small set of cases, and drawing policy inferences from case studies. Actual case studies analyzed and prepared.
R. K. Yin

11.230 Institutional Analysis

Prereq.: —
Year: G (2)
4-0-8

Basic theories of institutional behavior, structure, and change for planners. Emphasis on those aspects of institutions which most directly affect the ability of planners to implement designs, policies, and development strategies. While students expected to demonstrate ability to work with fundamental conceptual frameworks in institutional theory, primary focus of subject is on application of institutional perspectives to practice-related issues. (Required of all first-year M.C.P. students.)
D. Schon, H. Minor

Environmental Planning and Design

11.240 Images of Cities

Prereq.: —
Year: G (2)
2-0-7

Examination of differences in attitudes and expectations which people have had about cities and how these influence planning practice. Covers: popular attitudes toward the city, metaphors and values that guide urban professionals' thinking and that shape their work, the intellectual and the city, radicals' views of the city, attitudes toward urban size and function, concepts of great and terrible cities, urban romanticism and anti-urbanism. Material includes readings from literature, history, philosophy, and selected films. (Open to qualified seniors as well as graduate students. ***Not offered 1981-82.***)
L. Rodwin

11.252 Legal Regulation of the Use and Development of Land

Prereq.: —
Year: G (2)
3-0-9

Analysis of the common law, statutory law, and Constitutional doctrines governing the use and development of land. Topics include private arrangements for controlling land use, eminent domain, zoning, growth control, and design control. ***(Not offered 1981-82.)***
Staff

11.253 The Regulation of Large-Scale Design

Prereq.: 11.200
Year: G (2)
3-0-6

Analysis of public and private regulations governing the design and development of large-scale housing, transportation, commercial and industrial projects. Considerations given to UDAGs, historic preservation, environmental contraints, transfers of development rights, PUDs, condominiums and cooperatives, land trusts, public financing, and similar mechanisms. Guest speakers invited. Students learn rudiments of legal research and analysis; some knowledge of zoning and land use planning helpful. Case studies of local projects. Field trips to developed and developing projects.
T. C. Landsmark

11.301J Introduction to Environmental Design (A)

(Same subject as 4.736J)
Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Introductory subject for incoming M.C.P. and S.M.Arch.S. students, examining both the structure of the environment and the nature of processes changing it. Class consists of lectures and seminars. Lecture topics: economic processes and urban form, the socio-spatial structure of cities, cities as behavior settings, knowledge and values of urban form, public certainty and environmental regulation, urban ecology, neighborhood change, and urban ideals and futures. In addition, a series of seminars reviews cases from contemporary practice, current theories of design, and theories of form and professional role.
G. A. Hack, J. Beinart

11.310 Psychological Perspectives on Urban Life and Urban Form

Prereq.: —
Year: G (2)
2-2-5

Examination of psychological and social psychological theory and research and of research methods relevant to an understanding of urban spatial structure and of human behavior in the city. Analysis of such concepts as crowding, territoriality, privacy, loneliness, proxemics, and cognitive mapping. Students gain experience in systematically studying human behavior in urban settings and in applying psychological theory to environmental design. ***(Not offered 1981-82.)***
Staff

11.311J Problem Setting in Environmental Programming (A)

(Same subject as 4.745J)
Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Seminar dealing with the conceptual and analytic processes which should precede the translation of human purposes into proposals for environmental modification. Formulation of issues with respect to particular environments and shaping of research strategies for their analysts. Conceptual, managerial, political, financial, and regulatory as well as physical design factors shaping environments. A number of short exercises drawn from programming for public buildings and facilities, service systems, and residential environments in both developed and developing countries.
T. F. Lee, E. Robbins

11.312J Environmental Programming (A)

(Same subject as 4.748J)
Prereq.: 11.361 or 4.772
Year: G (2)
3-0-6

Methods for synthesizing the broad range of financial, managerial, behavioral, regulatory, and process issues which must be reconciled in determining a set of environmental standards or the programmatic specifications for built environments. Techniques for informing decisions, including performance evaluation, in-situ research, and user involvement. Application of methods to the preparation of urban design guidelines, development regulations, building programs, space-use management systems, and public infrastructure improvement programs. (Permission of instructor required.)
G. A. Hack

11.313J Urban Settlements in Developing Countries (A)

(Same subject as 4.753J)
Prereq.: Permission of Instructor
Year: G (2)
3-0-6

A critical analysis of conflicting views on urbanization processes, squatters, and low-income housing policy. Alternative strategies with respect to: infrastructure, design and construction, land markets, financing, employment generation, building standards and regulations. Case materials of industrialized housing, aided self-help sites and services, and squatter and speculative settlements drawn from capitalist, socialist, and mixed economies. ***(Not offered 1981-82.)***
L. R. Peattie, T. F. Lee

11.316J Environmental Design III (Total Studio) (A)

(Same subject as 4.162J)
Prereq.: Permission of Instructor
Year: G (1)
Arr.

Concentrates on process and skills in planning and designing for a definable area undergoing major spatialphysical changes. Major emphasis on synthesis in the face of complexity, incomplete data, multiple owners, users and values, diverse implementation agencies. Studio based on a real-world problem for a client with a program for land and building development in conjunction with social change. Focuses on problem statement, synthesis, evaluation and implementation. A professional report produced for the client. Emphasis on interdisciplinary work and all work done in teams.
T. F. Lee

11.320 History of the Physical Environment of Urban America

Prereq.: —
Year: G (2)
3-0-6

Readings and discussions about the history of selected features of the physical environment of urban America. Among features considered are parks, romantic cemeteries, dumbbell tenements, romantic suburbs, civic centers, superblocks, and shopping centers. Students expected to undertake independent historical research projects.
R. M. Fogelson

11.325 Understanding the Development Process (A) (New)

Prereq.: 11.200
Year: G (2)
4-0-8

Examines urban and suburban developments of varied size and complexity, with an emphasis on housing, using original cases. Develops a conceptual framework which facilitates analysis of each development, and understanding of the interrelationships between the disciplines involved, the impact of policies chosen and their implementation over a period of time. Understanding the tools used by the various participants (financial analysis of real estate, architectural plans, sources of financing, tax policies) permits an evaluation of the performance of each development from the perspective of the individual developer, the investor, the architect/planner, the local housing authority or redevelopment authority, the state planning/development agency, the neighbors and the end-user.
F. S. Jones, G. Bauer

11.328J Community, Class and Race: A Social Perspective (A) (New)

(Same subject as 4.766J)
Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Undertakes to examine the nature of the community as a social reality. Emphasis on the differential meaning and empirical variability the concept "community" connotes. The methodological assumptions and problems underlying notions of community are discussed. Among other things the subject covers: Theories of Community, The Community Study in America, The Community Study in Europe, Community Studies as Social Method, Community as Place, Community and Conflict, Class as "Community," Race and Ethnicity in the Definition of "Community," Networks as "Community," The Community and Context, Community and the State, and Is a Notion of Community Viable? Students asked to read and evaluate theoretical, descriptive, and methodological writings on community. One research or analytical paper required.
E. Robbins

11.330J Theory of City Form (A)

(Same subject as 4.747J)
Prereq.: 4.236J or 11.301J
Year: G (2)
3-0-6

Deals with theories about the form that settlements should take. First section discusses the nature of theory and attempts a distinction between descriptive and normative theory by examining examples of various theories of city form over time. Second section concentrates on origins of the modern city and theories about its emerging form, including the transformation of the 19-century city (London, Paris, Rome), theory of city organization, utopian theories, and some 20th-century realizations of theories of equalization (the socialist city in Russia and the British new towns). Third section analyzes city form in relation to various theories of citymaking, social structure, and spatial design and includes case studies of the colonial and post-colonial city (Delhi and Havana), bi-polar cities (Johannesburg and San Diego/Tijuana), and contemporary and future ideas.
J. Beinart

11.332 City Design (A) (Revised Content)

Prereq.: Permission of Instructor
Year: G (2)
Arr.

Studio which focuses on the design of extensive physical environments. Intended to develop design skills among architects and planners in structuring the layout of a large area of the city to be developed over time, fitting built forms to the natural and manmade context, enabling desirable patterns of social relationships through the physical form of development, conceptualizing infrastructure and service systems and guiding the visual character of development. Students expected to produce individual designs that are responsive to the program for the site. (Limited enrollment, primarily for students wishing to specialize in urban design.)
G. A. Hack

11.334 Environmental Ecology and Natural Resource Management

Prereq.: —
Year: G (1)
3-0-6

Study of the contributions of environmental science to the formulation of policies for managing natural resources and improving environmental quality. Population and resources, environmental degradation (pollution, the impacts of urbanization, and meteorological consideration), and the problems of natural resource management. Economic, legal, and administrative issues considered to the extent that they are or could be informed by scientific judgment and the principles of environmental ecology.
Staff

11.336J Site Planning

(Same subject as 4.744J)
Prereq.: —
Year: G (2)
1-8-3

Seminar acquaints students with basic considerations in site planning and provides practice in their applications to housing development. Physical aspects of environmental planning such as earth moving, microclimate, vegetation, etc. and behavioral aspects such as social uses of public space introduced. Workshops involve work with simulation models and design exercises supplemented by a comprehensive analysis of existing housing sites.
D. Lee

11.360 Community Growth and Land Use Planning

Prereq.: Permission of Instructor
Year: G (1)
3-0-6

Seminar and fieldwork components on the application of methods of planning and control for growth and land use. Emphasis on participatory approaches to the design of intervention strategies, chiefly at the municipal level. Readings and discussion on growth and its local consequences, land use planning approaches, implementation tools including zoning, subdivision controls, infrastructure systems, and fiscal techniques. Projects arranged with students as small teams serving a municipal client in an ongoing planning program.
P. B. Herr

11.361 Environmental Policy and Regulation (A) (Revised Content)

Prereq.: 11.210 or 14.01
Year: G (2)
3-0-9

Analysis of rationales for government intervention to protect the environment. Review of policy instruments available to promote environmental quality including standards, taxes, marketable rights and liability rules.
L. S. Bacow

11.362 Land Use and Environmental Policy Implementation (A)

Prereq.: 11.360
Year: G (2)
3-0-6

Analysis of national, state, and regional efforts to plan for the allocation and use of land resources in the US Discussions focus on strengths and weaknesses of traditional planning and regulatory mechanisms. Political obstacles to plan implementation and strategies for citizen participation in land use policy making receive special attention. Students expected to prepare in-depth case studies of land use policy reforms and policy implementation strategies.
L. E. Susskind

11.363 Environmental Planning Practicum (A)

Prereq.: 11.223, 11.225, 11.361
Year: G (1)
4-4-8

Focuses on an actual environmental planning problem in conjunction with a governmental or community client. Collaborative interaction both with other students and with the client

provides an opportunity to develop and apply professional planning skills. While the topic changes from year to year, issues of energy facility siting, land use planning, environmental impact assessment, pollution control, and the design of more effective regulatory strategies for environmental protection are likely to be emphasized. (Permission of instructor required.)
Staff

11.364 Environmental Dispute Resolution (New)

Prereq.: Permission of Instructor
Year: G (1)
3-0-6

Introduction to methods and formal theories of negotiation, mediation and compensation as techniques to resolve environmental disputes. Examination of ten current EPA cases involving rule making, permitting, and enforcement. Included are disputes over power plant siting, energy conversion from oil to coal, and sewage treatment standards. Consideration of specific bargaining tactics and their strategic implications.
L. E. Susskind

11.365J Coastal Zone Management (A)

(Same subject as 13.98J)
Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Introduction to the problem of achieving the conservation and beneficial use of land and water resources in coastal regions. Emphasis on ways of thinking about the problem as well as methods for its resolution. Discussion of the spectrum of relevant topics, including physical and ecological processes characteristic of shoreland areas; the catalogue of human activities placing demands on coastal resource base; incidence and magnitude of adverse effects on ecological and amenity values; institutional setting for coastal decision making; and management tools, including resource allocation economics, planning law, and environmental design and regulation. Exploration of recent legislative developments, special problem areas, and critical policy issues.
P. B. Herr, J. T. Kildow

11.380J Urban Transportation Planning (A)

(Same subject as 1.252J)
Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Historical development of urban transportation planning over the past two decades. Particular attention given to the movement of the transportation policy perspective from limited interpretations to multi-objective planning, and from an emphasis on large-scale facility planning toward an increased reliance on small-scale, traffic management techniques. The methodological change that has accompanied this evolution in transportation planning discussed in detail. Promising theories for understanding institutional relations and change also presented. Discussion of newly proposed methodological approaches to urban transportation planning which respond to multiple objectives. Consequences of certain planning approaches highlighted in selected case studies of corridor and project planning in the Boston metropolitan area.
R. A. Gakenheimer, M. D. Meyer

11.382J Transportation Institutional Analysis and Policy (A)

(Same subject as 1.251J, CTS 120J)
Prereq.: Permission of Instructor
Year: G (1)
3-0-6

Introduction to policy and institutional analysis in the transportation sector. Principal policy-making actors and interest groups at the national, state, and local level. Emphasis placed on developing a basic understanding of organizational behavior and implications for policy formulation and implementation. General policy analysis framework developed with specific attention given to problem definition, selection of alternatives, and implementation considerations. Comparisons made between strategic planning in private sector and policy analysis in public sector.
M. D. Meyer

11.384J Transportation Policy and Planning in Developing Countries (A)

(Same subject as 1.254J)
Prereq.: Permission of Instructor
Year: G (1)
3-0-6

Research seminar on policy and technical issues in transportation in developing countries. Major policy and planning issues. Political and cultural factors influencing transportation planning and decision making. Institutional arrangements, coordination of transportation planning with other sectors, integration of programming and planning. The influence of foreign and international factors in transportation policy. Technical methods: demand analysis, technological tradeoffs, evaluation procedures, large-scale models, simple policy-analysis techniques. Participation of guest lecturers from MIT, international organizations, and developing countries. ***(Not offered 1981-82.)***
R. A. Gakenheimer, M. L. Manheim

Neighborhood, City, and Regional Development in the US and Other Parts of the World

11.410J Urban Economic Analysis I (A)

(Same subject as 1.283J, 14.573J)
Prereq.: 14.04 or 14.03
Year: G (1)
3-0-9

Patterns and processes of growth and structural change within metropolitan areas. The land use market, spatial structure of the metropolitan community and the transportation system. Congestion, indivisibilities, and optimal pricing and investment policies. Analysis of modal demand. Models of the metropolis and the transport system. Relationships between the housing market and the transport network.
W. C. Wheaton

11.411J Urban Economic Analysis II (A)

(Same subject as 14.574J)
Prereq.: 11.410J
Year: G (2)
3-0-9

Urban housing markets. Economics of slums, ghettos, and public policy. Congestion and pollution. Local government in metropolitan areas. Criteria for public action on housing, transportation, land use, segregation, and development.
J. Rothenberg

11.413 Social Aspects of Development (A)

Prereq.: Permission of Instructor
Year: G (1)
2-0-7

Seminar discussion of the social and cultural aspects of economic development and planning in developing countries. Strategies with respect to urban growth, city planning, education, family policy considered in the context of issues of choice as to the general path of development, linking "social issues" with their technical, economic, and institutional parameters.
L. R. Peattie

11.415 Public Policy and Economics in Developing Countries (New)

Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Some frameworks for analyzing public policy problems in developing countries discussed in first part of subject. These frameworks (neoclassical and bureaucratic-institutional) are then used for descriptive and normative analysis of specific policy problems. Among other topics: pricing and physical distribution of food, scarcity situations, pricing of utilities and energy inputs, minimum needs programs, choices for transportation, and overall limitations of policy instruments.
Staff

11.417 Planning in Socialist Countries (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Introduction to the political economy of development strategies of the USSR, Eastern Europe, and the People's Republic of China. Analysis focuses on significant theoretical debates leading to or emerging from experiences with three approaches to planning for socialism that coexist or appear at different stages of development: national administrative, limited market, and producer's self-government. Students required to participate in one of several study groups that deal with specific issues.
T. F. Lee, K. R. Polenske

11.420J Neighborhood Planning (A)

(Same subject as 4.743J)
Prereq.: 11.200, 11.210, 11.220; or 4.144
Year: G (2)
3-0-6

Techniques of neighborhood planning. Class organized around issues commonly faced by planners working at the neighborhood scale. Planning skills and methods useful when time and money are limited. Topics: location of new and rehabilitated housing; neighborhood business district improvement; planning and siting for community services and facilities; open space and transportation planning at the neighborhood level. Professional techniques: how to define information needs; how to get and use the data; mapping use of professional standards; zoning; surveying physical conditions, and resident attitudes and behavior; alternative methods of allocating resources among neighborhood units; approaches to citizen involvement, client and interagency relationships; major models for organizing neighborhood planning functions within municipal government. First several weeks devoted to study of neighborhood theory and to historical review of shifting concepts and methods of neighborhood planning. Reading assignments and planning exercises.
T. F. Lee

11.431 Financial Analysis in Urban Planning (Revised Content)

Prereq.: —
Year: G (1)
4-0-8

Through a series of case discussions and readings, first part seeks to acquaint students with financial concepts and tools frequently used in analysis of both private development projects and public investment decision. To develop an understanding of the resources needed to finance such investments, second part examines the institutional and economic factors affecting the allocation of mortgage funds to the credit markets. Last section extends the examination of the credit system by focusing on the residential credit activities of the federal government and their relationship to federal housing goals. Primary focus is on housing finance, but throughout the subject applications of the concepts to nonresidential real estate and community development are emphasized. Assumes little or no prior background in the above areas.
L. B. Sagalyn

11.432 Urban Land Development (A)

Prereq.: 11.431, 11.450
Year: G (2)
2-0-7

Treats the management problems involved in developing many kinds of real estate, ranging from multifamily housing, office buildings, hotels and motels, to shopping centers, industrial parks, residential subdivisions, recreational facilities, urban renewal projects, and new towns. Approaches real estate as a commodity determined by market and demographic forces and subject to unique financial requirements. Takes an integrated management approach to such diverse problems as determining the optimal use and price of land, the market demand for the kind of space being developed, the design and type of structure to be put on the land within the framework of zoning and building codes, and the minimum rent levels.
P. David

11.435 Employment and Economic Development Policy and Planning I (A)

Prereq.: 14.001, 14.002 or 11.210 or 14.51
Year: G (1)
3-3-6

Examination of employment problems of central cities and older regions of the US and the reproduction of poverty and unemployment. Critical assessment of the prevailing explanations: inadequate education and training, discrimination, changing metropolitan form (suburbanization), labor market segmentation, and more general tendencies of market economies toward inequality and uneven development. Alternative policies evaluated through case studies. Previous cases have addressed minority access to the construction trades, civil service barriers to minority employment, and municipal unions and public service employment. Critical evaluation of employment planning techniques: job design, task analysis, cost-benefit analysis, input-output and industry-occupation matrices.
B. Harrison

11.436 Employment and Economic Development Policy and Planning II (A)

Prereq.: 11.435 or 14.63 or 14.671J
Year: G (2)
3-3-6

Analysis of Federal, but especially state and local, economic development policy in the US. Class, race, and inter-regional conflict over public investments and subsidies considered. Critical assessment of plans for "ghetto" economic development, reorganization of low-wage jobs, greater public control over capital markets and industrial locations, public enterprise and worker ownership.
B. Harrison

11.437 The Political Economy of Development in New England

Prereq.: 11.210
Year: G (2)
3-0-9

Introduction to the political economy of New England including a review of social and economic history of region and transformations that have taken place over the past 50 years. Mill-based industries, capital goods sector, service sector, changing sources of labor power, changes in organization of work, and impact of industrial decline on the social structure in cities and rural areas of the region ex-

amined. Working class protest and ideology of "business climate" also discussed. Alternatives to conventional economic development strategies debated.
B. Harrison

11.441 Issues and Strategies in Community Development

Prereq.: —
Year: G (1)
Arr.

Current issues in community development: tactics, experiences, alternative strategies. (Primarily for those in the Community Fellows Program; others admitted by permission of instructor.)
M. H. King

11.442 Seminar in Community Development

Prereq.: 11.441
Year: G (2)
Arr.

Continuation of 11.441. Discussion and analysis of case studies presented by Community Fellows. Emphasis on preparation of written reports. (Permission of instructor.)
M. H. King

11.445 Community Development in Urban Neighborhoods

Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Politics of community-oriented economic development, with a particular focus on minority areas of large cities. The problems of increasing political and economic power of ghetto residents.
M. H. King

11.450 Housing Issues and Policy (Revised Content and Unit)

Prereq.: —
Year: G (1)
2-0-7

Introduction to housing issues and public policy. Focuses on the interdisciplinary nature of the field — the social, physical, economic, and political components. Readings, lectures, and class discussions are organized to give students a working familiarity with the elements of the housing system as well as a sense of current policy issues and the historic context from which those policies have emerged.
L. C. Keyes

11.451 Housing Practicum (A)

Prereq.: 11.450
Year: G (2)
4-0-8

Focuses on actual housing problems in conjunction with a governmental or community client. Collaborative interaction with other students and with client provides an opportunity to develop and apply professional planning skills. While topic changes from year to year, issues of housing management, public housing design, neighborhood revitalization, and financing strategies are likely to be emphasized.
L. C. Keyes

11.455 Housing for Populations with Special Needs (New)

Prereq.: —
Year G (2)
2-2-6

Explores housing for population groups with special needs. Includes single parent families, elderly, physically and mentally handicapped. Subject assumes that our current understanding of housing must be redefined to satisfy future changes in population, family, and lifestyle characteristics. Emphasis on housing and social policy; its evolution and prospect for the future. Also examines strategies for environmental and participatory design.
M. L. Joroff

11.461 Urban and Regional Growth Issues in Developing Countries (A)

Prereq.: 11.210
Year: G (1)
Arr.

Examination of the changing aims and approaches to the formulation and implementation of national and regional development strategies in less developed countries. Focuses on the planning, market, neo-Marxist, and ecological perspectives. Class includes case studies, role playing, extended readings, and a research paper. ***(Not offered 1981-82.)***
L. Rodwin

11.462 Housing Problems, Goals and Policies in Developing Countries

Prereq.: —
Year: G (2)
2-0-7

Seminar focuses on how the definition of housing problems and goals affect design and management of national policies and handling of issues related to land taxation, financing, building processes, self-help, tenure, and existing stock of housing. Other major concerns are price and subsidy policy and linkages between housing and national development strategies. Examined from several standpoints, including the paradigms of the mixed economy and of Marxism.
W. C. Wheaton

11.468 The Implementation of Metropolitan Planning in Developing Countries

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Emphasis on techniques for management and guidance of housing programs and land occupancy and their effects on development and equity in developing countries. Roles of urban planning in developing countries. Analysis of cases of planning and decision making, the study of "terms of reference" for planning services, and the programming of urban infrastructure. Costs of city building and the evaluation of different urban forms.
R. A. Gakenheimer

11.481 Regional Economic Accounts, Theories and Techniques (Revised Content)

Prereq.: 11.210
Year: G (2)
3-0-9

Survey of the basic accounting frameworks, theories, and techniques used in regional and multiregional economic analyses. Emphasis given to the aspects of each relevant to their use in program impact and distribution studies. Problem sets used to illustrate the different accounts, theories, and techniques.
K. R. Polenske

11.482 Applications of Regional Economic Theory

Prereq.: 11.481
Year: G (1)
3-0-9

Critical examination of the use of multi-regional accounts and models for regional development analysis, including applications of economic base, regional growth, general equilibrium, and inter-regional trade models. Special attention given to the use of regional input-output models and to current regional analyses being made of transportation, energy, pollution, income distribution, and employment problems. Some foreign regional studies also included.
K. R. Polenske

11.483 Workshop in Regional Economic Planning in Developing Countries (A)

Prereq.: 11.210, 11.417, 11.481
Year: G (2)
3-0-9

Students work together to formulate a regional economic plan for a particular developing country, with consideration given to the link between regional and national planning strategies. Specific data and materials from capitalist and socialist countries used for case studies.
K. R. Polenske

11.484 Social Cost-Benefit Analysis of Projects and Programs (Revised Unit)

Prereq.: —
Year: G (1)
3-3-6

Practical introduction to the theory and practice of project analysis and evaluation. Development of quantitative skills through case study or practice. Problem-solving emphasis on cost and benefit valuation (both economic and noneconomic) and on considerations of time, space, scale, externalities, multiple-objectives, risk and uncertainty, and indirect benefits and costs. Examination of usual institutional setting and of the practical influences of analytical procedures or project design and selection.
R. Sah

11.485 Rural Development: Theory and Practice in the Regional Context

Prereq.: —
Year: G (2)
3-0-6

Seminar on role of the nonmetropolitan, largely rural areas in regional development and of ways to ensure that rural development leads to equitable improvements in rural welfare. Emphasis on agricultural growth and transformation, including social and political aspects. Consideration also of opportunities for increasing nonfarm productive activities. Examination and analysis of current rural development programs in Africa, Latin America, and Asia.
A. M. Strout

11.486J The Finite Earth: Agendas for a More Just, Sustainable, and Participatory Society (New)

(Same subject as 4.761J, 17.440J, 21.919J, 22.83J)
Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Problems such as food supply, energy, material resources, global environment, and rapid changes in third world countries often tend to be looked on as separate; but each affects the other, and the connective tissue between them is too often lost. Subject explores several of these issues (especially food, energy, technology transfer, world security, and the views from alternative social systems) in context. Each topic cannot be developed in depth; purpose of subject is to introduce interested students to these issues; to ways in which they interactively influence the quality of social life for many in today's world; and to assess choices and directions for the future, both generally and as they may affect the student's own personal and professional interests. Content developed via a combination of lectures and discussion groups.
A. M. Strout, J. Beinart, M. Diskin, N. B. Herman, W. R. Johnson, D. J. Rose

11.487 Practicum in Area Planning for Developing Countries (A)

Prereq.: 11.461, 11.413, 11.481
Year: G (1)
4-4-5

Focuses on actual area planning problems in conjunction with an international planning and development agency or a client group in one of the developing countries. Collaborative interaction with other students and with client provides an opportunity to develop and apply professional planning skills. While topic changes from year to year, issues of rural development, squatter settlements, site and services policy, growth strategies, urban-rural relationships, agricultural development, transportation investment and migration are likely to be emphasized. (Permission of instructor required.)
A. M. Strout

Public Policy Formulation, Implementation, and Evaluation

11.500 Introduction to Public Policy and Management

Prereq.: —
Year: G (1)
4-0-8

Introduction to the theory and practice of public policy formulation and implementation. Consideration of real-world problems faced by planners and decision makers in the public sector. Focus is on ways in which obstacles to effective public management influence policy design. Theories of public policy implementation examined for their implications for effective management in the public sector. Emphasis on applications and limitations of public policy analysis. Case studies and exercises on the "solutions" to problems of selected decision makers operating at various levels of government.
M. Rein, H. Minor

11.501 Practicum in Public Management (A)

Prereq.: 11.500
Year: G (2)
4-4-8

Focuses on actual public management problems in conjunction with a governmental or community client. Collaborative interaction with other students and with client provides an opportunity to develop and apply professional public management skills. While topic changes from year to year, issues of municipal fiscal management, desegregation and decentralization of schools, public employee unionism, personnel policy, race relations, and intergovernmental relations are likely to be emphasized. (Permission of instructor required.)
H. Minor

11.502 Seminar in Program Design (A)

Prereq.: Permission of Instructor
Year: G (2)
2-0-7

Advanced seminar in planning methods for selected areas of urban social policy. Emphasis on program design. Focus, varying from year to year, on current issues in such fields as health services, low-income housing, and community development.
B. J. Frieden

11.504 Seminar in Political Economy (New)

Prereq.: Permission of Instructor
Year: G (1)
2-4-6

Research seminar which explores the interaction of the family, the state, and the market, using various theoretical frameworks and a comparative perspective. Each year a different specific topic is selected for study. Participants in the seminar commit themselves to doing a piece of empirical research on the selected topic. Students may use this research as a first step towards a master's or doctoral thesis.
L. R. Peattie, M. F[illegible]

11.505J Urban Politics, Planning and Public Policy (A)

(Same subject as 17.288J)
Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Examination of the politics of urban planning, policy development, and policy implementation. Urban policy viewed as a product of the entire American Federal system. Selected policy topics examined in detail, including land use planning, urban renewal, fiscal policy, transportation, and air pollution control. Special attention paid to the bases for alternative theoretical interpretations, such as Marxist and neo-conservative, of the record in each policy arena.
A. A. Altshuler

11.510 Seminar on Sociological Aspects of Policy Research

Prereq.: —
Year: G (2)
3-0-6

Each year this seminar deals with a topic at the intersection of sociological knowledge and public policy. Details announced shortly before the beginning of each term.
M. Rein

11.514 Social and Demographic Aspects of Public Policy in Urban Communities

Prereq.: Permission of Instructor
Year: G (1)
3-0-6

Focuses on the social structure differentiation and metropolitan communities. Designed to help students understand issues of program design and public policy and community development that have a territorial basis. Special attention given to impact of demographic changes on the nature of housing demand. While the class focuses on housing, much of the material is generic to public policy analysis in substantive areas in which social structure must be taken into account.
P. L. Clay

11.515 Municipal Finance (A)

Prereq.: 11.210
Year: G (1)
4-0-8

Practical introduction to the principles and practice of municipal financial planning. Topics: the property tax as a source of municipal revenue, an overview of the US capital and money markets, a review of the municipal bond market, and an examination of the relationship between cities and banks, thrift institutions, and other financial institutions. Also includes participation in a municipal finance fieldwork project for those students who are interested.
W. C. Wheaton

11.521 Policy Analysis of Social Service Systems (A)

Prereq.: 11.210, 11.220
Year: G (2)
3-0-9

Introduction to issues of explanation, policy formation, and resource allocation in designing social service systems. Particular attention to housing, health, and social insurance. Special attention given to competencies central to making diagnostic/prescriptive studies, evaluations, legislative reviews, and program designs, including the use of models in policy making. Individual projects and subject work are integrated.
J. Ferreira, Jr.

11.523J Evaluation of Public Programs (A)

(Same subject as TPP 41J)
Prereq.: 11.521
Year: G (2)
2-0-7

Evaluations characterized and compared as to methodology, scale and scope, sponsorship, audience, and feasibility. Experimental design and related statistical issues are considered. Political, social, economic, and institutional contexts of evaluation are analyzed. Several evaluations drawn from health, housing, and criminal justice are examined as case studies.
R. C. Larson

11.526J Logistical and Transportation Planning Methods (A) (Revised Content and Unit)

(Same subject as 1.203J, 6.281J, 13.665J, 15.078J, 16.76J, TPP 43J)
Prereq.: 6.431, 15.075
Year: G (1)
3-0-6

Quantitative techniques of operations research with emphasis on applications in transportation systems analysis (urban, air, ocean, highway, pick up, and delivery systems) and in the planning and design of logistically oriented urban service systems (e.g., fire and police departments, emergency medical services, emergency repair services). Unified study of functions of random variables, geometrical probability, multiserver queueing theory, spatial location theory, network analysis and graph theory, and relevant methods of simulation. Discussion of implementation difficulties. Examples of applications: design of ambulance systems having both specialized and general-purpose vehicles; emergency response to oil spills; estimation of energy consumption by commuters in a metropolitan area; design of dial-a-ride transportation systems; controlling randomness in mass transit systems; evaluation of technologies for vehicle location, routing and control.
A. I. Barnett, R. C. Larson, A. R. Odoni, H. N. Psaraftis

11.550 Conflict, Dispute Resolution and Negotiation in the Public Sector

Prereq.: 11.200, 11.230
Year: G (2)
3-0-6

Investigates social conflict and organizations that process disputes in public sector. While theoretical aspects of conflict generation, processing, and resolution are considered through a review of the current literature, focus is on the roles of dispute processing agencies and negotiative processes in public decision mak-

ing. Courts, administrative tribunals, and mediative agencies compared by exploring their decision-making processes and their consequences for participants and societies. Examples drawn from a wide range of general purpose tribunals, such as courts and court-appointed arbitrators, and those specialized ones such as labor management negotiating boards, administrative regulatory agencies, and consumer complaint boards. Attempts to build a strategy for using dispute processing agencies more effectively.
S. T. Buckle, L. G. Buckle

11.562 Housing Analysis and Public Policy (A)

Prereq.: 11.210, 11.450
Year: G (2)
2-0-7

Focuses on the development of techniques for policy analysis and their application to problems of housing and community development. Reviews the dynamics of urban housing markets: disinvestment, renewal, and discrimination. Emphasizes use and limitations of economic analysis in dealing with policy issues such as housing abandonment, homeownership for the poor, and suburban fringe development. Special emphasis on economic planning techniques: cost-benefit analysis, simulation models, and housing market studies. Application of techniques through case studies: housing the urban poor; slum formation and abandonment; effects of housing allowances. Preparation of housing policy analysis.
L. Sagalyn

11.571 Issues in Criminal Justice (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Examination of police, courts, and correctional agencies as social service systems. Introduction to the central issues facing professional planners, administrators, and legal practitioners in the criminal justice system. Discussion of the unique characteristics of these agencies: theories about criminals and crime, use of information and performance measures, nature of decision making by agency personnel, flow of clients through the criminal process, and problems of coordination within the system and with other service systems. ***(Not offered 1981-82.)***
S. T. Buckle, L. G. Buckle

11.572 Planning for the Criminal Justice System (A)

Prereq.: 11.571
Year: G (2)
3-0-6

An exploration of the roles of planning in the criminal justice system. Federal support for local criminal justice programs, administrative reorganization of courts, police, and corrections, restructuring of the criminal law, and direct commmunity action as illustrative modes of planning in this emerging field. Specific cases discussed in class include efforts to deinstitutionalize corrections, rationalize police patrol, reform court procedure, and divert offenders from the criminal justice system.
S. T. Buckle, L. G. Buckle

11.573 Fundamentals of Community Health Planning (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Analysis of the organizations which shape the health care system at the community level. Discussion focuses on the administration, responsibilities and methods of organizations responsible for community health planning: assessment of needs and resources; establishment of appropriate relationship between clients and providers; development of financing and remuneration systems; administrative and regulatory controls. Uses case studies to examine the interrelationships between the health care delivery system, governmental institutions, community advocate groups, and other community subsystems. ***(Not offered 1981-82.)***
M. Joroff

Doctoral Seminars

11.800 Doctoral Seminar I (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Analysis and practice in research competence fundamental to Urban Studies and Planning. Required of all first-year Ph.D. candidates.
R. M. Fogelson, B. Frieden, G. Marx, M. Rein

11.801 Doctoral Seminar II (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Analysis and practice in research competence fundamental to Urban Studies and Planning. Required of all first-year Ph.D. candidates.
R. M. Fogelson, B. Frieden, G. Marx, M. Rein

11.802J Seminar on Complex Models of Social Systems (A) (New)

(Same subject as 17.848J)
Prereq.: Permission of Instructor
Year: G (2)
Arr.

The research seminar focuses on the communicative content of social and political interactions. Grammatical approaches to the modeling of social and political competence and performance reviewed as well as data analysis procedures for uncovering linguistic codes and messages. Models from biological, linguistic, logical, semiotical, and artificial intelligence traditions discussed. Examples drawn from small group, urban, national and international contexts.
H. R. Alker, Jr., A. Fleisher

11.900 Doctoral Proseminars (A)

Prereq.: Permission of Instructor
Year: G (1, 2)
Arr.

Designed primarily for advanced doctoral candidates. A selection of Proseminars is offered each year for groups of students affiliated with the various research clusters in the Department. Proseminars for 1981-82 include Environmental Regulation, Neighborhood and Community Analysis, Theories of Economic Development, Organizational Design and Analysis, Theories of Planning Practice.
Staff

Tutorials, Research, and Fieldwork Subjects

11.901 Research Seminar: Topics in Urban Studies and Planning (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-6

11.902 Research Seminar: Topics in Urban Studies and Planning (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Special research issues in urban planning selected each term for special study. (Open to graduate students with permission of instructor.)
Staff

11.911 Reading Seminar in Urban Studies and Planning (A)

Prereq.: Permission of Instructor
Year: G (1)
Arr.

11.912 Reading Seminar in Urban Studies and Planning (A)

Prereq.: Permission of Instructor
Year: G (2)
Arr.

Reading and discussion of special topics in urban studies and planning.
Staff

11.932 Preparation for Thesis (A)

Prereq.: —
Year: G (1, 2)
Arr.

Selection of thesis subject, definition of method of approach, and preparation of preliminary thesis outline. Independent study, supplemented by frequent individual conference with staff members. (Restricted to doctoral candidates.)
Staff

11.941-11.948 Special Studies in Urban Studies and Planning (A)

Prereq.: —
Year: G (1, 2)
Arr.

Small group study of advanced subjects under staff supervision. For graduate students wishing to pursue further study in advanced areas of urban studies and city and regional planning not covered in regular subjects of instruction.
Staff

11.962 Urban Fieldwork and Internships (A)

Prereq.: Permission of Instructor
Year: G (1, 2)
Arr.

Practical application of planning techniques to towns, cities, and regions, including problems of replanning, redevelopment, and renewal of existing communities. Includes internships in municipal and state agencies and departments under staff supervision.
Staff

11.981 Graduate Tutorial

Prereq.: —
Year: G (1)
Arr.

11.982 Graduate Tutorial

Prereq.: —
Year: G (2)
Arr.

Planned programs of individual instruction. Students and faculty members must make arrangements prior to the beginning of the term.
Staff

12 Earth and Planetary Sciences

Undergraduate Subjects

12.UR Undergraduate Research

Prereq.: —
Year: U (1, 2)
Arr.

Undergraduate research opportunities in Earth and Planetary Sciences.
Staff

12.002 The Earth and the Planets

Prereq.: —
Year: U (2) SD
2-0-4

Introduction to comparative study of the planets and the earth. Properties of planetary atmospheres, surfaces, interiors, magnetic fields. Review of data from new space missions.
M. N. Toksöz

12.007 Dynamics of the Earth: Plate Tectonics and Continental Drift (New)

Prereq.: —
Year: U (1)
3-0-3

Introduction to large-scale movements of the earth's surface and dynamic processes in the earth's interior. Chemical, mechanical, and thermal structure of the earth. Rifting of continents and formation of ocean floor by sea-floor spreading. Large-scale horizontal motions of lithosphere and continental drift. Destruction of ocean floor at island arcs and the creation of mountains during continental collisions. Relations among earthquakes, volcanoes, mountains, basins, and the flow of material beneath the earth's surface. Emphasis on a physical understanding of the dynamics of the earth.
P. Molnar

12.01 Geological Processes, Features and History

Prereq.: —
Year: U (1) SD
3-4-5

Basic introduction to geology. Brief survey of major rock-forming minerals, rock-forming processes, and rock types. Origin and description of geologic structures and relationships observable in the field. Geologic time scale; nature of fossil record; dating of rocks by fossil and radiometric methods. Production, transportation, and deposition of sedimentary materials; development of landforms by moving water, wind, and ice; petrology and stratigraphy of ancient sedimentary rocks. Crustal evolution; survey of geologic history of the continents. Laboratory identification and description of rocks and minerals, with emphasis on sedimentary rocks; laboratory study of geologic mapping techniques, sedimentary processes, and major fossil groups. Three non-required weekend days of field trips.
J. B. Southard, J. G. Sclater

12.011 Sedimentary Processes: Rivers

Prereq.: 12.01
Year: U (1)
1-0-3

Nature of streamflow; modes of fluvial sediment transport; development of meandering and braided channel patterns; sedimentary structures and sedimentary sequences developed in fluvial deposits; recognition and interpretation of ancient fluvial sequences. (Alternate years. ***Offered 1981-82.***)
J. B. Southard

12.012 Sedimentary Processes: Glaciers

Prereq.: 12.01
Year: U (2)
1-0-3

Development and flow of valley glaciers and continental ice sheets; erosion and transportation of sedimentary material by glaciers; modes and forms of accumulation of glacial deposits; Pleistocene glacial history of North America; record of glaciations through geologic time. (Alternate years. ***Offered 1981-82.***)
J. B. Southard

12.013 Sedimentary Processes: The Wind

Prereq.: 12.01
Year: U (1)
1-0-3

Dynamics of wind erosion and transportation; form, migration, and stratification of sand dunes; loess; wind-borne sediment supplied to the oceans; recognition of eolian deposits in the geological record. (Alternate years. ***Not offered 1981-82.***)
J. B. Southard

12.014 Sedimentary Processes: Coastlines

Prereq.: 12.01
Year: U (1)
1-0-3

Movement of sand on beaches; form and stratification of beach deposits; estuaries and estuarine sedimentation; sediment distribution and transportation on modern continental shelves; nearshore sediments in the geological record. (Alternate years. ***Not offered 1981-82.***)
J. B. Southard

12.016 Sediments and Sedimentary Rocks

Prereq.: 12.01
Year: U (2)
2-2-2

Characterization of size, shape, and roundness of clastic constituents of modern and ancient sediments. Major sedimentary minerals, both detrital and authigenic. Petrology and classification of the major terrigenous rock types: sandstones, shales, and conglomerates. Dynamics of modern carbonate depositional environments; nature of modern carbonate sediments; petrology of ancient carbonate rocks. Brief treatment of other sedimentary rock types, including chert, ironstones, evaporites, and coal. Origin and interpretation of primary sedimentary structures. Processes of lithification and diagenesis. Survey of modern terrigenous depositional environments; principles and techniques of environmental interpretation. Laboratory work emphasizes petrologic characterization, classification, and interpretation of the major sedimentary rock types, based on both hand specimens and thin sections. One weekend field trip.
J. B. Southard

12.02 Chemistry and Physics of Minerals and Rocks

Prereq.: 3.091 or 5.60
Year: U (2) SD
3-4-5

Introduction to rock-forming minerals and their occurrence in the earth and extraterrestrial bodies. Combines a systematic presentation of mineralogy, emphasizing crystal chemistry and structure, with discussions of the formation of sedimentary, metamorphic and igneous rocks in terms of phase equilibria, geodynamics and planetary evolution. Laboratory work emphasizes identification of common rock-forming minerals, crystal structure and its relation to physical and chemical properties, and elementary optical mineralogy. Two weekend days of field-work.
R. G. Burns

12.03 Structural Geology

Prereq.: 12.01
Year: U (1)
3-3-6

Introduction to mechanics of rock deformations. Discussion and interpretation of faults, folds, structural features of igneous and metamorphic rocks, and superposed deformations. Introduction to regional structural geology and tectonics. Laboratory includes techniques of structural analysis, recognition and interpretation of structures on geologic maps, and construction of interpretive cross sections.
B. C. Burchfiel

12.043J Introduction to Mining and Mineral Technology (New)

(Same subject as 1.384J, 2.742J, 3.095J)
Prereq.: —
Year: U (1)
3-0-6

A basic introduction to mining and the minerals industry with emphasis on state-of-the-art technology. Includes mineral exploration, surface and underground mining, extractive metallurgy, health and safety, and environmental considerations. Integration of diverse subject matter stressed. Guest lectures by a variety of faculty members, classroom discussions based on assigned reading.
R. G. Lundquist, G. B. Baecher, J. F. Elliott, C. R. Peterson, R. G. Burns

12.051 Field Geology I

Prereq.: 12.02, *12.03*
Year: U (1)
2-2-2

Introduction to techniques of geological field study. Several weekend field exercises provide practical experience in preparation for 12.052. In addition some introductory material on the regional geology of the locale of 12.052 is presented.
B. C. Burchfiel

12.052 Field Geology II

Prereq.: 12.051, 12.03
Year: U (J, 2)
Arr.

During January, methods of modern geological field study are practiced during an intensive four-week excursion. Exercises include geological mapping on topographic, photographic, and ERTS image base maps, correlating geochemical and geophysical field measurements with geology, examining and sampling a wide variety of geological features. The excursion also includes visits to working mines, oil wells, and other places of geological interest. Following term includes: 1) laboratory analysis of samples, interpretation of geological, geophysical, and geochemical data, and 2) preparation of reports based on field studies conducted during January. Students receive a J grade at end of January term; they must enroll again for same subject second term. No new students accepted in second term. (Twelve units of Laboratory credit given upon successful completion of 12.051 and 12.052.)
B. C. Burchfiel

12.061 Petrology I

Prereq.: 12.02
Year: U (1)
3-6-3

Principles of optical mineralogy with emphasis on use of petrographic microscope for identification of minerals in rock thin sections and mineral grain mounts. Introduction to thermodynamics of heterogeneous phase equilibria and its application to experimental and natural rock systems. Introduction to experimental silicate systems. Survey of igneous rocks, emphasizing distribution, composition, mineral associations, origin and relationship to tectonic environment.
F. S. Spear, T. L. Grove

12.062 Petrology II

Prereq.: 12.061
Year: U (2)
2-6-4

Continuation of 12.061. Introduction to mineral facies concept and graphical representation of metamorphic mineral associations. Petrographic examination of igneous and metamorphic rocks in thin section. Interpreting igneous and metamorphic rock paragenesis through application of experimental petrology to natural rock systems. Relationship of igneous and metamorphic rock associations to plate tectonic environment. Three weekend days of field trips.
F. S. Spear, T. L. Grove

12.066 Analysis of Geological Materials (Revised Unit)

Prereq.: 12.02
Year: U (2)
2-6-4

Introduction to the study of geologic materials. Analytical techniques include X-ray fluorescence, neutron activation, atomic absorption, mass spectrometry, electron microprobe, experimental petrology, Mössbauer, and other absorption spectral methods. Special projects in laboratory employ techniques to analyze and interpet geological materials. (Enrollment limited to 12 students.)
F. A. Frey, R. G. Burns, S. R. Hart, T. L. Grove

12.07 Chemistry and Physics of the Earth (New)

Prereq.: 8.02, 18.03
Year: U (1)
3-0-9

An integrated, problem-oriented introduction to the chemistry and physics of the solid Earth. Focuses on a series of major interdisciplinary problems in the areas of the internal constitution, dynamics and evolution of the Earth; the geochemical and geophysical techniques appropriate for attacking each of these problems treated in this context. Topics include magma genesis and the geophysical structure of mid-ocean ridges and island arcs; the structure, composition and dynamics of the mantle; the formation and present characteristics of the core; and the evolution of the Earth's crust and mantle.
S. R. Hart, S. C. Solomon

12.091-12.094 Special Problems

Prereq.: —
Year: U (1, 2)
Arr.

Reading, laboratory, or fieldwork in Earth and Planetary Sciences. Written report required.
Staff

12.095 Teaching Earth and Planetary Sciences

Prereq.: Permission of Instructor
Year: U (1, 2)
Arr.

For undergraduate students with appropriate course experience to assist in laboratory and classroom teaching, or in the composition and grading of outside assignments, under faculty supervision. Available positions listed in department headquarters well before the start of each semester. (Students selected by interview. Pass/fail subject.)
Staff

12.101 Physics of the Earth

Prereq.: 8.03, 18.03
Year: U (1)
3-0-9

Survey of the earth's interior, thermal regime, composition, structure, elastic and inelastic properties, equation of state as revealed by physical measurements on the surface and on laboratory samples. Reviews results of heat flow, seismology, earth gravity and magnetism, high-pressure geophysics and regional geophysics.
G. Simmons

12.102 Plate Tectonics and Marine Geophysics (A)

Prereq.: 8.02; 18.03
Year: G (2)
3-0-9

Introduction to the formal theory of plate tectonics. Application of methods and results of geophysical studies of the crust and upper mantle to problems of sea-floor spreading, plate tectonics and plate structure. Seismic refraction and reflection. Earthquake mechanisms. Interpretation of gravity and magnetic anomalies. Loading and lithospheric flexure. Electromagnetic exploration techniques. Paleomagnetism. Heat flow. Basin and continental margin subsidence.
J. G. Sclater, S. C. Solomon

12.105 Introduction to Field Geophysics

Prereq.: 18.03
Year: U (1)
2-2-2

Introduction to geophysical field techniques and instruments. Description of seismic, gravity, magnetic and electrical methods and instruments. Some local field trips on weekends to test these techniques. For students with no experience in field geophysics. (Alternate years. ***Not offered 1981-82.***)
P. Molnar, T. R. Madden

12.106 Geophysics Field Study

Prereq.: 12.105
Year: U (J, 2)
Arr.

Application of geophysical field techniques and data interpretation to study crustal structure and geological problems. Intensive four-week field measurements in snow-free area during January, and interpretation of data during spring term. Fieldwork includes seismic, gravity, magnetic and electrical measurements, and geologic studies. Data interpretation includes data reduction and computer modeling to determine structure and properties of the field area. Students receive a J grade at end of January field study; they must enroll again for same subject during spring term for interpretation of field data. No new students accepted during spring term. (Twelve units of Institute laboratory credit given upon successful completion of 12.106. Alternate years. ***Not offered 1981-82.***)
P. Molnar, T. R. Madden

12.111 Survey of Astronomy I

Prereq.: —
Year: U (1) SD
2-0-4

Introductory survey of solar system astronomy, primarily for non-science majors. History of astronomy; place of solar system in the cosmos; physical and chemical properties of planets, asteroids, and meteorites; new information gathered from space probe research; celestial coordinate systems and time keeping. Opportunities for astronomical observations, including visits to Wallace Astrophysical Observatory. ***(Not offered 1981-82.)***
W. H. Pinson

12.112 Survey of Astronomy II

Prereq.: —
Year: U (2) SD
2-0-4

Introductory survey of stellar and galactic astronomy and cosmology for non-science majors, with emphasis on history of astronomy and historical development of modern astronomical concepts. Properties of stellar and related objects; qualitative stellar evolution; modern methods of observation and instrumentation. Opportunities to observe at Wallace Astrophysical Observatory.
W. H. Pinson

12.113 Astronomy I

Prereq.: —
Year: U (1) SD
3-0-9

Introductory subject in astronomy of the solar system. Mathematically and physically oriented on an elementary level, and an emphasis on problem solving. Topics: elementary celestial mechanics; celestial coordinate systems and time keeping; definitions of the elementary terminology of distances and magnitudes; interpretation of planetary surface and atmospheric features; interpretation of lunar data; nature of comets, meteors, meteorites, and asteroids; geochronology and methods of age dating solar system events; review of theories of origin of the solar system; solar eclipses and solar observational features; nature of interplanetary medium. Trip to Wallace Astrophysical Observatory.
W. H. Pinson, J. L. Elliot

12.114 Astronomy II

Prereq.: —
Year: U (2) SD
3-0-9

Introductory stellar and galactic astronomy. Mathematically and physically based with problem assignments, like 12.113. Topics: properties of the stars; observational methods of obtaining astrophysical data; elementary stellar interiors theory; thermonuclear processes of energy production in stars; the sun; variable stars; systems of stars; nature of galaxies; radio and X-ray astronomy, and theories of the nature of such newly discovered objects as X-ray sources, pulsars and quasars. Field trip to Wallace Astrophysical Observatory.
W. H. Pinson

12.115J Dynamical Astronomy

(Same subject as 8.293J)
Prereq.: 18.03
Year: U (2) SD
3-0-9

Kepler's laws and the law of gravitation. One- and two-body motion: orbits in space and time. General and special cases of the n-body problem. Disturbed motion of two bodies: variation of orbital elements; planetary and satellite theory; periodic and secular effects; orbital resonance. Astronomical coordinate systems and time. Numerical integration of orbits. Maximum-likelihood estimation of orbital initial conditions and astronomical constants.
C. C. Counselman, I. I. Shapiro

12.117J Observational Techniques of Optical Astronomy (Revised Unit)

(Same subject as 8.287J)
Prereq.: 12.113 or 8.282
Year: U (1) LAB
3-4-5

Fundamental physical and optical principles used for astronomical measurements at visible wavelengths and practical methods of astronomical observations. Topics: astronomical coordinates, time, geometrical optics, telescopes, photomultipliers and other detectors, photon counting, signal-to-noise ratios, limita-

Graduate Subjects

tions imposed by the earth's atmosphere on optical observations, photography, photometry, spectroscopy and time variability. Project at Wallace Astrophysical Observatory.
J. L. Elliot, T. Dunham

12.121 Exploration of the Solar System

Prereq.: 8.02, 18.02
Year: U (2)
3-0-9

Survey of instrumental techniques and strategy underlying measurements of the solar system. A description of optical, ultraviolet, infrared, radio, radar and particle detectors as applied to remote observations made either from the ground or from space probes. Role of occultation techniques and two-frequency propagation paths as a means of studying the solar corona, interplanetary plasma and planetary atmospheres. Use of planetary atmospheric entry and landing probes to make direct *in situ* measurements of planetary characteristics. (Alternate years. ***Offered 1981-82.***)
G. H. Pettengill, J. S. Lewis, J. L. Elliot

12.131J Planetary Physics and Chemistry I

(Same subject as 8.291J)
Prereq.: 8.02, 18.02
Year: U (1) SD
3-0-9

12.132J Planetary Physics and Chemistry II

(Same subject as 8.292J)
Prereq.: 8.02, 18.02
Year: U (2) SD
3-0-9

Study of planetary system: evolution, composition, present configuration, dynamics, interiors, surfaces, atmospheres, and magnetospheres of the planets and, where appropriate, similar aspects of the satellites, asteroids, and comets. Theoretical interpretations of existing data stressed. First term: a general description of solar system and its origin and a comprehensive discussion of outer planets. Second term: solar system dynamics, the interplanetary medium, and interiors, surfaces, and atmospheres of inner planets.
J. S. Lewis, I. I. Shapiro

12.20J Environmental Chemistry of the Ocean-Atmosphere System

(Same subject as 19.05J)
Prereq.: —
Year: U (1)
3-0-9

The earth's air and water. Factors controlling steady-state composition of ocean and atmosphere. Response times of system to natural and anthropogenic perturbations. Exchange of material between ocean and atmosphere. Global and regional balances of water, carbon, oxygen, hydrogen, sulphur and nitrogen. Residence times of these species in the various subsystems. Cycle of aerosols and role of rain and snow as removal processes. Continental weathering cycle and its effect on the composition of the dissolved and suspended load of rivers. Special problems involving use of radiocarbon, tritium, radon, and other natural and artificial radioactive and stable isotopes as tracers. Effect of human activities on the various interrelated cycles that control chemistry of global environment. (The prerequisite will be satisfied by the General Institute Science requirement or equivalent.)
J. M. Edmond, R. E. Newell

12.21 Physics of the Ocean

Prereq.: 8.03, 18.03
Year: U (1) SD
3-0-9

Introductory survey of oceanic circulation and dynamics. Descriptive aspects of water mass movement, currents, and physical properties of the ocean. Dynamic models of currents and waves using equations of fluid dynamics. (Similar to 19.83. Alternate years. ***Offered 1981-82.***)
C. C. Eriksen

12.221-12.229 Project Studies in Oceanography

Prereq.: —
Year: U (1, 2)
Arr.

Extended participation in work of a research group, including independent study of the literature, direct involvement in group's research (commensurate with student's skills and preparation), or project work under an individual faculty member extending over more than one term. Admission by arrangement with individual MIT and Woods Hole faculty members.
Staff

Geology and Geochemistry

12.301-12.304 Seminar in Geology and Geochemistry (A)

Prereq.: 12.02
Year: G (1, 2)
2-0-4

Seminar continuing throughout academic year on topics of current interest in geology and geochemistry. Required background preparation for students taking pre-doctoral general examinations in these subjects.
S. R. Hart, Staff

12.31 World Regional Tectonics (A)

Prereq.: 12.103
Year: G (2)
3-0-6

Brief review of evolution of the ocean floor with emphasis on phenomena occurring at plate boundaries. Late Cretaceous and Cenozoic tectonics of continental regions, where plate motions are known and the geology is well studied. Emphasis on Cordilleran belt of western North America and on Alpide belt as examples of an Andean margin and of continental collisions. Application of principles and phenomena associated with these regions to older orogenic belts, where plate tectonics cannot be applied directly. Each student becomes familiar with a part of one orogenic belt in detail, as well as the basic history of all regions of the earth. (Alternate years. ***Not offered 1981-82.***)
B. C. Burchfiel

12.311 Seminar in Regional Tectonics (A)

Prereq.: 12.31
Year: G (1 or 2)
3-0-6

Techniques of tectonic synthesis applied to study the roles of particular orogenic belts in global plate tectonics. Different applications treated in different terms, so that the subject may be taken repeatedly to learn the range of orogenic responses to temporal and spatial variations of activity at plate boundaries. (Permission of instructor required.)
B. C. Burchfiel

12.32 Mechanics of Sedimentary Processes (A)

Prereq.: 1.05
Year: G (2)
3-0-9

Aspects of turbulent flow mechanics relevant to sediment movement. Mechanics of sediment erosion, transportation, and deposition: modes of particle entrainment and motion in turbulent shear flows; sediment bed configurations; erosion and deposition of cohesive sediments; turbidity currents; sorting of sediments by particle size and density. Interpretation of primary structures and textures in modern and ancient sedimentary deposits on the basis of sediment-transportation mechanics.
J. B. Southard

12.33 Petroleum Geology

Prereq.: Permission of Instructor
Year: G (1 or 2)
3-0-6

Origin, migration, and accumulation of petroleum. Geology of major oil producing regions of the world. Geological and geophysical exploration techniques. Other topics of current interest. Taught by Crosby Visiting Professors. (Alternate years. ***Offered 1981-82.***)
Staff

12.34 Mineral Deposits

Prereq.: Permission of Instructor
Year: G (1 or 2)
3-0-6

Geological occurrence of the principal types of mineral deposits. Description of important examples in each category, together with examination of the ores. Modern hypotheses of origin of deposits and of metallogenic provinces. Discussion of relationships with plate margins. Taught by Crosby Visiting Professors. (Alternate Years. ***Not offered 1981-82.***)
Staff

12.35 Rock Mechanics (A)

Prereq.: 2.30 or 12.03; 8.03, 18.03
Year: G (1)
3-0-9

Review of certain tensor and non-tensor properties of crystals, including elastic, thermal, and optical properties, cleavage and fracture. Derivation of aggregate from single crystal properties with application to rocks under geologic conditions. Microstructure of rocks and rock masses in its application to elasticity, strength, ductility, and transport phenomena. Modern theories of brittle fracture, and frictional behavior of rocks. (Alternate years. ***Offered 1981-82.***)
W. F. Brace

12.355 Seminar in Rock Mechanics (A)

Prereq.: —
Year: G (1 or 2)
2-0-4

Discussion of current research or advanced topics in continental tectonics, rock mechanics, or experimental structural geology.
W. F. Brace

12.37 Stresses in The Crust (A)

Prereq.: 12.03
Year: G (1)
3-0-6

Review of observed failure conditions for fracture and friction of rocks at crustal pressure and temperatures. Measurement of *in situ* stress in drill holes and surface outcrops. Use of active faulting, orientation of plutons, and fault plane solutions to infer stress directions. For regions where many measurements are available, comparison with stresses deduced from plate motions and plate geometry. Review of paleostress techniques. (Alternate years. ***Not offered 1981-82.***)
W. F. Brace

12.385-12.399 Special Problems in Geology-Geochemistry (A)

Prereq.: —
Year: G (1 or 2)
Arr.

For graduate students desiring to perform special investigations, special laboratory work, or special fieldwork in geology, petrology, mineralogy or geochemistry. *F. S. Spear* (12.385); *W. F. Brace* (12.386); *T. L. Grove* (12.387); *R. G. Burns* (12.388); *J. M. Edmond* (12.389); *F. A. Frey* (12.390); *S. R. Hart* (12.393); *W. H. Pinson* (12.394); *B. C. Burchfiel* (12.395); *J. B. Southard* (12.396); *J. S. Lewis* (12.397); *Staff* (12.398, 12.399).

12.411 Isotope Geology (A)

Prereq.: 12.02
Year: G (2)
3-0-6

Applications of the variations in the relative abundance of radiogenic and stable isotopes to geologic problems. Topics: geochronology, studies of petrogenesis, geologic processes that can be traced by stable isotope fractionations, techniques, and instrument design. (Alternate years. ***Offered 1981-82.***)
S. R. Hart

12.42 Geochemistry of the Solid State (A)

Prereq.: 3.091, 12.02
Year: G (1, 2)
3-0-6

Applications of resonance spectroscopic techniques to the study of energy levels and chemical bonding in minerals. Topics: quantum theory, atomic energy levels, and spectroscopic states; group theory, crystal field theory, and electronic absorption spectra of silicates; molecular orbital theory, band theory, and properties of sulfides; the use of experimental techniques such as Mossbauer, electron paramagnetic resonance, and electronic absorption spectroscopy for determining the crystal chemistry and geochemistry of transition metals in geological materials. (Offered every third term. ***Offered Term 2, 1981-82.***)
R. G. Burns

12.45 Trace Element Geochemistry (A)

Prereq.: 12.071
Year: G (1)
3-0-9

Study of element distribution in rocks and minerals using data obtained from natural and experimental systems. Emphasis on models describing trace element partitioning and on applications of trace element geochemistry to problems in igneous geology.
F. A. Frey

12.46 Geochemical Kinetics (A)

Prereq.: 12.02
Year: G (2)
2-0-4

Basic principles of kinetics, both theoretical and phenomenological. Solutions of diffusion equation; review of experimental data and techniques for silicate liquids and solids. Applications to natural geochemical systems. (Alternate years. ***Offered 1981-82.***)
S. R. Hart

12.47 Advanced Metamorphic Petrology (A)

Prereq.: 12.062
Year: G (1)
3-3-6

Advanced topics in metamorphic petrology including graphical and algebraic analysis of mineral composition space, thermodynamics of heterogeneous phase equilibria. Investigation of properties of fluid phase during metamorphism. Application of experimentally determined phase equilibria to interpretation of physio-chemical conditions of metamorphism, investigation of metamorphic processes such as reaction kinetics, diffusion and infiltration metasomatism. Laboratories stress petrographic and textural analysis of metamorphic rock suites, X-ray diffraction, electron microprobe analysis, fundamentals of experimental petrology and computer applications. Two weekend days of field trips. (Alternate years. ***Offered 1981-82.***)
F. S. Spear

12.48 Advanced Igneous Petrology (A)

Prereq.: 5.60
Year: G (2)
3-3-6

Thermodynamics, experimental phase equilibria, and kinetics combined to infer the physical conditions of igneous rock crystallization and magma production. Experimental investigations in synthetic and natural systems used to constrain processes that give rise to the diversity of igneous rocks, and that control magma genesis. Theoretical and experimental approaches to thermometry-barometry techniques involving solid/solid and mineral/liquid reactions critically evaluated. Role of kinetics in the crystallization, differentiation, and melting of igneous rocks and the physical and thermodynamic properties of silicate melts. (Alternate years. ***Not offered 1981-82.***)
T. L. Grove

12.490-12.499 Advanced Seminar in Geology and Geochemistry (A)

Prereq.: Permission of Instructor
Year: G (1 or 2)
Arr.

Problems of current interest in geology and geochemistry. Subject matter varies from term to term. *Staff* (12.490); *T. L. Grove* (12.491); *R. G. Burns* (12.492); *F. A. Frey* (12.493); *S. R. Hart* (12.494); *Staff* (12.495); *W. H. Pinson* (12.496); *F. S. Spear* (12.497); *Staff* (12.498-12.499).

Geophysics and Planetary Physics

12.512 Geoelectricity (A)

Prereq.: 8.03, 18.076
Year: G (2)
3-0-9

Electrical properties of earth's crust and mantle and application of electrical measurements to a variety of geological and geophysical problems both practical and impractical. Subject matter includes conductivity of porous media, surface conduction and cross coupling effects in porous media, induced polarization, conduction properties of minerals at high temperatures. Applications include resistivity, self-potential, magnetotelluric and other E-M measurements to investigate rock types or implacements, fluid flows, earth strains, and mantle temperatures. (Alternate years. ***Offered 1981-82.***)
T. R. Madden

12.514 Geomagnetism (A)

Prereq.: 8.03, 18.076
Year: G (2)
3-0-9

Survey of magnetic and electromagnetic properties and processes in the earth's environment. Plasma environment of earth's magnetosphere and ionosphere and electromagnetic wave and particle phenomena occurring therein. Electric properties of the earth's interior. Magnetohydrodynamic origin of magnetic fields of earth and other astronomical bodies. (Alternate years. ***Not offered 1981-82.***)
T. R. Madden

12.521 Elements of Seismology (A)

Prereq.: 18.075
Year: G (1)
3-1-8

A basic subject in seismology and the utilization of seismic waves for the study of the earth's interior. Introduction of techniques necessary for understanding of elastic wave propagation in layered media. Seismic ray theory and interpretation of travel times. Surface wave dispersion and layered media. Seismicity, earthquake magnitude, energy.
M. N. Toksöz

12.522 Advanced Seismology (A)

Prereq.: 12.521, 18.284
Year: G (2)
3-0-9

Advanced methods of theoretical seismology; the general properties of seismic waveforms; separate discussions on sources and media; head waves, normal modes, leaky modes, and exact synthetic seismograms in layered media; seismic scattering due to lateral heterogeneity of the earth; near-field and far-field of seismic radiation from natural and artificial sources; wave propagation in anisotropic media; mechanism of attenuation.
K. Aki

12.523 Seismology Seminar (A)

Prereq.: 12.521
Year: G (1 or 2)
2-0-6

An advanced reading and seminar subject on topics in seismology and closely related fields involving critical analysis of current literature.
K. Aki, P. Molnar, S. C. Solomon, M. N. Toksöz

12.53 Inverse Problems in Geophysics (A)

Prereq.: 18.075
Year: G (1)
3-0-6

Problems of determining physical parameters of the earth's interior from surface observation of wave and potential fields. Iterative methods and linear analysis of parameter sensitivity and data error effects. Stochastic models of parameter fluctuations. Exact inversion methods for one-dimensional problems. Topics: seismic reflection, refraction and dispersion, free oscillations, seismic source properties, holography, magnetotellurics, magnetic variations, resistivity, magnetics and gravity.
T. R. Madden, K. Aki

12.54 Planetary Interiors (A)

Prereq.: 12.07, 18.075
Year: G (2)
3-0-9

Graduate-level discussion of the constitution, evolution, and structure of the interiors of the terrestrial and Jovian planets and of their satellites. Surface and integral properties of the planets and satellites. Gravitational fields and equilibrium configurations of planetary bodies. Equations of state of planet-forming materials. Internal structure of the planets and satellites. Planetary magnetic fields. Thermal evolution, convection, and their relation to surface tec-

tonics. Critical evaluation of current models of interiors and theories of the origin and development of the solar system. (Alternate years. ***Not offered 1981-82.***)
S. C. Solomon

12.56 Advanced Seminar in Plate Tectonics (A)

Prereq.: 12.101, 12.102
Year: G (2)
3-0-6

Basic observations and theoretical developments in sea-floor spreading, plate tectonics, continental tectonics, and marine geophysics. Data from seismic, magnetic, heat flow, gravity measurements and other sources used to study the properties of the lithosphere, the asthenosphere, and the motions of the plates. Key papers and latest articles reviewed.
M. N. Toksöz, P. Molnar, S. C. Solomon, J. G. Sclater

12.581-12.589 Seminar in Geophysics (A)

Prereq.: —
Year: G (1 or 2)
Arr.

Problems of current interest in geophysics; subject matter varying from term to term. *Staff* (12.581, 12.582); *K. Aki, M. N. Toksöz* (12.583); *T. R. Madden, S. C. Solomon,* (12.584); *G. Simmons* (12.585); *Staff* (12.586, 12.587); *I. I. Shapiro* (12.588); *P. Molnar, J. G. Sclater* (12.589).

12.591-12.599 Special Problems in Geophysics (A)

Prereq.: —
Year: G (1 or 2)
Arr.

For graduate students desiring to perform special investigations, special laboratory work, or special fieldwork in geophysics. *Staff* (12.591); *M. N. Toksöz* (12.592); *K. Aki, S. C. Solomon* (12.593); *T. R. Madden* (12.594); *G. Simmons* (12.595); *Staff* (12.596, 12.597); *W. F. Brace* (12.598); *P. Molnar, J. G. Sclater* (12.599).

12.626J Radio Interferometry (A)

(Same subject as 6.664J, 8.952J)
Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Principles, techniques, and applications of radio interferometry, emphasizing current research using very long baselines. Techniques applicable to natural continuum, as well as artificial sources. Synthesized wide band group-delay interferometry, continuous phase-delay interferometry, and differential interferometry. Inference of astronomical and geophysical parameters from interferometric observations: tests of relativity theory; source angular brightness distributions, positions, and proper motions; propagation-medium effects; geodesy; solid earth tides; polar motion and spin rate; tracking of artificial satellites, lunar and planetary probes. (Knowledge of electronic signals, systems, and noise theory required. Alternate years. ***Offered 1981-82.***)
C. C. Counselman, I. I. Shapiro, D. H. Staelin

12.627J Techniques of Radar Astronomy (A)

(Same subject as 6.663J)
Prereq.: 8.03, 18.075
Year: G (1)
3-0-9

Discussion of techniques required in generating high-power radio emissions and in detecting their echoes from extraterrestrial objects and plasmas. Interpretation of received signal in terms of the characteristics of interplanetary plasma and planetary atmospheres as they affect propagation, and in terms of detailed characteristics of surface of planets and satellites as they affect reflection. Radar equation. Ambiguity function and its calculation for waveforms of interest to radar astronomy. Modulation and detection techniques. Digital processing in data reduction. Target scattering function and its generalization in terms of arbitrary polarization: the scattering matrix, using Stokes' vector formalism. Angular scattering laws and their relationship to statistical properties of a planetary surface. Use of interferometric techniques in mapping local scattering characteristics and topography. (Alternate years. ***Offered 1981-82.***)
G. H. Pettengill, D. H. Staelin

12.631 Planetary Atmospheres (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-6

Discussion in light of recent spectroscopic and space-probe data of compositions, structures, and origins of the atmospheres of the planets. Thermodynamics of atmospheric structure, cloud precipitation, and mineral buffers of pressures of reactive gases. Photolysis; escape rates, mineralogy of surface rocks. Chemical behavior of a solar-composition atmosphere: the solar nebula, the interiors of the major planets. Models for the origin and development of planetary atmospheres. (Alternate years. ***Not offered 1981-82.***)
J. S. Lewis

12.636 Current Research in Meteoritics (A)

Prereq.: Permission of Instructor
Year: G (1)
Arr.

Discussion of current research and special problems in meteoritics. Composition and structure of important classes of meteorites; meteorite dating methods and their results; thermodynamics of meteoritic minerals; geochemistry and isotopic chemistry of meteoritic and lunar surface material. Evidence concerning the origin of meteorite classes and proposed genetic relationships. Conditions in the solar nebula. (Alternate years. ***Not offered 1981-82.***)
J. S. Lewis

12.691-12.699 Special Problems in Planetary Physics (A)

Prereq.: —
Year: G (1 or 2)
Arr.

For graduate students desiring to perform special investigations, special laboratory work, or special fieldwork in planetary physics. *Staff* (12.691, 12.692); *G. H. Pettengill* (12.693); *I. I. Shapiro* (12.694); *J. L. Elliot* (12.695); *C. C. Counselman* (12.696); *J. S. Lewis* (12.697); *Staff* (12.698, 12.699).

Oceanography

12.72 Oceanic Volcanology and Petrology (A)

Prereq.: Permission of Instructor
Year: G (2)
3-2-4

Lectures, discussion sessions, and laboratory exercises on igneous and metamorphic processes occurring within and around the major ocean basins. Topics may vary from year to year and focus on current observational data and hypotheses proposed to explain the observations. Discussion of volcanic processes at spreading centers, using information obtained by dredging, submersible sampling, and deep drilling. Tectonics and vulcanism along fracture zones, island arcs, and subduction zones. Vulcanism and magmatic trends along linear island chains. Laboratory work on examination of hand specimens and thin sections, plus techniques of chemical and microprobe analysis. (Intended for Joint Program students in Geology and Geophysics.

although other Joint Program students may enroll with permission of instructor. Given at Woods Hole Oceanographic Institution. Alternate years. ***Offered 1981-82.***)
(Woods Hole Staff): W. Bryan, H. Dick

12.73 Introduction to Marine Geology (A) (Revised Unit)

Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Designed to acquaint those without a background in geology with the processes responsible for the composition and morphology of the ocean's floors. Through the understanding of processes, ranging from organic productivity to sea-floor spreading, the student can make reasonable predictions about global seafloor geology. Topics: techniques and instruments of marine geology; *The Continental Margin:* shorelines, estuaries, continental shelves, sea level changes, marginal seas, continental slopes, submarine canyons, continental rises; *The Deep Sea Floor:* trenches, island arcs, atolls, seamounts, plateaus, abyssal plains, abyssal hills, mid-oceanic ridges, fracture zones, theories of seafloor evolution; *Sedimentary Processes:* sediment source, distribution, physical properties, age dating, movement and deposition of cohesive and incohesive material, benthic environment of modern and ancient ocean basins; *Results of the Deep Sea Drilling Project. (Alternate years.* ***Offered 1981-82.***)
(Woods Hole Staff): B. Tucholke, D. Aubrey

12.74 Marine Micropaleontology (A)

Prereq.: Permission of Instructor
Year: G (1)
2-3-4

Basic principles of Micropaleontology, its historic development and its applications in the marine realm, particularly biostratigraphy and biochronology, paleoecology and paleoclimatology, for nonspecialists. Major groups of marine microfossils, with special emphasis on groups most commonly used as tools in various aspects of paleooceanography, (e.g. Planktonic Foraminifera, Calcareous Nannoplankton, Radiolaria, Diatoms and Dinoflagellates). Laboratory work includes preparation techniques, light and SEM microscopic work, and introduction to quantitative methods. (Given at Woods Hole Oceanographic Institution. Intended for Joint Program students in Geology and Geophysics. Other Joint Program students may enroll with the consent of instructor. (Alternate years. ***Not offered 1981-82.***)
(Woods Hole Staff): B. Haq

12.75 Marine Sediments (A)

Prereq.: 12.73
Year: G (1)
3-0-9

Sedimentary processes and interpretation of the depositional record in coastal environments, continental margins, and the deep ocean. Nearshore processes; sediments and structure of continental margins; deep ocean sediments (carbonates, clays, volcanogenic, authigenic); physical and acoustic properties of sediments; marine stratigraphy (excluding biostratigraphy); abyssal processes; and applications of marine sediments to paleo oceanographic studies. (Intended for Joint Program Students in Geology and Geophysics. Permission of instructor required. Given at Woods Hole Oceanographic Institution. Alternate years. ***Not offered 1981-82.***)
(Woods Hole Staff): D. A. Johnson

12.76 Plants, Animals and Sediments (A) (New)

Prereq.: Permission of Instructor
Year: G (2)
2-2-8

Interaction of organisms with their sedimentary environments, emphasizing both processes and the organisms themselves. Processes include biologic habitats, feeding, photosynthesis, carbonate and silicate budgets in the oceans, skeletons (their formation and preservation), and the effects of non-skeletal processes (such as burrowing, boring, trail-making, and fecal pellets). Organisms discussed are phylum by phylum, with respect to their mode of living, skeleton formation, composition, and identification of skeletal and non-skeletal remains, as well as their general role (and importance) in the geologic record. (Alternate years. ***Offered 1981-82.***)
(Woods Hole Staff): J. Milliman

12.77 Marine Geophysics (A)

Prereq.: Permission of Instructor
Year: G (1)
3-2-6

Lectures and laboratory sessions on the measurements and geological modeling of marine magnetic and gravity anomalies; bathymetry and heatflow; reflection and refraction seismology. Classical and recent accomplishments on theory and application with laboratory devoted to actual data. Introduction to time-series analysis, designed to convey certain skills used in subsequent topics. During each of the geophysical disciplines examined, special attention paid to the confidence of models arising from the data. Overall purpose to acquire working knowledge in data interpretation; to gain an appreciation for the power, limitations, and pitfalls of the major marine geophysical techniques; and to bridge the gap between geophysical method and geological understanding. (Given at Woods Hole Oceanographic Institution. Alternate years. ***Offered 1981-82.***)
(Woods Hole Staff): C. Denham, H. Schouten

12.771-12.779 Seminar in Oceanography at Woods Hole (A)

Prereq.: —
Year: G (1 or 2)
Arr.

Topics in marine geology and geophysics, physical, dynamical, and chemical oceanography. Content varying from term to term.
Woods Hole Staff

12.781 Special Problems in Chemical Oceanography at Woods Hole (A)

Prereq.: Permission of Instructor
Year: G (1, 2)
Arr.

For graduate students desiring to perform special investigations, special laboratory work, or special fieldwork in chemical oceanography.
Woods Hole Staff

12.79 Marine Sediments Laboratory (A) (New)

Prereq.: *12.75*
Year: G (1)
1-4-1

Principles of the petrographic analysis of sediments and the interpretation of their results. Subjects include textural, compositional, and mass physical properties, involving both microscopic and analytical analyses. Emphasis on both assigned readings and laboratory exercises for each topic. Should be taken concurrently with 12.75. (Alternate years. ***Not offered 1981-82.***)
(Woods Hole Staff): J. Milliman

12.791 Special Problems in Marine Geology and Geophysics at Woods Hole (A)

Prereq.: Permission of Instructor
Year: G (1, 2)
Arr.

For graduate students desiring to perform special investigations, special laboratory work, or special fieldwork in marine geology and geophysics.
Woods Hole Staff

12.80 Marine Chemistry (A)

Prereq.: Permission of Instructor
Year: G (2)
4-0-10

Chemistry of the oceanic water column. Salinity, major ion composition and speciation, and the physical properties of seawater. Gaseous equilibrium and exchange with the atmosphere. General circulation and the use of advection-diffusion models with specific application to the oceanic nutrient-oxygen-carbon dioxide systems. Naturally occurring and fallout radionuclides and their use in elucidating chemical processes. Geochemistry of minor elements in seawater, oxidation-reduction processes and the chemistry of the surface micro-layer. (Given at Woods Hole Oceanographic Institution. Alternate years. ***Offered 1981-82.***)
(Woods Hole Staff): M. Bacon, P. G. Brewer, W. J. Jenkins

12.810J Wave Motions in the Atmosphere and Oceans (A) (New)

(Same subject as 19.71J)
Prereq.: 18.350 or 19.69
Year: G (2)
3-0-9

Introduction to general concepts in wave theory, dispersive and nondispersive waves, energy flux, wave action, ray theory. Derivation of wave equations in geophysical systems: Laplace tidal equation, shallow water theory, planetary waves, topographic waves, internal gravity waves. Wave-mean flow and wave-wave interactions.
(Woods Hole Staff): N. G. Hogg

12.82 Marine Geochemistry of Sediments (A)

Prereq.: 5.41 or 3.091, 5.60
Year: G (2)
3-0-9

Chemical and isotopic composition of sediments in space and time. Present-day surface sediments. Equilibria, kinetics, and interface chemistry of precipitation/dissolution reactions. Effect of sedimentary processes on the chemical composition of seawater. Dating and accumulation rate estimation. Oxygen and carbon isotope biostratigraphy. Effect of climate fluctuations and tectonics on sedimentary processes. Decoding the sediment record by qualitative and quantitative methods. Student development of current problems emphasized, as are mathematical techniques and modeling where appropriate. (Alternate years. ***Not offered 1981-82.***)
E. A. Boyle

12.822 Paleoceanography (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

History of the earth surface environment as deduced from the record in deep-sea sediments. Micropaleontological, isotopic, geochemical, and mineralogical changes observed in piston cores and DSDP materials used to infer changes in temperature and current field of the ocean and atmosphere, changes in seawater chemistry, and tectonic evolution of the seafloor. Also used to evaluate and constrain theories of environmental change. Research strategies for improving our understanding considered. Marine sediment record is supplemented by evidence from continental sediments (e.g., ancient shorelines as indicators of sea level and the geochemistry of nearshore fossils) and geophysical data (e.g., magnetic lineations and paleo-poles) where appropriate. (Alternate years. ***Offered 1981-82.***)
E. A. Boyle

12.83 Marine Geochemistry (A)

Prereq.: 5.41 or 3.091, 5.60
Year: G (1)
3-0-9

Composition of seawater: chemistry of aqueous solutions, ionic association and dissociation, and relevant calculations: concepts of steady state and residence times of species and discussion of static versus dynamic chemical models of the ocean. Effect of oceanic circulation on the chemistry illustrated by the CO_2, silicate, and isotopic distributions. Discussion of authigenic sediments, control of seawater composition, geochemical cycles. Emphasis on development of problems and topics by students and on calculations. (Alternate years. ***Offered 1981-82.***)
J. M. Edmond

12.84 Marine Organic Geochemistry (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Topics include dissolved and particulate organic carbon in the sea, clay-organic interactions, analytical methods and the chemistry of kerogen, humus, petroleum, and coal. Movements of synthetic organic compounds through the marine environment used to illustrate some aspects of the cycling of organic carbon in the ocean. (Given at Woods Hole Oceanographic Institution. Alternate years. ***Not offered 1981-82.***)
(Woods Hole Staff): J. Farrington, R. Gagosian

12.85 Oceanographic Time Series (A)

Prereq.: 18.075
Year: G (2)
3-0-6

Examines aspects of the problems encountered in using real, finite, discrete time series data from oceanographic experiments. Includes z-transforms, Wiener filters, minimum phase systems, spectra, bi-spectra, array antennas, data adaptive methods. (Alternate years. ***Not offered 1981-82.***)
C. C. Eriksen

12.87 Equatorial Physical Oceanography (A)

Prereq.: 19.70
Year: G (2)
3-0-6

Observations of equatorial oceans and dynamical models intended to explain various features. Comparative review of measurements in each ocean and discussion of meteorological forcing. Theories of steady circulation and equatorially-trapped waves. Discussion of equatorial undercurrents, El Nino, monsoonal ocean variability, and other topics. (Permission of instructor required. Alternate years. ***Offered 1981-82.***)
C. C. Eriksen

12.881-12.889 Seminar in Oceanography at MIT (A)

Prereq.: —
Year: G (1, 2)
Arr.

Topics in marine geophysics, physical, dynamical, and chemical oceanography. Content varying from term to term.
MIT and Woods Hole Staff

12.891—12.899 Special Problems in Oceanography at MIT (A)

Prereq.: —
Year: G (1, 2)
Arr.

For graduate students desiring to perform special investigations, special laboratory work, or special fieldwork in oceanography.
C. I. Wunsch (12.891); *Staff* (12.892); *T. M. Atwater* (12.893); *J. M. Edmond, E. A. Boyle* (12.894); *Staff* (12.895); *J. G. Sclater* (12.896); *C. C. Eriksen* (12.897); *Staff* (12.898-12.899).

13 Ocean Engineering

13.UR Undergraduate Research

Prereq.: —
Year: U (1, 2)
Arr.

The Department concentrates on engineering for the ocean environment. It covers engineering for modern ocean sciences, ocean exploration, ocean transportation, ship and naval engineering, and the utilization of ocean resources. Program also includes operations research, systems analysis, marine economics, public policy and use of the sea, and some aspects of marine-related management. Research carried out in hydrodynamics, underwater acoustics, ship/rig/platform design, ship and ocean structures, underwater vehicles, sailing yachts, systems analysis applied to problems of ocean operations, ship production, and development of marine resources. Well-equipped and modern facilities include: Design Laboratory, Marine Data Systems Laboratory, Ship Model Towing Tank, Acoustic and Vibration Laboratory, Wave Facility, and Circulating Water Tunnel. All available for undergraduate research. (Coordinator: K. Keays)
Staff

13.001 Introduction to Marine Applied Mechanics

Prereq.: 8.01, 18.02
Year: U (1) SD
4-0-8

Introduction to fluid mechanics. Development of the governing equations of motion of a viscous compressible fluid. Derivation and applications of Bernoulli equation and momentum theories. Similitude considerations for an incompressible fluid with particular application to ocean engineering. Introduction to potential flows, sources dipoles and simple bodies. Flows with vorticity. Generation of lift. Introduction to theory of water waves. Introduction to laminar and turbulent boundary layer theory with application to marine vehicles. Brief consideration of compressible flows.
J. E. Kerwin

13.002 Marine Applied Mechanics

Prereq.: *18.03*
Year: U (2)
4-0-8

Introduction to mechanical behavior of deformable solids under applied load. Equilibrium relations for axial force, shear and bending moment. Shear and bending moment diagrams. Stress due to applied axial, bending, shear, and torsional loads. Linear stress-strain laws and strain energy. Thermal stresses and strains. Deflections of beams, rods, and shafts. Introduction to energy methods, statically indeterminant structures and buckling. Marine applications: ships, offshore structures, pressure vessels.
J. K. Vandiver

13.003J Dynamics

(Same subject as 2.03J)
Prereq.: *2.01* or *2.002*; 2.02 or 13.001; 18.03
Year: U (1, 2)
4-0-8

Dynamics of lumped and continuous models of mechanical, electrical, and electromechanical systems. Kinematics and dynamics of rigid bodies in two- and three-dimensional motions. Formulation of equations of motion by momentum principles and Lagrange's equations. Behavior of linearized models: natural modes and frequency response of lumped systems, wave transmission and reflection in continuous systems.
P. Leehey, J. H. Williams, Jr., H. M. Paynter

13.004 Linear Systems in Ocean Engineering (Revised Content)

Prereq.: 18.03
Year: U (2)
3-0-9

Basic subject in linear system theory with applications in ocean engineering. Complex variable theory, Fourier series and integrals, Laplace transforms, linear systems analysis including time and frequency domains, convolution, concepts of system energy and power, system input-output relations, concepts of continuous random variables, excitation of linear systems by random processes, power density spectra. Applications included throughout.
J. H. Milgram

13.011 Hydrostatics

Prereq.: —
Year: U (1, 2)
2-0-2

Principles of hydrostatics with applications to ships and ocean engineering structures. Computer calculation of hydrostatic characteristics. Classes meet during first third of each term. Credit cannot be given for students also receiving credit for 13.012 or 13.40.
Term 1: *M. A. Abkowitz*
Term 2: *C. Chryssostomidis*

13.012 Applied Hydrostatics

Prereq.: —
Year: G (S)
1-7-2

Elementary principles of naval ship design and statics of naval architecture. Work in the project room on fairing of naval ship lines, calculations for and drawing of displacement and other curves, cross curves of stability, curves of statical stability and floodable length curves for a naval ship from preliminary design data. (Primarily for students in Course XIII-A; others admitted by permission of instructor.)
J. H. Sweeney

13.013J Water, Air and Interface Vehicles

(Same subject as NS 51J)
Prereq.: —
Year: U (2) SD
3-0-9

The competitive position of diverse water, air and interface vehicles in the world today, determined from basic engineering principles. Development of concepts of buoyancy, hydrodynamic lift, hydrodynamic drag, propulsor thrust, and scaling laws as applied to surface ships, deep submersibles, dirigibles, airplanes, hydrofoil craft, planing craft, and air-cushion vehicles. Comparison of performance criteria among these different vehicle types as well as evaluation of the effect of vehicle size, speed, and fluid density on these performance criteria.
M. A. Abkowitz, J. H. Sweeney

13.014 The Oceans

Prereq.: —
Year: U (2) SD
3-0-9

Introduction to ocean environment as a place where man lives, works, and harvests some of the world's resources. Principal physical and dynamical properties of the oceans are presented in the context of their influence on humanity's endeavors in the ocean and, where appropriate, the significance of man's impact on the ocean environment. Topics include: physical/chemical properties of seawater, ocean currents, tides, surface and internal waves. The effects of these topics in terms of forces and durability of marine structures, ocean energy conversion, dispersion of containments, and development of mineral and biological resources discussed.
J. K. Vandiver, C. N. Flagg

13.021 Marine Hydrodynamics I (A)

Prereq.: 1.05 or 2.20 or 13.001; *18.075* or *13.004*
Year: G (1)
4-1-7

Development of hydrodynamic principles and their application to ships, buoys, fixed platforms, and other marine vessels and structures. Dimensional analysis, similitude and model testing. Hydrostatics. Potential flows, added-mass and lift forces, water waves, viscous flows.
R. J. Van Houten

13.022 Marine Hydrodynamics II (A)

Prereq.: 13.021; 18.075 or 13.004
Year: G (2)
4-0-8

Continuation of 13.021, with emphasis on analytical methods. Laminar and turbulent boundary-layer theory. Ideal flows in three dimensions. Lifting-surface theory for steady, unsteady, and cavitating hydrofoils. Wave resistance and motions in waves. Hydrodynamics of slender bodies, maneuvering, strip theory of ship motions.
R. W. Yeung, F. Noblesse

13.031 Numerical Methods for Free-Surface Flows (A)
(New)

Prereq.: *13.022*, 13.50
Year: G (2)
3-0-9

Computational methods for fluid-flow problems that are of interest to the marine field. Steady inviscid external flows about arbitrarily shaped bodies. Consideration of free-surface complexities due to water waves and cavities. Use of Green functions and their numerical evaluation. Comparison and contrast of methodologies based on integral-equation, finite-element, and finite-difference formulations. Hybrid methods. Techniques for unsteady water-wave hydrodynamics. Numerical methods discussed are illustrated by application to problems of ship waves, wave loads on structures, multiple-body hydrodynamics, and nonlinear breaking waves
R. W. Yeung

13.04 Hydrofoils and Propellers (A)

Prereq.: 18.076 or 18.304
Year: G (2)
3-0-9

Theory and design of hydrofoil sections; lifting and thickness problems for sub-cavitating sections, unsteady flow problems. Computer-aided design of low drag, cavitation free sections. Lifting line and lifting surface theory with applications to hydrofoil craft, rudder and control surface design. Propeller lifting line and lifting surface theory; computer-aided design of wake adapted propellers, unsteady propeller thrust and torque. Flow about axially symmetric bodies and low aspect ratio lifting surfaces. Experimental projects in the variable pressure water tunnel.
J. E. Kerwin, P. Leehey

13.05 Boundary Layers (A)

Prereq.: 2.20 or 13.002; 18.076 or 18.304
Year: G (1)
3-0-9

Laminar boundary layers. Stability. Transition. Separation. Design of low drag bodies. Oscillatory viscous flows. Turbulent boundary layers. Prediction of frictional resistance. Roughness effects. Dynamics of turbulent boundary layers. Sub-layer bursting phenomena. Measurement techniques. (Alternate years. ***Not offered 1981-82.***)
P. Leehey

13.07 Free Surface Hydrodynamics (A)

Prereq.: 13.022; 18.076 or 18.304
Year: G (1)
3-0-6

Water wave phenomena pertinent to problems in naval architecture and ocean engineering. Generation, propagation, and diffraction of plane progressive waves. Exciting and restoring forces on floating and submerged bodies. Ship waves and wave resistance. Selected topics of interest in non-linear wave propagation, internal waves, slender-body theory, or seakeeping. (Some background in water waves assumed, equivalent to that covered in 13.022. Alternates with 13.09. Alternate years. ***Offered 1981-82.***)
J. N. Newman

13.08 Stability and Motion Control of Ocean Vehicles (A)

Prereq.: 13.021; 18.075 or 13.004
Year: G (2)
4-0-8

Development of equations of motion in six degrees of freedom and formulation of mathematical simulation models for ocean vehicle dynamics. Concepts of automatic control and extension of the model to include effects of controls and the various excitations and restraints from the ocean environment. Comparisons between mathematical model and physical reality. Solution of equations for stability determination and for the important vehicle motion responses. Discussion of applications to motion evaluation and reduction on typical ocean vehicles such as hydrofoil boats, ships, submarines, submersibles, buoys, towed systems, drilling platforms, and others.
M. A. Abkowitz

13.09 Potential Flows (A)

Prereq.: 13.022; 18.076 or 18.304
Year: G (1)
3-0-6

Development and application of potential theory to the flow past marine vehicles. Review of ideal fluid theory. Simple potential flows. Two-dimensional flows based on complex variable theory. Three-dimensional flows based on separation of variables and Green's theorem. Matched-asymptotic expansions and slender-body theory. Hydrodynamic pressure forces and the added-mass tensor. Strip theory. (Alternates with 13.07. Alternate years. ***Not offered 1981-82.***)
J. N. Newman

13.10J Introduction to Structural Mechanics

(Same subject as 2.071J)
Prereq.: 2.01 or 2.015 or 13.002
Year: U (1)
3-0-9

Selected structural mechanics concepts applicable to marine and mechanical structures; thick-walled spheres, compound cylinders, mooring lines. Beam design and optimization. Introduction to ABS rules. Stability and determinacy of structures, methods for computing deflections, principles of virtual forces and displacements, theorem of stationary potential energy with applications to equilibrium and buckling problems, statically indeterminate

structures. Matrix analysis of structures using force and displacement methods. Introduction to plastic analysis, stability of equilibrium, and plastic buckling of columns.
P. C. Xirouchakis, J. H. Williams, Jr.

13.111 Structural Mechanics (A)

Prereq.: 13.10J
Year: G (1)
3-0-9

Nonsymmetrical bending of beams. Transverse shear stresses in beams. Energy methods of analysis. Bending of circular and rectangular plates. Influence of typical stiffeners on rectangular plates used in naval architecture. Elastic instability of rectangular plates. General theory of elastic shells. Membrane and bending behavior of cylindrical and spherical shells. Influence coefficients and shell intersections of interest in ocean engineering.
J. G. de Oliveira

13.112J Analysis and Design of Offshore Structures (A)

(Same subject as 1.553J)
Prereq.: 13.10J or 1.503
Year: G (2)
3-0-6

Offshore structural configurations: concrete gravity structures vs. piled steel jackets. Functional requirements; material considerations. Concrete as a structural material; concrete in the marine environment. Critical loads for design and analysis. Wave theory; wave action on structures. Stability calculations. Design methods for concrete and steel structures; codes. Static and dynamic analyses. Fatigue considerations. Computer methods. Safety assessment for offshore structures; development of risk-based loading criteria for ambient and extreme conditions. Spectral representation of loads on offshore structures. Geotechnical aspects: site investigation, foundation performance. Lectures given by several members of the Civil and Ocean Engineering faculty and by guest lecturers from the offshore engineering industry.
J. K. Vandiver, P. C. Xirouchakis, O. Buyukozturk, J. J. Connor, Jr., E. H. Vanmarcke

13.121 Ship Structures (A)

Prereq.: 13.111
Year: G (2)
3-0-6

Ship longitudinal strength and hull primary stresses. Inertia effects. Hull deflections, exact and approximate methods. Effect of superstructures and dissimilar materials on primary strength. Transverse shear stresses and thermal stresses in the hull girder. Torsional strength of open and closed sections with free and restrained warping. Effective breadth and width. Grillages, ship plates, and the effect of stiffeners. Ship transverse strength. Hull dynamics. Statistical approach to strength.
J. G. de Oliveira

13.122 Ship Structural Design (A)

Prereq.: 13.10J
Year: G (2)
1-5-0

Ship structural design concepts. Role of the Classification Societies in structural design process. Design loads. Design of common naval architecture structural elements, like girders, stanchions, plates, and grillages. Plastic design methods and structural optimization. Design of joints and connections and typical structural details. Cost and management considerations in structural design process. Several projects carried out during term, including the midship section design, design of a main ship structural component, like a platform deck or a transverse bulkhead, and structural optimization of a typical naval architecture structure. Computer as well as analytical methods used. (Graduate students encouraged to take 13.122 concurrent with or after taking 13.121.)
J. G. de Oliveira

13.123 Advanced Analysis and Design of Ocean Engineering Structures (A)

Prereq.: 13.111 or 13.112J
Year: G (2)
3-0-6

Ocean engineering structural configurations: fixed-base platforms, semi-submersibles, cable and moorings, pipelines, marine risers, OTEC pipes. Environmental loads: wave, wind, current, ice forces. Introduction to materials for ocean engineering. Fixed-base platforms: static response, space frame analysis, dynamic response, deterministic vs. stochastic approach. Dynamic analysis of flexible structures. Marine pressure vessels: thick cylindrical and spherical shell, instability of a thin cylindrical and spherical shell, penetrations, reinforcements, closures, hatch design, stiffened cylindrical shells, sandwich shells. Tubular joint design. (Alternate years. ***Not offered 1981-82.***)
P. C. Xirouchakis

13.131 Plastic Analysis of Structures (A)

Prereq.: 13.111
Year: G (1)
3-0-6

Elastic-plastic behavior of thick-walled cylinder. Yield criteria. Drucker's stability postulate, normality and convexity. Limit theorems. Static plastic collapse of beams, plates, shells, shell intersections, and other structures encountered frequently in ocean engineering, naval architecture, and other branches of engineering. Discussion of relevant experimental work. Influence of finite deflections. Shakedown theorem. General theorems for the dynamic behavior of rigid-plastic structures. Theoretical and experimental behavior of beams, plates, and shells when subjected to dynamic loads of an intensity sufficient to cause plastic flow. Introduction to soil mechanics and reinforced concrete structures. Applications in various branches of engineering considered. (Alternate years. ***Offered 1981-82.*** See 2.073 and 16.24. Consult advisor.)
J. G. de Oliveira

13.132 Advanced Structural Topics (A)

Prereq.: 13.111
Year: G (1)
3-0-6

Advanced topics in structural analysis and design with various contents. Offers students the possibility to become acquainted with some of the current research within the Department. Includes potential topics such as imperfection sensitivity and post-buckling behavior of shells, plastic buckling of structures, dynamics and creep buckling of structures, composite materials, reinforced concrete structures, behavior of ships and offshore structures in ice-infested water. (Alternate years. ***Offered 1981-82.***)
P. C. Xirouchakis

13.14J Structural Mechanics in Nuclear Power Technology (A)

(Same subject as 1.565J, 2.084J, 3.82J, 16.261J, 22.314J)
Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Structural components in nuclear power plant systems: their functional purposes; mechanical, thermal, and nuclear operating conditions; mechanical-structural design requirements. Mechanics of continuous media combined with models of material behavior to determine adequacy of component design. Effects considered include: mechanical loading, hydraulic forces, elevated temperatures, and neutron irradiation; normal operation, accident situations, and seismic effects. Lectures given by several members of Institute faculty and by guest lecturers from the nuclear power industry.
P. C. Xirouchakis, A. S. Argon, O. Buyukozturk, J. E. Meyer, R. M. N. Pelloux, T. H. H. Pian

13.15 Materials for Ocean Engineering

Prereq.: —
Year: G (2)
3-0-8

Properties of metals used for the construction of ships and ocean engineering structures. Microstructures, processing, heat treatment, service behavior, and failures with special emphasis on corrosion resistance of ferrous and nonferrous metals. ***(Not offered 1981-82.)***
K. Masubuchi

13.16J Fracture of Structural Materials (A)

(Same subject as 1.591J, 3.90J)
Prereq.: 1.02J or 2.30 or 3.141 or 13.15
Year: G (1)
3-0-6

Analysis of criteria for crack initiation and propagation leading to structural failure. Study of fracture mechanics starting with Griffith theory for ideally brittle materials and through plane strain fracture toughness phenomena. Effects of geometry, rate, environment, fatigue, temperature, composition, and microstructure. Fracture behavior of welded metals, heat affected zone. Relation to dislocation mechanics. Significance of fracture surface morphology. Metals, cementitious materials, rock, polymers, fiber reinforced composites. Emphasis on current research in field.
K. Masubuchi, F. J. McGarry

13.17J Welding Engineering (A)

(Same subject as 3.36J)
Prereq.: 3.02 or 3.141 or 13.15
Year: G (1)
3-0-6

Detailed study of processing variables involved in joining materials by welding, brazing, and adhesive bonding. Synthesis of elementary physical phenomena such as transient heat flow, phase transformations, and dimensional changes into the complex overall reactions associated with joining. Testing, inspection, and properties of finished joints. Laboratory demonstrations of arc, electron beam, resistance, and other electric welding processes.
K. Masubuchi

13.21 Ship Power and Propulsion (A)

Prereq.: 2.40
Year: G (1)
3-1-8

Examination of ship power and propulsion systems for commercial and naval ships. Consideration of steam, diesel, and gas turbine power plants together with speed reducers and propulsors. Project study and economic evaluation of the propulsion system for a commercial or a naval ship.
A. D. Carmichael

13.25J Thermodynamics of Power Systems

(Same subject as 2.41J)
Prereq.: 2.40 or 16.006
Year: U (2)
3-0-9

Application of thermodynamics to power-generating systems. Thermodynamics of combustion and mixtures of gases. Analysis of Carnot, Rankine, Brayton, Otto, and Diesel cycles. Availability. Performance of modern steam plants, gas turbines, internal combustion engines, refrigeration plants, marine power plants. Economic and pollution aspects. New power generation concepts, such as fuel cells, MHD, vapor engines, solar, wind, tidal.
A. D. Carmichael, J. B. Heywood, H. M. Paynter, J. L. Smith, Jr.

13.26J Thermal Power Systems (A)

(Same subject as 2.601J)
Prereq.: 2.402 or 2.40 or 16.006; 2.20; 2.51
Year: G (2)
3-0-9

Design of thermal power system components and system optimization. Review of thermodynamics, gas dynamics, and heat transfer. Design of axial and centrifugal compressors and pumps, axial and radial inflow turbines, heat exchangers, evaporators, boilers, and condensers. Problems and examples taken from the fields of space, electrical utility, and marine power systems. Knowledge of elementary heat transfer and simple thermal power cycles assumed.
A. D. Carmichael, W. M. Rohsenow

13.39 Analysis of Techniques for Fabricating Structures (A)

Prereq.: 3.13 or 13.15 or 13.17J
Year: G (2)
2-0-4

Analysis of problems related to fabrication of structures, such as ships, aircrafts, rockets, pressure vessels, buildings, and ocean engineering structures by various joining processes including welding, riveting, and adhesive bonding. Discussion of such problem areas as fracture characteristics of welded structures; residual stress, distortion, and stress relieving; advanced welding metallurgy; non-destructive testing of structural welds. Laboratory demonstrations of some tests. (Alternate years. ***Not offered 1981-82.***)
K. Masubuchi

13.40 Elements of Ocean Engineering Design

(13.79)
Prereq.: *13.002*
Year: U (2)
3-3-6

Development of analytic and experimental techniques necessary to design ocean-based systems. Brief overview of an integrated design approach to ocean-based structures and vehicles. Models and modeling techniques applicable to the field of ocean engineering. Hydrostatics and stability calculations for ocean engineering structures and vehicles including damaged and partially floating conditions. Preliminary calculations to ensure that an ocean engineering structure and vehicle have sufficient structural strength, and have the desired performance characteristics in calm and rough seas. Dynamic modeling and extrapolation of scale test results. Selection of main propellers and auxiliary thrusters to match vehicle and power plant. Morison's equation, loads on

fixed platforms and other offshore structures. Calculation for subsystems requirements, such as anchoring and mooring. Laboratory tests, demonstrations and computer exercises of the various concepts discussed in class.
C. Chryssostomidis

13.41 Ocean Engineering Design Principles (A)
(New)

Prereq.: 13.40, *13.021*
Year: G (1)
2-2-5

Loads and motions of ships and offshore structures caused by waves, winds and currents; Morison's equation; inertia-dominated flows; impact loads; wave drift forces in regular and irregular seas. Short term and long term statistics, wave spectra and wind spectra, theory and selection of appropriate parameters for specific applications, the one hundred year wave. Hydrostatics for floating platforms and ships; influence in the overall configuration. Mooring statics and dynamics; design and sizing of thrusters and propellers; dynamic positioning. Emphasis on appropriate selection of coefficients and parameters involved, and design considerations that lead to safe and economic systems. Theory underlying important programs in design. Application to the design of systems such as semi-submersibles, ships, and offshore platforms.
C. Chryssostomidis, M. Triantafyllou

13.411 Principles of Naval Ship Design (A)

Prereq.: 13.012; 13.021; 13.10J or 13.111 or 13.122 or 13.40
Year: G (1)
2-4-6

Design of ship platforms for naval applications; formal optimization procedures applied to ship design; mathematical model of ship design process; engineering and economic principles governing selection of dimensions and coefficients of naval surface ships and submarines; design of hull form; influence of hull form and dimensions selection on mobility characteristics in calm water and rough seas; principles governing internal subdivisions for efficient internal arrangement and maximum survivability. Design exercise in applications of principles.
D. V. Burke, C. Chryssostomidis

13.412 Principles of Ship Design (A)

Prereq.: 13.021; 13.10J or 13.111 or 13.122; 13.41
Year: G (2)
2-4-6

Ship in context of a larger system; formal optimization procedures applied to ship design; assumption of subsystems sufficiency; mathematical model of ship design process; engineering and economic principles governing selection of dimensions and coefficients of ships and submarines; design of hull form; principles governing internal subdivision for maximum survivability; influence of hull form and dimension selection on operability in rough seas. Design exercise in application of principles. (Not recommended for students who have taken 13.441. Alternate years. ***Not offered 1981-82.***)
C. Chryssostomidis, M. Triantafyllou

13.431 Methods of Naval Ship-System Design (A)

Prereq.: 13.012 or 13.40
Year: G (S)
3-0-6

Overview of naval snip design and acquisition process; mechanics of designing a ship system; development of a design philosophy, design requirements and constraints; identification of ship design elements; formulation of selection/optimization criteria; development of a systematic design plan. Ship design analysis; determination of the impact of design features on overall ship system through use of ship synthesis models, marginal cost factors and design analysis techniques; trends in ship design. Design exercises and projects in application of principles.
D. V. Burke

13.441 Offshore Engineering Design (A)

(13.48)
Prereq.: 13.10J, 13.40
Year: G (2)
2-4-6

General discussion of a methodology applicable to offshore engineering system design. Definition of design problem emphasizing problem objectives, design criteria, and modeling techniques. General solution of offshore engineering system design problems and role of decision process and the constraints upon it. Impact of engineering, economic, environmental, and social considerations on selection of principal characteristics of an offshore engineering system. Illustration of above considerations using designs of current interest. Design exercise in application of principles involving ships, fixed platforms, and semisubmersibles. (Not recommended for students who have taken 13.412. Alternate years. ***Offered 1981-82.***)
M. Triantafyllou

13.442J Interdisciplinary Design of Wave-Power Conversion Devices
(New)

(Same subject as 2.745J)
Prereq.: Permission of Instructor
Year: G (2)
3-4-5

Analysis and design of devices for converting ocean wave power to electricity. Topics include a survey of previous work and inventions, a description of the wave environment, hydrodynamic performance, structural loading, turbines, and other power conversion devices, and power storage. Lectures in these areas followed by preparation of designs for each element, laboratory testing to validate the design elements and simulate the performance of a wave power conversion device, and preparation of a final report. The subject is structured to examine the design of a wave power conversion device for a particular site and application, e.g., a US Coast Guard light tower. (Alternate years. ***Not offered 1981-82.***)
A. D. Carmichael, J. N. Newman, H. M. Paynter, D. G. Wilson

13.451 Projects in Naval Ships Conversion Design (A)

Prereq.: 13.012; 13.111 or 13.122; 13.411 or 13.412; 13.431; 13.21
Year: G (2)
Arr.

Project type studies focused on conversion design of a naval ship. Students select a current ship design and define a new mission requiring significant ship modification. Students required to identify all technical aspects of the ship impacted by the new requirements and address each in sufficient detail to demonstrate feasibility and desirability of concept. Formal written and verbal reports required. Participation by several students in a single project encouraged.
J. H. Sweeney, D. V. Burke

13.461 Projects in New Construction Naval Ship Design (A)

Prereq.: 13.012; 13.111 or 13.122; 13.411 or 13.412; 13.431; 13.21
Year: G (1, 2, S)
Arr.

Project-type studies focused on a conceptual design of a new naval ship. Students select a ship type and then define a design philosophy and design requirements and constraints, develop selection/optimization criteria, perform system level tradeoff studies and select "best" concept, develop concept into a balanced ship design. Emphasis placed on total ship integration resulting from attention to sound technical and technical arrangement principles. Formal written and verbal reports required. Participation by several students in a single project extending over two terms encouraged.
J. H. Sweeney, D. V. Burke

13.462 Projects in Ocean Engineering System Design (A)

Prereq.: 13.441, 13.411 or 13.412
Year: G (1, 2, S)
Arr.

Determination of design criteria for ocean-based systems such as ships, submersibles, platforms, etc. derived from a set of system mission requirements specified by the student in consultation with the instructor. Preparation of preliminary design of system fulfilling selected criteria. Students intending to take 13.462 should plan a two-term sequence, preferably beginning in the first term. Participation by several students in a single project is particularly encouraged. (Primarily for graduate students in Ocean Engineering; others admitted by permission of instructor.)
C. Chryssostomidis, M. Triantafyllou

13.463 Engineering System Design (A)

Prereq.: Permission of Instructor
Year: G (2)
2-4-6

Development of basic techniques employed in planning and design of complex systems through involvement in a specific project. Specific background developed through lectures dealing with the selected project. Student results presented formally at the end of term. Each year's project announced during IAP.
C. Chryssostomidis

13.50 Computer Applications to Marine Problems

Prereq.: 18.03
Year: G (1)
3-2-5

Programming and numerical techniques applied to marine-related problems. Highlights of FORTRAN. Accuracy and efficiency of computations. Functional approximations. Quadrature techniques. Spline curves. Numerical solution of differential equations. Discrete-element methods. Assigned projects based on realistic problems in naval architecture and ocean engineering, selected to illustrate advantages and difficulties encountered in computer applications. (Prior experience in FORTRAN IV desired but not required.)
R. W. Yeung

13.51 Computer Models of Physical and Engineering Systems (Revised Unit)

Prereq.: 18.02, 8.01
Year: U (1) SD
3-0-9

Reduction of physical and engineering systems to simplified physical and mathematical models; representation using networks; graphs and finite element methods. Process simulations using random variables (Monte-Carlo techniques) and linear and dynamic programming. Manipulation of the resulting models using algorithms on digital computers. Examples drawn from fields primarily of interest to scientists and engineers, with some attention to styles of problem solving. Extensive "hands-on" computing experience. (Working knowledge of FORTRAN expected.) This subject is an Engineering School-Wide Elective.
B. Schumacker, R. Kaplow, K. J. Bathe

13.52 Management in Engineering

Prereq.: —
Year: U (1)
3-0-9

Introduction to the concepts of management of the engineering function, as found in a variety of industrial and non-industrial settings. Aim is to help the student acquire: 1) recognition of role of engineering and its relationship to other functions in getting a job done, 2) familiarity with some of the managerial tools and concepts employed in engineering organizations, 3) practice in dealing with both short- and long-term managerial problems in a range of real-life circumstances, and 4) incentive to develop a career strategy relevant to engineering training. Topics: financial principles; management of innovation; engineering project planning, scheduling, and control; human factors; career planning; contracts; patents; and technical strategy for firms. Taught, in part, by case method, which emphasizes student participation in discussion. (Intended for juniors, seniors, or graduate students; others should consult the instructor in charge.) This subject is an Engineering School-Wide Elective.
R. T. Lund, D. P. Hoult, H. S. Marcus

13.61 Network Scheduling, Routing, and Planning (A)

Prereq.: 1.07 or 6.041 or 13.004; 1.143 or 13.622J
Year: G (1)
3-0-6

Critical path methods — Pert; decision critical path methods; graphical evaluation and review techniques; flow graph networks; conditional probabilistic networks; scheduling, planning, and routing by network models; network optimization by mathematical programming, search, and other techniques; practical problems in engineering, construction, scheduling, ship routing, transportation, production, project planning, and management. (Alternate years. ***Offered 1981-82.***)
E. G. Frankel

13.62 Engineering Systems Analysis (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-6

Synthesis of analytic procedures for the identification and selection of optimal systems. Review of the economic framework for analysis. Systematic survey of theory and applications of mathematical optimization to engineering problems. Evaluation procedures for single and multiattributed problems covering utility theory and decision analysis in addition to standard procedures. Application of this material to real problems in planning and design stressed throughout term. (Open to qualified undergraduates. Knowledge of probability, microeconomics, and computer systems at an undergraduate level required.) This subject is an Engineering School-Wide Elective.
R. de Neufville, J. P. Clark

13.621 Engineering Risk-Benefit Analysis (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Risk evaluation and cost-benefit analysis techniques for assessment of engineering projects involving risks. Emphasis on public sector. Balancing risks and benefits with concern for financial uncertainties, environmental risks, and, especially, issues of human safety. Introduction to decision analysis, value of information, problems with multiple goals and issues related to collective decisions. Issues of public policy and regulation. Case studies with attention to the nature of public discussion. Cases drawn from dam safety, safety of nuclear reactors, transport and storage of liquefied natural gas, seismic risk problems, and offshore oil exploration. Some background in elementary probability assumed. (Subject intended mainly for graduate and upperclass students in the School of Engineering, and is an Engineering School-Wide Elective.)
M. E Patè, A. W. Drake

13.622J Mathematical Optimization Techniques (A) (New)

(Same subject as 1.143J)
Prereq.: Permission of Instructor
Year: G (1)
3-0-6

Systematic survey of theory and application of mathematical optimization techniques to engineering problems. Emphasis on general problem formulation and application of techniques. Linear programming and network algorithms covered in depth. Survey material in various nonlinear topics, such as, classical optimization methods, dynamic programming, integer programming, separable programming, search methods, and geometric programming. (For graduate students and advanced undergraduates. Some knowledge of linear algebra, matrix manipulation, calculus, and computer science assumed. Please see instructor if there is any question about prerequisites.)
H. N. Psaraftis, D. H. Marks

13.63 Reliability, Availability, and Maintainability of Systems (A)

Prereq.: 1.143 or 13.622J, 6.041 or 13.004
Year: G (2)
3-0-6

Time independent reliability; Markov and Semi-Markov models for systems service reliability, availability, and maintainability; component availability and systems performance; spare part inventory and maintenance scheduling policy development; replacement and maintenance strategies. Applications to a wide range of contemporary systems. (Alternate years. ***Offered 1981-82.***)
E. G. Frankel

13.631 Port Planning and Development (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Lectures, discussions, and panel reviews of critical areas in port planning and development including offshore and prefabricated ports. Systems engineering study of one or more major port projects. Approach to planning and development of port based on modern concepts of systems analysis. Topics: modern trends in port development; port functions and requirements; forecasting of port demand; influence on planning of coastal geomorphology, hydrography, geology, and hydrodynamics; dredging technology and dredging requirements, port design, investment planning, operations, analysis, regulation and environmental impact assessment. First half: lectures. Second half: discussions and review sessions to support project work undertaken. (Participants should have some background in microeconomics, operations research, and engineering — ocean, civil, or mechanical. Alternate years. ***Not offered 1981-82.***)
E. G. Frankel

13.65 Production Analysis (A)

Prereq.: 1.143 or 13.622J, 13.412 or 13.441
Year: G (1)
3-0-6

Analysis of production processes; evaluation of facility layout, production and material flow; process and facility design; production process control; mathematical and economic analysis of production; production and inventory scheduling; management information system; organization of manufacturing plants.
E. G. Frankel

13.661J Economics of Ocean Transportation (A)

(Same subject as 15.937J)
Prereq.: 14.120 or 15.012 or CTS 110J (1.281J)
Year: G (2)
3-0-6

Study of the economics of the principal ocean transportation markets and of resource allocation to ocean transportation. Structure of the markets and of the industries involved; barriers to entry and competition; theory of international trade; spot and term freight rate formation in the tanker, dry bulk and tramp shipping markets; analysis of risks facing the industry, charter market operators and charterers; world petroleum transportation network; relationship between oil prices and tanker rates; liner shipping rate making; impact of maritime policies and regulations on private and national income. Economic implications of alternative strategic decisions and policies of those who operate in the ocean transportation markets.
H. N. Psaraftis, Z. S. Zannetos

13.665J Logistical and Transportation Planning Methods (A) (Revised Content)

(Same subject as 1.203J, 6.281J, 11.526J, 15.078J, 16.76J, TPP 43J
Prereq.: 6.431, 15.075
Year: G (1)
3-0-6

Quantitative techniques of operations research with emphasis on applications in transportation systems analysis (urban, air, ocean, highway, pick up and delivery systems) and in the planning and design of logistically oriented urban service systems (e.g., fire and police departments, emergency medical services, emergency repair services). Unified study of functions of random variables, geometrical probability, multiserver queueing theory, spatial location theory, network analysis and graph theory, and relevant methods of simulation. Discussion of implementation difficulties. Examples of applications: design of ambulance systems having both specialized and general-purpose vehicles; emergency response to oil spills; estimation of energy consumption by commuters in a metropolitan area; design of dial-a-ride transportation systems; controlling randomness in mass transit systems; evaluation of technologies for vehicle location, routing and control.
H. N. Psaraftis, A. I. Barnett, R. C. Larson, A. R. Odoni

13.67 Marine Decision Making Under Uncertainty (A)

Prereq.: 1.07 or 6.041
Year: G (2)
3-0-6

Bayesian decision theory applied to a number of marine problems involving decisions under uncertainty including capital investment, timing of charters, maintenance and overhaul policies, ship optimal routing, optimal search in the ocean, offshore petroleum exploration, and other selected topics. (Alternate years. ***Offered 1981-82.***)
H. N Psaraftis

13.68 Management of Marine Systems (A)

Prereq.: 15.516
Year: G (1)
3-0-6

Analysis of current technological, market, and regulatory trends in various segments of the marine industry and government development programs such as: liner trades, vessel chartering, shipbuilding, defense systems, coastal facilities, and fishing; description of resources and constraints involved; impact of trends on management decisions; analysis of problems actually existing in the field. Emphasizes the position of managers rather than public policy makers. (Prerequisite may be waived for students in Ocean Engineering by permission of instructor.)
H. S. Marcus

13.681J Issues in Transportation Management (A)

(Same subject as 1.285J, CTS 130J)
Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Introduction to problems facing transportation management. Brief description of basic managerial tools and the industry characteristics of each transportation mode. Focus on specific managerial issues facing transportation industry, including technological, economic, marketing, labor-related, legal, institutional, and political aspects. Similarities and dissimilarities among the modes analyzed. Problems viewed from managerial perspective of both private and public sector.
H. S. Marcus, P. O. Roberts

13.682J Current Issues in Engineering

(Same subject as 1.491J, 3.562J, 6.941J, 22.87J)
Prereq.: —
Year: G (S)
3-0-6

Review of a selection of technological developments of great significance to industrialized societies, choosing from current areas such as electronic materials and microprocessors, conventional and new energy technology, and practical aspects of cell manipulation. Key features of the technologies, and their relationships to social, economic, and managerial issues that their development implies.
T. H. Lee

13.683J Cases and Projects in Engineering Management (A) (New)

(Same subject as 1.492J, 3.563J, 6.942J, 22.88J)
Prereq.: 13.682J
Year: G (1)
3-1-5

Continuation of 13.682J with a shift from macro-level of technologies toward micro-level of projects. Case studies of and student projects involving several real engineering and scientific programs in industrial firms and government agencies. Cases chosen from new ventures as well as mature firms, in both product and process development. All aspects of projects assessed.
T. H. Lee

13.684J Technology Planning (A) (New)

(Same subject as 1.493J, 3.564J)
Prereq.: —
Year: G (1)
3-0-6

Methods for planning RD&E projects and multi-project programs. Cost and schedule control of technical work. Approaches to technology forecasting and resource allocation among technical areas. Technical planning in companies and government agencies.
J. M. Utterback, R. D. Logcher

13.685J Manufacturing Technology Interface (A) (New)

(Same subject as 3.565J, 15.365J)
Prereq.: 15.311 or 15.5 5 or 15.361
Year: G (1)
3-0-6

Focus on the management of process innovation. Economic and other influences on manufacturing process change. Interactions between research, development, and engineering activities and manufacturing operations. Transfer of new product developments into manufacturing.
J. M. Utterback

13.69 International Shipping (A)

Prereq.: 13.68 or *13.681*
Year: G (2)
3-0-6

Explores internal operating, financial, and marketing issues as well as external market and technological factors which define the international shipping environment in the future. Includes effect of world energy crisis and changing trade patterns upon demand for shipping; evaluation of shipping capacity requirements in terms of capital needs, demand for ship construction, and technological alternatives; new ship and terminal technologies for bulk and general cargo vessels; and effect of changing international relationships. Topics examined through readings and discussion of literature, supplemented by guest speakers from industry and government. Each student responsible for a class presentation and a paper. (Prerequisite waived for second-year Course XV students and others by permission of instructor.)
H. S. Marcus

13.700-13.709 Special Problems in Ocean Engineering

Prereq.: —
Year: U (1, 2, S)
Arr.

Special reading, study, design, and/or investigation under supervision of a qualified member of the staff. Topics in ocean engineering, naval architecture, or marine engineering individually arranged to suit interest of the student. Consult Department Student Administration Office for subject number which will be assigned in accordance with the technical area of the topic selected.
J. K. Vandiver

13.710-13.719 Special Problems in Ocean Engineering (A)

Prereq.: —
Year: G (1, 2, S)
Arr.

Special reading, study, design, and/or investigation under supervision of a member of the staff. Topics in ocean engineering, naval architecture, or marine engineering individually arranged to suit interests of student. Consult Department Student Administration Office for subject number which will be assigned by the Department in accordance with the technical area of the topic selected.
A. D. Carmichael

13.73 A Survey of Ocean Engineering

Prereq.: —
Year: U (2)
1-1-1

Series of lectures primarily to acquaint undergraduate students in ocean engineering with the many facets of the field including naval architecture and marine engineering. Exploration of relationships and interfaces with the various engineering and scientific disciplines. Current problems and research projects used for illustration. Each session conducted by a different faculty member, with concentration on that faculty member's area of interest. (Undergraduate and graduate students from all departments are welcome.)
Staff

13.730-13.739 Seminar in Ocean Engineering

Prereq.: Permission of Instructor
Year: G (1, 2)
Arr.

Weekly lectures on new topics in ocean engineering by members of the MIT staff. Consult Department Student Administration Office for subject number assigned in accordance with the technical area of the topic selected.
Staff

13.74J Marine Data Systems (A)

(Same subject as 6.455J)
Prereq.: 2.02 or 6.003 or 13.004; 6.041, 18.075 or 13.004
Year: G (1)
3-0-9

Analysis of systems and techniques used in the measurement of oceanographic data. Review of linear systems; applications to data recording and control systems, analog and digital filters. Temporal random processes, correlation and spectral analysis, Gaussian processes, characterization of time series data in oceanography. Sonar, radar, echosounders and seismic systems; transmitters and receivers for estimating range and velocity of reflectors in media with ambient noise and reverberation. Space/time random processes, frequency-wave number characterizations, sensor arrays and spatial processors; applications in arrays for ambient noise and passive sonar, surface, and internal waves. Measurement of power spectra and wave number functions by indirect, direct, and adaptive methods. (Alternate years. ***Not offered 1981-82.***)
A. B. Baggeroer, R. C. Spindel (Woods Hole Staff)

13.75 Control Theory Applications in Ocean Engineering (A)

(13.401)
Prereq.: 18.076, 13.08, 6.003, or 2.02
Year: G (2)
3-3-6

Time and frequency domain representations of linear time invariant systems. Controllability, observability, stability. Compensation techniques to achieve satisfactory performance. Control force producing devices available in ocean engineering. Specific applications selected from such areas as dynamic positioning of drilling vessels, antirolling mechanisms, submarine control. (Control theory background preferred but not required.)
M. Triantafyllou

13.76 Introduction to Random Processes in Ocean Engineering (A)

Prereq.: 18.04 or 18.075 or 13.004
Year: G (2)
3-0-9

Fundamentals of random process theory and its application to physical and engineering problems. Elements of probability theory and statistics, harmonic analysis of deterministic and random processes, correlation, linear systems including those with frequency dependent parameters such as ships in a seaway, analog and digital filtering, spectral analysis and extremal statistics. Applications include ocean waves, seakeeping, offshore structures in storms, and the establishment of design criteria. (Alternate years. ***Not offered 1981-82.***)
J. H. Milgram, R. J. Van Houten

13.77J Invention

(Same subject as 2.941J, 6.935J, 10.802J, 16.671J)
Prereq.: —
Year: G (1)
3-0-6

Process of invention analyzed with intention of enhancing the skill of the student inventor. Includes the following phases of the process: a) technology observation to increase the technology background of potential inventor; b) need analysis to define clearly the requirements and limitations of needed inventions; c) parameter analysis, to focus attention of inventor on the important parameters of the problem and on potential solutions; d) creative step, to develop techniques for providing innovative solutions. Students encouraged to provide innovative solutions to invention needs of their own choice.
A. D. Carmichael, W. C. Flowers, D. G. Jansson, J. B. Howard

13.771 Engineering Internship

Prereq.: —
Year: U (1, 2, S)
0-6-0

Enrollment restricted to students registered in Course XIII-C. Provides academic credit for assignments affiliated with the XIII-C Program. Students register for this during their first company assignment and then register for it again during their second company assignment, thus accumulating a total of 12 units. Credit given upon satisfactory completion of company assignments, receipt of favorable evaluation of student by company supervisor, and receipt of a favorable evaluation of student's report about company assignment by student's faculty counselor.
C. Chryssostomidis

13.772 Industrial Practice in Ocean Engineering

Prereq.: 13.771
Year: U (1, 2, S)
Arr.

Enrollment restricted to students registered in Course XIII-C and terminating with S.B. degree only. Provides academic credit for the seven-month assignment of students at companies or establishments affiliated with the XIII-C Program. Credit given upon satisfactory completion of the company assignments, the receipt of favorable evaluation of student by

company supervisor, and receipt of a favorable evaluation of student's report about company assignment by student's faculty counselor.
C. Chryssostomidis

13.774 Advanced Engineering Internship

Prereq.: 13.771
Year: G (1, 2, S)
0-6-0

Enrollment restricted to students registered in Course XIII-C. Provides academic credit for assignments of students at companies or establishments affiliated with the XIII-C Program. Students register for this during their third company assignment and then register for it again during their fourth company assignment, thus accumulating a total of 12 units. Credit given upon satisfactory completion of company assignments, receipt of favorable evaluation of student by company supervisor, and receipt of a favorable evaluation of student's report about company assignment by student's faculty counselor.
C. Chryssostomidis

13.78 Entrepreneurship

Prereq.: —
Year: G (2)
4-0-5

Introduction to the various issues faced by technical innovators interested in becoming entrepreneurs. Lectures and discussions held on concept evaluation, patents, licensing, contract negotiation, marketing, business planning, financing, accounting, and small business management. Students encouraged to use their own innovative ideas as the object of study topics. This subject is an Engineering School-Wide Elective (open to undergraduates by permission of instructor).
D. G. Jansson

13.80J Mechanical Vibration

(Same subject as 2.06J)
Prereq.: 2.03J or 13.003J
Year: G (1)
3-0-9

Concepts of mechanical vibration, including free and forced vibration of single and multi-degree of freedom systems. Modal analysis and matrix formulation of vibration problems. Approximate solution techniques. Vibration and modal analysis of continuous systems: beams, rods, and strings. Introduction to the response of linear systems to random excitation. Numerous examples and application of vibration measurement and analysis, including vibration isolation and dynamic absorbers, ships, offshore structures, engines, and rotating machinery.
J. K. Vandiver, R. H. Lyon

13.81J Principles of Acoustics (A)

(Same subject as 2.060J, 16.081J)
Prereq.: 13.003J (2.03J) or 16.004, 18.075 or 13.004
Year: G (1)
3-0-9

Combined with subject 13.82J, forms a two-term sequence in acoustics at advanced level; subjects may be taken in any order. Subject emphasizes acoustics of fluids: derivation of basic equations, radiation of sound, diffraction and scattering and acoustics of ducts and rooms. Acoustic, thermal, and vorticity fluctuations as first order perturbation of equations of fluid dynamics; energy density and intensity. Multipole expansions of source fields, spherical harmonics, radiation impedance and directivity. Scattering and diffraction of sound by obstacles. Natural modes of sound propagation in ducts; excitation and reverberation of sound in rooms.
P. Leehey, R. H. Lyon, S. E. Widnall

13.82J Sound and Structural Vibration (A)

(Same subject as 2.063J)
Prereq.: 13.003J (2.03J) or 16.004, 18.075 or 13.004
Year: G (2)
3-0-9

Combined with subject 13.81J, forms a two-term sequence in acoustics at advanced level; subjects may be taken in any order. Emphasizes interaction of sound in fluids with structural vibration. Review of dynamics of strings, beams, and plates. Normal modes, phase and group velocity, decay of vibrational energy. Radiation impedance of beams and plates, reciprocity, energy equilibrium between sound field and structure. Concepts of statistical energy analysis (SEA). Sound transmission through walls using "classical" and SEA procedures.
P. Leehey, R. H. Lyon

13.84J Flow Noise (A)

(Same subject as 2.065J, 16.082J)
Prereq.: 16.004 or 2.20 or 13.002
Year: G (1)
3-0-9

Elements of aerodynamic and hydrodynamic sound. Subsonic and supersonic jet noise. Jet noise suppression. Vortex sound and feedback resonance effects. Propeller, compressor, and helicopter rotor noise and noise suppression techniques. V/STOL noise. Boundary layer noise. Mach wave radiation, structural response, and re-radiation. (Alternate years. ***Offered 1981-82.***)
P. Leehey, S. E. Widnall

13.85 Fundamentals and Applications of Underwater Sound (A)

Prereq.: 13.004 or 18.075
Year: G (2)
3-0-6

Fundamentals relating to design of underwater sound systems as controlled by physical principles and physical and chemical properties of the ocean and its boundaries. Analysis of present-day sonar systems and exploration of future design directions. Absorption in seawater. Transmitting and receiving arrays. Scattering and reflection. Refraction and propagation loss. Noise and reverberation. Sonar design principles. Depth sounders, speedometers and logs, echo locators, imaging systems, oceanographic sensors, seismic systems, defense systems, communications and beacons. Discussion of applications in charting, navigation, station keeping, fishing, petroleum, exploration, telemetry. (Primarily for graduate students. Ocean-related curriculum not required. Juniors and seniors admitted by permission of instructor.)
I. Dyer

13.89 Ocean and Seabed Acoustics (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Survey of important properties of the ocean and seabed and of predictive models of sound propagation, in relation to sonar and seismic system design and/or to the use of sound to uncover oceanic properties. Dependence of sound on temperature, salinity, and pressure, and their time/space dependence in the ocean. Simplified models of density and sound speed stratification of the seabed. Ray and wave theories of propagation in vertically stratified media. Approximate propagation theories for a horizontally varying ocean. Reflection and transmission of sound by a stratified ocean bottom. Scattering from a random sea

surface and seafloor. Reverberation and ambient noise. Sound fluctuations induced by ocean dynamics including turbulence and internal waves. Application of acoustic techniques to sonar systems and marine seismic exploration. Students should have at least introductory knowledge of Fourier analysis, probability, and wave propagation. (Alternate years. ***Offered 1981-82.***)
A. B. Baggeroer, G. Frisk (Woods Hole Staff)

13.87 Wave Propagation in Random Media (A)
(New)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Emphasis on physical principles and mathematical techniques common to most problems of wave propagation through and scattering in random media. The ocean as a random medium. Scattering by discrete scatterers, by a continuous inhomogeneous medium, and by irregular boundaries. Statistics of the medium and the propagating wave. Single and multiple scattering, saturation. Geometric, Rytov, and parabolic approximations; path integral method; transport equations; propagation of moments. Specific applications and examples taken mostly but not exclusively from sound propagation in the ocean. Discussion and interpretation of experimental results. (Given at MIT. Alternate years. ***Offered 1981-82.)***
Y. Desaubies (Woods Hole Staff)

13.901 Ocean Engineering Laboratory I

Prereq.: —
Year: U (1, 2) LAB
1-5-0

Orientation experiments on the MIT Research Vessel in early fall as weather permits. Design and development of experimental equipment for operation in ocean environment. Equipments include mechanical, electrical, optical, and acoustical devices. Emphasis on instrumentation and equipment for oceanographic and ocean engineering purposes, including ocean mining, environmental monitoring, underwater work, search, and salvage. Some lectures on basic measurement systems. (Offered both terms. Upon successful completion of both, Laboratory Requirement will be fulfilled.)
Staff

13.902 Ocean Engineering Laboratory II

Prereq.: —
Year: U (1, 2) LAB
1-5-0

Completion of experiments using equipment designed and built during 13.901 and at-sea testing on the MIT Research Vessel during late spring, and earlier as weather permits. Preparation of technical report describing apparatus and experiments. Some lectures on calibration and ocean engineering facilities. (Students ordinarily complete 13.901 before registering in 13.902, but it is possible to register for 13.902 first and then 13.901.)
Staff

13.903 Advanced Ocean Engineering Laboratory (A)

Prereq.: Permission of Instructor
Year: G (1, 2, S)
0-6-0

Design and construction of advanced experimental equipment for operation in the ocean environment. Planning and execution of laboratory and at-sea tests of the equipment and/or instrumentation. The MIT Research Vessel and/or smaller auxiliary boats used as weather permits.
A. D. Carmichael

13.92 Public Policy and Use of the Sea (A)

Prereq.: 17.57
Year: G (1)
3-0-6

Survey of national and international ocean policy issues; institutions/organizations involved in ocean activities; technical advisory function in policy making for the sea; impact of offshore technologies on national interests; problems of exploitation of resources in the sea; problems of conflicting uses of the sea. (Prerequisite may be waived for students in Ocean Engineering programs by permission of instructor.)
J. T. Kildow.

13.93 Fisheries Management (A)

Prereq.: 14.01
Year: G (1)
3-0-6

Analysis of US fisheries management with emphasis on economic and social structure of the industry and on bio-economic modeling as a method for analysis. Includes discussion of institutional arrangements for fisheries management on local, national, and international levels. Case studies used to relate modeling, economics, social influences and institutional arrangements. Case studies include: groundfish in New England, salmon in the North Pacific, and tunas in the Atlantic and Pacific. Also, brief discussion of worldwide production and consumption of fish, including the likely future of fishing technology and management techniques, aquaculture, post-harvest loss, and special problems of developing countries. (Permission of instructor required.)
L. Smith, S. Peterson (Woods Hole Staff)

13.94J Ocean Engineering and Law Seminar (A)

(Same subject as 15.228J)
Prereq.: 13.962 or 13.92
Year: G (2)
3-0-6

Interdisciplinary research seminar which examines selected problems involving law and ocean engineering. Analysis of implementation of new technological systems in the ocean under evolving legal regimes. Students expected to participate in interdisciplinary team exercises on such matters as establishment of traffic separation schemes and administration of extended jurisdiction zones. Research paper required on a problem involving law and ocean engineering. Covers international and municipal legal, policy, applied economics, and technical aspects. (Offered jointly with Harvard Law School. Alternate years. ***Not offered 1981-82.***)
J. D. Nyhart

13.961J Resources Management (A)

(Same subject as 3.581J)
Prereq.: 14.04, 15.012
Year: G (2)
3-0-6

Contemporary global perspectives on the nature of natural resources, their utilization and management. General topics: changing perceptions of importance of natural resources; including concerns over their availability and costs; results of pressures of increasing demand; effects of new technologies on patterns of development and distributions; compelling factors for new management systems; evolving role of resources in international economic and political affairs; and results of institutional and process changes in public and private sectors. Cases of several resources undergoing marked changes in their management systems used as basis for much of the analysis and discussion. Marine ferromanganese deposits and fisheries are the resource cases, although other resources are discussed as need and interest arise. (Open to qualified undergraduates.)
J. T. Kildow, J. P. Clark, L. Smith (Woods Hole Staff)

13.962 Legal Aspects of Ocean Resources and Systems Management (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-6

A firm grounding in legal problems of managing ocean resources and systems. Federal, state, and international regulation of offshore structures and uses, including OCS regime, tanker regulation, and the law governing deepwater ports, and new technologies such as deep ocean mining, ocean thermal energy conversion, and other new energy sources. Current UN Law of the Sea issues, with emphasis on questions of jurisdiction and implementation arising from prospective economic zones or unilateral extensions. Principles governing applicability of civil and criminal law on offshore structures. Introduction to applicable maritime law. Regulatory control over the ocean's environment. Legal aspects of shipping: traffic control, safety and construction standards. Focus throughout on relationship of law and technology and on the use of technology in implementing and enforcing regulatory regimes offshore. (Open to undergraduates by permission of instructor.)
J. D. Nyhart

13.97 Introduction to Technology and Law

Prereq.: —
Year: U (1)
3-0-9

Introduction to basic principles and functions of law, using legal cases and materials arising from scientific and technical issues. Provides an understanding of the law and legal processes as they impact upon the work of engineers and scientists. Study of judicial law making focuses on elementary civil procedure and how change in legal doctrine takes place. Examination of statutory law making shows how Federal and state power to govern grows as technology grows. Administrative law making focuses on the regulatory agencies' role in controlling and supporting technology as well as extent and curbs on their power. Study of law cases, using so-called "Socratic method," and of legal processes and doctrines, provides insight into the lawyer's working methods. Law's task of resolving conflicts found in scientific and engineering alternatives sensitizes students to choice of values questions. This subject is an Engineering School-Wide Elective. ***(Not offered 1981-82.)***
J. D. Nyhart

13.98J Coastal Zone Management (A)

(Same subject as 11.365J)
Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Introduction to the problem of achieving conservation and beneficial use of land and water resources in coastal regions. Emphasis on ways of thinking about the problem as well as methods for its resolution. Discussion of the spectrum of relevant topics, including physical and ecological processes characteristic of shoreland areas; catalogue of human activities placing demands on the coastal resource base; incidence and magnitude of adverse effects on ecological and amenity values; institutional setting for coastal decision making; and management tools, including resource allocation economics, planning law, and environmental design and regulation. Exploration of recent legislative developments, special problem areas, and critical policy issues.
J. T. Kildow, P. B. Herr

13.990J Oceanographic Systems I

(Same subject as 1.697J)
Prereq.: —
Year: G (S)
2-4-6

Orientation subject for students entering the MIT—Woods Hole Oceanographic Institution program in oceanographic engineering. Oceanographic experiments of research interest in Cape Cod waters carried through experiment design, instrumentation design, construction and test, deployment, data taking and interpretation of results. Research teams made up of students in 13.990J and 13.991J together. Participation in summer seminars at WHOI. (Given at Woods Hole Oceanographic Institution.)
Woods Hole Staff

13.991J Oceanographic Systems II

(Same subject as 1.698J)
Prereq.: —
Year: G (S)
2-4-6

Continuation of 13.990J during second summer term in the MIT—WHOI joint program in oceanographic engineering. (Given at Woods Hole Oceanographic Institution.)
Woods Hole Staff

13.994 Buoy Engineering (A)

Prereq.: 2.01 or 2.03J/13.003J or 13.80J; 18.03
Year: G (2)
3-0-6

Theoretical and practical aspects of buoy systems structural design. Basic principles of mechanics of floating bodies. Stability of immersed and surface floating bodies. Simple harmonic wave theory. Heave and roll response of buoys to ocean wave excitation. Hydrodynamic forces on constrained bodies. Elements of model testing. Mechanics of mooring lines. Equilibrium trajectories of immersed cables. Closed loop solutions. Cable functions. Two-dimensional and three-dimensional models for computer analysis. Statics of multileg systems. Dynamics of mooring lines. Solutions by wave equation in continuous elastic medium. Mooring line as a linear and nonlinear spring mass system. Oceanographic buoy systems. Classes, advantages and limits. Outline of practical aspects of buoy system design. Buoyancy materials. Mooring line components, metals and non-metals. Anchoring. Buoy system installation and retrieval. Back-up recovery systems. Student project and sea trip. (Given at MIT. Alternate years. ***Offered 1981-82.***)
H. O. Berteaux (Woods Hole Staff)

13.998 Principles of Oceanographic Instrument Systems — Sensors and Measurements (A)

Prereq.: 2.03J/13.003J, 18.075 or 13.004
Year: G (2)
3-3-6

Introduction to theoretical and practical principles in design of oceanographic sensor systems. Transducer characteristics for acoustic, current, temperature, pressure, electric, magnetic, gravity, salinity, velocity, heat flow, and optical devices. Limitations on these devices imposed by ocean environment. Signal conditioning and recording; noise, sensitivity, and sampling limitations; standards. Examples of system design from physical oceanography, geophysics, submersibles, acoustics. Laboratory project required. (Given at Woods Hole Oceanographic Institution. Alternate years. ***Not offered 1981-82.***)
A. J. Williams (Woods Hole Staff)

13.999J Special Projects in Oceanographic Engineering (A)

(Same subject as 1.699J)
Prereq.: Permission of Instructor
Year: G (1, 2, S)
Arr.

Special problems in oceanographic engineering carried out under supervision of members of the staff of the Woods Hole Oceanographic Institution. (Given at Woods Hole Oceanographic Institution.)
Woods Hole Staff

14 Economics

General Economics and Theory

14.UR Undergraduate Research

Prereq.: 14.02
Year: U (1, 2)
Arr.

Participation in research with an individual faculty member or research group, independent research or study under the guidance of a faculty member. (Admission by arrangement with individual faculty member.)
P. Temin

14.01 Economic Principles I

Prereq.: —
Year: U (1, 2, S)
3-0-6

Introduction to microeconomic concepts and analysis. Supply and demand analysis, theories of the firm and of individual behavior, competition and monopoly, welfare economics. Applications to problems of current economic policy. (A special section is offered for potential majors.)
Term 1: *P. Temin*
Term 2: *R. L. Bishop*

14.014J Engineering Aspects of Economic Analysis

(Same subject as 1.01J)
Prereq.: —
Year: U (1)
4-0-8

Same subject as 14.01 with additional recitation sections scheduled for Civil Engineering majors to relate the concepts covered in lectures to engineering problems and applications. (Credit is not given for both 14.01 and 14.014J or 1.01J.)
Staff, M. E. Pate

14.02 Economic Principles II

Prereq.: —
Year: U (1, 2, S)
3-0-6

Introduction to macroeconomics. Determinants of the overall levels of economic activity, fiscal and monetary policy, price controls, distributional effects of macroeconomic policies, inflation and unemployment. Applications to problems of current economic policy. (A special section is offered for potential majors.)
T. J. Kehoe

14.03 Applied Microeconomics

Prereq.: 14.01
Year: U (1, 2)
3-0-6

Designed for non-majors who desire further exposure to microeconomics and its applications. Basic theory of consumer and producer behavior and welfare analysis presented at an intermediate level. Emphasis on applications, including cost-benefit analysis, transportation, price regulation, research and development, and pollution.
Term 1: *J. v. R. Farrell*
Term 2: *T. G. Cowing*

14.04 Intermediate Microeconomic Theory

Prereq.: 14.01
Year: U (1)
4-0-8

Basic theory of consumer behavior, production and costs, partial equilibrium analysis of pricing in competitive and monopolistic markets, general equilibrium, welfare and capital. (Credit not given for both 14.03 and 14.04. May *not* be counted toward Humanities Requirement.)
J. A. Hausman

14.05 Current Economic Problems

Prereq.: 14.01, 14.02
Year: U (1)
3-0-6

Analysis of current economic policy problems. Content varies from year to year, but consists usually of detailed analysis of one microeconomic and one macroeconomic problem. ***(Not offered 1981-82.)***
P. Temin

14.06 Intermediate Macroeconomic Theory

Prereq.: 14.02
Year: U (1, 2)
4-0-8

Theory of national income determination, static and dynamic; components of aggregate demand; analysis of aggregate supply. Theory of growth and inflation.
Term 1: *L. H. Summers*
Term 2: *R. M. Solow*

14.07 History of Economic Thought

Prereq.: 14.01, 14.02
Year: U (2)
3-0-6

A selective historical survey of the development of economic analysis; varying degrees of attention given to the contributions of Aristotle, Aquinas, Mun, Hume, Smith, Malthus, Ricardo, Marx, Mill, Walras, Marshall, Keynes, and Schumpeter.
R. L. Bishop

14.09 Reading Seminar in Economics

Prereq.: *14.04, 14.06*
Year: U (1, 2)
Arr.

Reading and discussion of particular topics in economics. (Open to advanced undergraduate students by arrangement with individual faculty members.)
Staff

14.101 Mathematics for Economists

Prereq.: 18.02
Year: G (1)
4-0-8

Linear algebra with emphasis on topics of interest to economists. Also topics in multivariate differential calculus and optimization theory. Provides mathematical prerequisites for econometrics.
T. J. Kehoe

14.102 Mathematics for Economists

Prereq.: 14.101
Year: G (2)
4-0-8

Optimization theory and duality. Dynamic optimization and the maximum principle. Elementary mathematical analysis and point set topology. Selected mathematical topics useful in economics. Primarily for people with interest in advanced economic theory. ***(Not offered 1981-82.)***

14.11 Mathematical Economics

Prereq.: 14.04
Year: U (1)
3-0-9

Introduction to the use of mathematical methods in economics, including a formal treatment of general equilibrium theory. (May *not* be counted toward Humanities Requirement. ***Not offered 1981-82.***)
E. S. Maskin

14.110J Applied Microeconomic Analysis (A)

(Same subject as 1.182J, CTS 110J)
Prereq.: 14.01
Year: G (1)
3-0-6

Designed for students with primary interests outside of economics but who wish to acquire some expertise in applied economic analysis. Development of microeconomic theory at an intermediate level, including consumer and producer theory, imperfect competition, capital and welfare economics, with emphasis on applications of particular relevance to engineers, such as problems related to transportation, energy, water resources, and constructed facilities. (Credit not given for this subject and 14.03, 14.04.)
D. L. McFadden, C. Winston

14.111J Economics of Project Evaluation (A)

(Same subject as 1.184J)
Prereq.: 14.03 or 14.120
Year: G (2)
3-0-6

Economic concepts of costs and benefits: consumers' and producers' surplus; shadow prices; and valuation of non-market costs and benefits. Investment criteria and the discount rate: static and dynamic; treatment of risk and uncertainty. Pricing policies and investment rules. Case studies in developed and underdeveloped countries: transportation, water resources, pollution abatement, energy, etc.
A. F. Friedlaender

14.120 Microeconomic Theory (A)

Prereq.: 14.03
Year: G (1)
3-0-9

Comprehensive survey, with emphasis on more advanced aspects as compared with similar undergraduate subjects. Equilibrium of the household, the firm, and markets with various degrees of competition and monopoly. Resource allocation and income distribution in static general equilibrium. Capital, interest, and dynamic equilibria. Cost-benefit analysis and welfare economics.
R. L. Bishop

14.121 Microeconomic Theory I (A)

Prereq.: 14.04
Year: G (1)
2-0-4

14.122 Microeconomic Theory II (A)

Prereq.: 14.04
Year: G (1)
2-0-4

Theory of consumption, production and distribution. Comparative static analysis, consumer surplus, duality, partial and general equilibrium, fundamental welfare theorem. Introduction to monopoly, oligopoly, and uncertainty.
R. M. Solow, D. L. McFadden

14.123 Microeconomic Theory III (A)

Prereq.: 14.122
Year: G (2)
2-0-4

Introduction to theory of resource allocation and price system. Emphasis on the use of efficiency prices as guide to decentralized decision making. Issues in central planning; externalities; second-best analysis.
M. L. Weitzman

14.124 Microeconomic Theory IV (A)

Prereq.: 14.121, *14.123*
Year: G (2)
2-0-4

Capital theory; one- and two-sector growth theory; welfare criteria and their limitations.
P. A. Samuelson

14.132 Schools of Economic Thought (A)

Prereq.: 14.04
Year: G (2)
3-0-9

Historical development of economics, as illustrated by selected writers: Aristotle, Aquinas, Hume, Smith, Ricardo, Malthus, Mill, Marx, Walras, Marshall. ***(Not offered 1981-82.)***
R. L. Bishop

14.141 Stability of General Equilibrium (A)

Prereq.: 14.124
Year: G (2)
2-0-4

Stability of general equilibrium. Tatonnement and non-tatonnement processes. The Hahn process. Modern developments. ***(Not offered 1981-82.)***
F. M. Fisher

14.142 Mathematical Optimization and Economic Theory (A)

Prereq.: 14.124
Year: G (1)
3-0-9

Linear and nonlinear programming, duality theory, dynamic programming, and optimal control. Applications to economic model building, including activity analysis, input-output theory, stochastic control, and optimal growth theory. ***(Not offered 1981-82.)***
M. L. Weitzman

14.144 Applied Price Theory (A)

Prereq.: 14.122
Year: G (2)
Arr.

Selected topics in price theory, with focus changing from year to year. Current emphasis on the economics of exhaustible and renewable natural resources. (Alternate years. ***Not offered 1981-82.***)
R. M. Solow

14.145 Economics of Uncertainty (A)

Prereq.: 14.124
Year: G (2)
3-0-9

Individual behavior under uncertainty. Equilibrium and welfare with uncertainty. Search and information.
J. v. R. Farrell

14.146 Social Choice Theory (A)

Prereq.: 14.122
Year: G (2)
2-0-4

Social welfare functions, interpersonal comparisons, equity and justice, manipulation of social choice procedures. ***(Not offered 1981-82.)***
E. S. Maskin

14.147 Economic Applications of Game Theory (A)

Prereq.: 14.122
Year: G (2)
2-0-4

Two-person zero sum games and the minimax theorem; non-cooperative games and Nash equilibrium; the core and market games; Shapley value, the bargaining set, and other cooperative solution concepts. ***(Not offered 1981-82.)***
E. S. Maskin

14.148 Advanced Topics in Microeconomic Theory (A)

Prereq.: 14.124
Year: G (1)
Arr.

14.149 Advanced Topics in Microeconomic Theory (A)

Prereq.: 14.124
Year: G (2)
Arr.

Advanced topics in microeconomic theory of current interest.
Staff

14.151 Mathematical Approach to Economics (A)

Prereq.: 14.124
Year: G (1)
3-0-9

The use of mathematical method in all the fields of economics.
P. A. Samuelson

14.152 General Equilibrium (A) (New)

Prereq.: 14.04
Year: G (1)
3-0-9

Theory of general competitive equilibrium from modern mathematical points of view. Topics include properties of aggregate demand functions, existence of equilibrium, fixed-point theorems and computational techniques, core of an economy, nonconvexities, stability and uniqueness of equilibrium, and empirical general equilibrium models.
T. J. Kehoe

14.153 Topics in Mathematical Economics (A)

Prereq.: 14.152
Year: G (2)
2-0-4

Subject matter varies from year to year. Topics may include: applications of differential topology to equilibrium theory, complexity of computational algorithms, economies with a continuum of agents, and empirical applications of general equilibrium models. (Permission of instructor required. Alternate years. ***Not offered 1981-82.***)
T. J. Kehoe

14.191 Economics Seminar (A)

Prereq.: 14.121
Year: G (1)
Arr.

14.192 Economics Seminar (A)

Prereq.: 14.121
Year: G (2)
Arr.

Special economic problems.
Staff

14.193 Seminar: Topics in Economics (A)

Prereq.: 14.121, 14.451
Year: G (1)
Arr.

14.194 Seminar: Topics in Economics (A)

Prereq.: 14.122, 14.452
Year: G (2)
Arr.

Topics in economics of current interest.
Staff

14.195 Reading Seminar in Economics (A)

Prereq.: 14.121
Year: G (1)
Arr.

14.196 Reading Seminar in Economics (A)

Prereq.: 14.121
Year: G (2)
Arr.

Reading and discussion of special topics in economics. (Open to advanced graduate students by arrangement with individual members of the staff.)
Staff

14.197 First-Year Graduate Seminar (A)

Prereq.: 14.04
Year: G (1)
2-0-6

Biweekly seminar limited to first-year graduate students. Discussion of projects of students, professional literature, methodology, economic policy, extending beyond regular curriculum. ***(Not offered 1981-82.)***
M. L. Weitzman

14.198-14.199 Teaching Introductory Economics

Prereq.: —
Year: G (1, 2)
2-0-2

Required of teaching assistants in introductory economics (14.01 and 14.02) under the supervision of the faculty member in charge of the subject. (Pass/fail subject.)
Term 1: *P. Temin, T. J. Kehoe*
Term 2: *R. L. Bishop, T. J. Kehoe*

Industrial Economics

14.20 Industrial Organization and Public Policy

Prereq.: 14.01
Year: U (1)
3-0-6

Analysis of the structure, behavior, and performance of industrial markets in the US economy. Topics include the measurement of monopoly power, behavior of firms in oligopoly markets, static and dynamic measures of market performance, anti-trust policy, and public utility regulation.
J. v. R. Farrell

14.21J Health Economics

(Same subject as HST 901J)
Prereq.: 14.01
Year: U (2)
3-0-6

Application of theoretical and empirical tools of economics to problems of health and medical care delivery. Concentration in depth on selected problems, such as: the welfare economics of "health" as a commodity; hospitals and the nonprofit sector; human capital and medical manpower; and innovation in medicine. ***(Not offered 1981-82.)***
P. Temin

14.22 Energy Economics

Prereq.: 14.01
Year: U (1)
3-0-9

Economic models of energy markets. Emphasis on world oil market and US energy policy. ***(Not offered 1981-82.)***
T. J. Teisberg

14.23 Government Regulation of Industry

Prereq.: 14.01
Year: U (2)
3-0-6

Examination of economic rationale for and against government regulation of prices, entry, product quality, and production processes in various US industries. Theoretical and empirical examination of economic effects of current regulatory practices through case studies.
P. L. Joskow

14.24 Law and Economics

Prereq.: 14.01
Year: U (1)
3-0-6

Impact of the legal system on resource allocation and income distribution; particularly consideration of contracts and torts. ***(Not offered 1981-82.)***
M. J. Simon

14.271 Problems in Industrial Economics (A)

Prereq.: 14.04
Year: G (1)
3-0-9

Small and large enterprises in the American economy; market structures; degrees of monopoly and competition; requisites of public policy.
P. L. Joskow, R. Schmalensee

14.272 Government Regulation of Industry (A)

Prereq.: 14.04
Year: G (2)
3-0-9

Use and evaluation of a variety of public policy instruments that affect the behavior and performance of industrial markets, such as anti-trust policy, public utility regulation, consumer protection, environmental policy, peak load pricing, and public enterprise.
P. L. Joskow, R. Schmalensee

14.281 The Energy Industries

Prereq.: 14.01
Year: G (1)
3-0-6

Survey of the main trends in production, pricing, and investment costs of coal, electric power, crude oil, and refined products. Economics of nuclear power. (Intended for students of either economics or engineering.)
M. A. Adelman

14.285J Current Economic and Regulatory Problems in Toxicology (A) (New)

(Same subject as 20.619J)
Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Examination of tools available to economists and toxicologists for decision making in a regulatory environment. Case method used with lectures on topics such as multistage carcinogenesis, diet and cancer, carcinogenesis and mutagenesis testing, some aspects of FDA and EPA regulatory law, extrapolation of test results, decision making, and risk assessment.
J. E. Harris, S. R. Tannenbaum

14.286 Health Economics Seminar (A) (New)

Prereq.: 14.04
Year: G (2)
3-0-9

Advanced subject in economics of health care sector. Selected topics considered in depth, such as design and financing of health insurance; behavior of nonprofit hospitals; role of competition in the medical care market; determinants of technological change; and effects of government regulations. (Permission of instructor required.)
J. E. Harris

14.291 Industrial Economics Seminar (A)

Prereq.: 14.04
Year: G (1)
3-0-6

14.292 Industrial Economics Seminar (A)

Prereq.: 14.271
Year: G (2)
3-0-6

Particular problems in industrial economics.
Staff

Statistics

14.30 Introduction to Statistical Method in Economics

Prereq.: 18.02
Year: U (1, 2) SD
4-0-8

Self-contained introduction to statistics with economic applications. Elements of probability theory, sampling theory, statistical estimation, regression analysis, and hypothesis testing. Elementary econometrics and other applications of statistical tools to economic data. (May *not* be counted toward Humanities Requirement.)
Term 1: *R. B. Litterman*
Term 2: *Staff*

14.31 Econometrics

Prereq.: 14.30
Year: U (1, 2) LAB
3-4-5

Introduction to basic econometric techniques with strong emphasis on applications. Problems in estimating such economic variables as consumption-income-price relationships, production functions, and in simulating economic models. (May *not* be counted toward Humanities Requirement.)
Term 1: *R. J. Shiller*
Term 2: *E. Kuh*

14.381 Statistical Method in Economics

Prereq.: 18.02
Year: G (1)
4-0-8

Self-contained introduction to probability and statistics as background for advanced econometrics. Elements of probability theory, sampling theory, asymptotic approximations, decision theory approach to statistical estimation focusing on regression, hypothesis testing, and maximum likelihood methods. Illustrations from economics and application of these concepts to economic problems.
D. J. Poirier

14.382 Econometrics I (A)

Prereq.: 14.101, 14.381
Year: G (2)
4-0-8

14.383 Econometrics II (A)

Prereq.: 14.382
Year: G (1)
4-0-8

Theory and economic applications of the linear multiple regression model. Identification and structural estimation in simultaneous models. Analysis of economic policy and forecasting in microeconomic models.
J. A. Hausman, D. L. McFadden, R. B. Litterman, D. J. Poirier

14.386 Advanced Topics in Econometrics (A)

Prereq.: 14.383
Year: G (2)
3-0-9

Selected topics including specification error, nonlinear estimation, simulation, aggregation and the derivation of economic policy models.
D. L. McFadden, D. J. Poirier

14.388 Applied Econometrics (A)

Prereq.: 14.101, 14.381
Year: G (2)
3-0-9

Theory and practice of econometrics. The linear regression model, tests of hypotheses, generalized least squares, distributed lags, and simultaneous equations. Emphasis on applications.
D. L. McFadden

14.389 Econometrics Paper (A)

Prereq.: 14.382 or 14.31
Year: G (1)
0-0-3

Paper in econometrics required of all Ph.D. candidates who do not take 14.383.
Staff

14.391 Workshop in Economic Research (A)

Prereq.: 14.124, 14.454
Year: G (1)
2-0-10

14.392 Workshop in Economic Research (A)

Prereq.: 14.124, 14.454
Year: G (2)
2-0-10

Designed to develop research ability of students through intensive discussion of dissertation research as it proceeds, carrying out of individual or group research projects, and critical appraisal of current reported research. Workshops divided into various fields, depending on interest and size.
Staff

National Income and Finance

14.40 Monetary and Banking Policy

Prereq.: 14.06
Year: U (2)
3-0-9

Monetary factors affecting the level of national income and relationships of financial institutions to these factors. Financial organization of society: the money-banking system, credit institutions, capital markets, and international financial relations. Monetary history.
R. B. Litterman

14.41J Distribution of Income and Employment Opportunity

(Same subject as 17.211J)
Prereq.: 14.01
Year: U (1)
3-0-6

Analysis of public policies deriving from concerns about the equity of the distribution of income and employment opportunities in the United States. ***(Not offered 1981-82.)***
Staff

14.42 Economics of Pollution

Prereq.: 14.01
Year: U (1)
3-0-6

Market processes with negative-good byproducts of production and consumption. Externalities in negative-good processes. Models of pollution and congestion. Nature of suboptimalities and the public policy problems. Approaches to public policy: property rights, controls, subsidies, public investment, pollution and congestion charges.
J. Rothenberg

14.43 Public Finance

Prereq.: 14.03 or 14.04; 14.06
Year: U (2)
3-0-9

Analysis of effect of taxation on microeconomic activity. Examination of directions for tax reform. Income and corporation tax, Social Security programs.
Staff

14.451 Macroeconomic Theory I (A)

Prereq.: 14.06
Year: G (2)
2-0-4

Macroeconomic analysis of general equilibrium. Financial markets and the money supply process. Models of asset demand and the channels of transmission of monetary and fiscal policy.
R. Dornbusch, R. J. Shiller

14.452 Macroeconomic Theory II (A)

Prereq.: 14.451
Year: G (2)
2-0-4

Determination of aggregate output, employment, and prices, Keynes and alternate theories. The Phillips Curve. Inflation in the short and long run.
R. Dornbusch, R. J. Shiller

14.453 Macroeconomic Theory III (A)

Prereq.: 14.452
Year: G (1)
2-0-4

Theory of involuntary unemployment; sources of wage and price stickiness; role of expectations.
R. M. Solow

14.454 Macroeconomic Theory IV (A)

Prereq.: 14.453
Year: G (1)
2-0-4

Quantitative macroeconomics. Consumption, investment, and other components of aggregate demand. Structure of complete econometric models of the US economy.
L. H. Summers

14.458 Advanced Topics in Macroeconomic Theory (A)

Prereq.: 14.454
Year: G (1)
Arr.

14.459 Advanced Topics in Macroeconomic Theory (A)

Prereq.: 14.454
Year: G (2)
Arr.

Advanced topics in macroeconomic theory of current interest.
Staff

14.462 Monetary Economics I (A)

Prereq.: 14.121, 14.451
Year: G (1)
3-0-9

Examination of sources and determinants of supply of money with special attention to roles of commercial banks, Federal Reserve System, and Treasury. Discussion of nature of demand for money. Role of monetary policy in determination of level of economic activity.
R. B. Litterman

14.463 Monetary Economics II (A)

Prereq.: 14.122, 14.452
Year: G (2)
3-0-9

General equilibrium theory of money, interest, prices, and output; portfolio problems, cost of capital, and the effects of monetary phenomena on investment and accumulation of wealth with special reference to problems arising from uncertainty.

14.471 Fiscal Theory I (A)

Prereq.: 14.04
Year: G (1)
2-0-4

Optimum fiscal analysis (income distribution, public goods, externalities). Introduction to constrained optimum analysis (deadweight burdens, Ramsey problem). Simple incidence.
A. F. Friedlaender

14.472 Fiscal Theory II (A)

Prereq.: 14.471
Year: G (1)
2-0-4

Fiscal incidence, social discount rates, fiscal changes in growth models.
A. F. Friedlaender

14.473 Government Decision Theory (A)

Prereq.: 14.04
Year: G (1)
2-0-4

Positive and normative analysis of governmental decision theory and the political process. ***(Not offered 1981-82.)***
J. Rothenberg

14.474 Fiscal Economics III (A)

Prereq.: 14.124
Year: G (2)
2-0-4

Topics of current research interest in advanced fiscal theory, such as optimal taxation, optimal expenditure policy, policies to deal with externalities.
P. A. Diamond

14.475 Fiscal Federalism and Local Government Economics (A)

Prereq.: 14.471
Year: G (1)
2-0-4

Role of government fiscal activity in a Federal structure. ***(Not offered 1981-82.)***
J. Rothenberg

14.476 Social Insurance (A)

Prereq.: 14.121, 14.122
Year: G (2)
3-0-9

Theory of social insurance and examination of some of existing and proposed US programs including some subset of Social Security, Unemployment Compensation, Worker's Compensation, National Health Insurance. ***(Not offered 1981-82.)***
P. A. Diamond, L. H. Summers

14.477 Quantitative Fiscal Analysis (A)

Prereq.: 14.04
Year: G (2)
3-0-9

Quantitative analysis of economic effects of fiscal instruments and fiscal changes, such as negative income tax, corporate income tax integration, general fiscal incidence, expenditure taxation. ***(Not offered 1981-82.)***
J. A. Hausman, L. H. Summers

14.478 Tax Institutions and Policy (A)

Prereq.: 14.04
Year: G (2)
2-0-4

Analysis of tax structures, tax instruments, and problems of formulating and implementing tax policy. ***(Not offered 1981-82.)***
E. C. Brown, A. F. Friedlaender

14.482 Income Distribution Economics (A)

Prereq.: 14.124
Year: G (2)
3-0-9

Modern theories and empirical studies of the determinants of the distribution of income. (Alternate years. ***Not offered 1981-82.***)
L. C. Thurow

International, Interregional, and Urban Economics

14.50 State and Local Government Finance

Prereq.: 14.01
Year: U (2)
3-0-6

Issues in state and local government finance with particular attention paid to role of labor costs and labor relations. Topics include urban fiscal crisis, school finance reform, public sector impasses, and impacts of public employee unions. ***(Not offered 1981-82.)***
H. C. Katz

14.51J Urban Economics

(Same subject as 11.008J)
Prereq.: 14.01
Year: U (1)
3-0-6

Analysis of urban problems in US using an economic methodology. Metropolitan growth and suburbanization, housing markets, segregation and urban renewal, transportation systems, ghetto economic development, municipal finance, and social service provision. Development of theoretical perspectives primarily through discussion of policy issues. ***(Not offered 1981-82.)***
J. Rothenberg, W. C. Wheaton

14.52 Economics of the Soviet Union and China

Prereq.: 14.02
Year: U (1)
3-0-6

Historical background. Russian and Chinese agriculture and industry before the Communist revolutions. Economic ideology of Communist regimes. General approach to industrialization. Agriculture and industry. Management and labor. Recent changes and discussions. Evaluation of the Soviet and Chinese experiments. ***(Not offered 1981-82.)***
E. D. Domar

14.53 Comparative Economic Systems

Prereq.: 14.02
Year: U (2)
3-0-6

Comparative study of the treatment of economic problems under different economic systems. Analysis of the economic ideology of capitalism, utopian writings, market socialism, workers' management, and Marxism. Functions of prices, profits, and planning in allocation of resources. Comparison of several capitalist and socialist countries including the US and Yugoslavia.
E. D. Domar

14.54 International Trade

Prereq.: 14.03 or 14.04
Year: U (1)
3-0-9

Theory of international trade and finance, and application to current problems, such as exchange restrictions, economic development, and foreign aid.
R. Dornbusch

14.573J Urban Economic Analysis I (A)

(Same subject as 1.283J, 11.410J)
Prereq.: 14.04
Year: G (1)
3-0-9

Patterns and processes of growth and structural change within metropolitan areas. The land use market, spatial structure of metropolitan community and transportation system. Congestion, indivisibilities, and optimal pricing and investment policies. Analysis of modal demand. Models of the metropolis and the transport system. Relationships between housing market and transport network.
W. C. Wheaton

14.574J Urban Economic Analysis II (A)

(Same subject as 11.411J)
Prereq.: 11.410J or 14.573J
Year: G (2)
3-0-9

Urban housing markets. Economics of slums, ghettos, and public policy. Congestion and pollution. Local government in metropolitan areas. Criteria for public action on housing, transportation, land use, segregation, and development.
J. Rothenberg

14.576J Topics in Transportation Economics (A)

(Same subject as 1.284J)
Prereq.: 14.03 or 14.04
Year: G (2)
3-0-9

Theory and behavior of large transportation systems: urban and intercity, passenger and freight; estimation and application of production, cost and demand functions. Evaluation of governmental transportation policies: economic regulation, infrastructure investments, pricing and financing; cost-benefit analysis and impacts upon economic efficiency, X-efficiency, and the income distribution.
C. Winston

14.581 International Economics I (A)

Prereq.: 14.04
Year: G (1)
3-0-9

Theory of international trade and applications in commercial policy.
P. R. Krugman

14.582 International Economics II (A)

Prereq.: 14.06, 14.581
Year: G (2)
3-0-9

Adjustment in international economic relations with attention to foreign exchange markets, balances of payments, and the international monetary system.
R. Dornbusch

Labor Economics and Industrial Relations

14.63 Labor in Industrial Society

Prereq.: —
Year: U (1, 2) HUM-D
3-0-6

Introductory analysis, through an integrated social science approach, of the nature of labor problems in an industrial society; with emphasis on unemployment, participation in the labor force, development of labor organizations, accommodation of management and unions through the dynamic bargaining process, industrial conflict, and other selected issues arising between management and labor in American society.
T. A. Barocci

14.64 Labor Economics and Public Policy

Prereq.: 14.01 or 14.63
Year: U (1, 2)
3-0-6

Particular applications of the analytical tools developed in prerequisite subjects to two aspects of the industrial relations scene: 1) economics of collective bargaining, problems presented by wage determination at firm, industry, and economy levels; and 2) development of public policy on the rights and obligations of employers, unions, and workers. (Permission of instructor required.)
Term 1: *K. G. Abraham*
Term 2: *Staff*

14.671J Labor Economics (A)

(Same subject as 15.671J)
Prereq.: 14.64 or 15.663
Year: G (1)
3-0-6

Primary emphasis on structure of labor markets and determinants of wage levels, unemployment, the distribution of income and employment opportunity. Special attention given to impact of unions on both wage and nonwage elements of collective bargaining in light of the characteristics and objectives of particular unions. Other special topics growing out of recent research in labor economics.
M. J. Piore

14.672J Public Policy on Employment and Industrial Relations (A)

(Same subject as 15.672J)
Prereq.: 14.64 or 15.663
Year: G (2)
3-0-6

Major trends in legislation and other government activities affecting the work place. Topics: wage and price controls, equal employment opportunity, and government regulation of union organization, collective bargaining, industrial disputes, wages and hours of work, and workplace health and safety. The broad economic and social questions raised by these trends also explored.
H. S. Farber, H. C. Katz

14.674J Comparative Systems of Industrial Relations and Human Resource Development (A)

(Same subject as 15.674J)
Prereq.: 14.64 or 15.663
Year: G (1)
3-0-6

International and comparative analysis of industrial relations systems and systems of human resource development. Concentration on an examination of selected issues involving the nature and functions of labor and management organization in different contexts; role of the state in establishing procedures and in shaping the substance of industrial relations; manpower and economic growth in the context of comparative systems of human resource development; worker participation in management, and other topics.
M. J. Piore

14.691J Research Seminar in Industrial Relations (A)

(Same subject as 15.691J)
Prereq.: 14.671J or 14.672J
Year: G (1)
3-0-6

14.692J Research Seminar in Industrial Relations (A)

(Same subject as 15.692J)
Prereq.: 14.691J
Year: G (2)
3-0-6

Discussion of important areas for research in industrial relations, frameworks for research, research techniques, and methodological problems. Centered mainly on staff research and thesis research of advanced graduate students and invited guest speakers.
Staff

Economic History

14.71 Economic History

Prereq.: 14.02
Year: U (1) HUM-D
3-0-6

Introduction to European economic history, with emphasis on the Industrial Revolution. Deals with both medieval antecedents and modern consequences of the Industrial Revolution. Specific topics vary yearly, including demographic history, American industrialization, the role of capital markets in industrial growth. (Enrollment limited to 20 students. Some knowledge of history desirable.)
E. D. Domar

14.731 American Economic History (A)

Prereq.: 14.04, 14.06
Year: G (1)
3-0-9

Survey of the beginnings of American industrialization, emphasizing a quantitative approach and the 19th century. Topics include effects of government economic policies such as land distribution and tariffs, importance of railroads, profitability of slavery. (Limited to 20.)
P. Temin

14.732 Problems in Russian Economic History (A)

Prereq.: 14.04, 14.06
Year: G (2)
3-0-9

Comparative study of major problems in Russian economic history prior to 1917 both for their own sake and as a background for an understanding of the events of 1917 and of Soviet policies since. Topics vary yearly, but land and peasant problems and industrialization methods emphasized.
E. D. Domar

14.733 European Economic History: Monetary and Financial Aspects (A)

Prereq.: 14.121
Year: G (1)
3-0-9

Survey of the development of money, banking, central banking, government and private finance, including capital markets, in Western Europe from 1600, with emphasis on comparative institutional changes in national systems and the development of European-wide institutions. ***(Not offered 1981-82.)***

Economic Development

14.734 Problems in Economic History (A)

Prereq.: 14.731, 14.732 or 14.733
Year: G (2)
3-0-9

Analysis of problems of industrial society, concentrating on the century after 1860 and on the American experience. Topics vary yearly including effects of wars on welfare and growth, nature of the long deflation of the late 19th century, contrast in international relations before and after 1914, depression of the 1930s. ***(Not offered 1981-82.)***
P. Temin

14.74 Economic Growth and Development

Prereq.: 14.02
Year: U (2)
3-0-6

Analytical treatment of the problems of economic growth and development combined with comparative studies of the growth of advanced and underdeveloped economies. Considerations of policy measures to promote economic development and growth.
M. L. Weitzman

14.771 Problems of Economic Development (A)

Prereq.: 14.121, 14.451
Year: G (1)
3-0-9

Analysis of problems of the rural sector in developing countries, urban-rural migration, unemployment, sectoral balance and efficiency of private resource allocation.
R. S. Eckaus, L. J. Taylor

14.772 Theory of Economic Development (A)

Prereq.: 14.121, 14.451
Year: G (2)
3-0-9

Analysis of problems in international trade and development; study of structure and use of planning models for development policy and use of cost-benefit analysis.
R. S. Eckaus, L. J. Taylor

14.774 Technology and Development (A)

Prereq.: 14.74
Year: G (1)
3-0-9

A survey, for noneconomics majors, of issues in identifying, choosing, and using particular technologies in developing countries and consequences of decisions made. Topics include economic analysis of implications of social, political, and technological criteria and constraints on choice in rural as well as urban production conditions. International transfer and adaptation of technology, including role of transnational corporations. Case studies develop and illustrate problems.
R. S. Eckaus

14.776 Theory and Problems of Economic Development (A)

Prereq.: 14.002
Year: G (2)
3-0-9

For non-economics majors on survey and analysis of problems of developing countries with special attention to interrelationships between agricultural and industrial sectors and urban-rural migration, analysis of dual economies in development processes, resource allocation, international trade and development problems, monetary and structural changes, applications of cost-benefit analysis and planning models for development. ***(Not offered 1981-82.)***
R. S. Eckaus

14.781J Political Economy I: Theories of the State and the Economy (A)

(Same subject as 17.156J)
Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Critical analysis of liberal, neoclassical, and Marxist perspectives on modern society. Alternative theories of economic growth, historical change, the state, classes, and ideology.
M. J. Piore, S. Berger

14.782 Capitalism, Socialism and Growth (A)

Prereq.: 14.121, 14.451
Year: G (1)
3-0-9

Comparative study of capitalism and socialism, including market socialism, workers' management (in Yugoslavia), Marxism and centrally-planned economies, with emphasis on the Soviet Union. Soviet industrialization debates and growth models. Development of the Soviet economy. Management of agriculture and industry. Prices and wages. Measures of relative efficiency. Comparisons with China. ***(Not offered 1981-82.)***
E. D. Domar

14.783 Theory of Central Planning (A)

Prereq.: 14.124
Year: G (2)
3-0-9

Multilevel planning. Decomposition principles and their application. Planning with prices and with quantities. Materials balancing and input-output. Applications of inventory theory. The problems posed by non-convexities. ***(Not offered 1981-82.)***
M. L. Weitzman

15 Management

Managerial Economics

15.UR Undergraduate Research

Prereq.: —
Year: U (1, 2)
Arr.

Extended participation in the work of a research group which includes such activities as independent study of the literature, direct involvement in the group's research commensurate with the student's skills and preparation, or project work under an individual faculty member extending over more than one term. (Admission by arrangement with individual faculty member.)
H. D. Toong

15.001 Managerial Economics

Prereq.: —
Year: U (1, 2)
4-0-8

Introduction to micro and macroeconomics with emphasis on model building and applications. Mechanisms of supply and demand and economics of consumer and business decisions. Operation of the price-profit system. Market structures and market behavior in specific industries. Determination of national income, aggregate level of economic activity, and interest rates. Introduction to fiscal and monetary policy. Analyses of economic problems of relevance to management.
J. J. Rotemberg, M. B. Zimmerman

15.011 Economics for Management

Prereq.: 14.02
Year: G (S)
5-0-10

Micro and macroeconomics for students of management, with emphasis on the construction and use of economic models. Price determination through supply and demand, models of consumer, business, and government behavior. General equilibrium in a closed economy and international trade. Determination of national income, aggregate economic activity, general price level, employment, and interest rates. Monetary economics and economic growth, inflation, unemployment and business cycles. Stabilization policies; monetary, fiscal, and incomes. Balance of payments problems. (Restricted to Sloan School of Management graduate students.)
Staff

15.012 Applied Micro and Macroeconomics (Revised Unit)

Prereq.: 14.02 or 15.001
Year: G (1)
4-0-8

Intermediate level subject in micro and macroeconomics, with special emphasis on applications to managerial decision making in both the private and public sectors. Microeconomics portion focuses on cost and demand analysis, market structure and industrial performance, design of pricing strategies, and effects of government regulation. Macroeconomics portion focuses on the measurement, forecasting, and interpretation of aggregate economic variables, how those variables are affected by government policies, and the implications for management.
R. S. Pindyck

15.013 Industrial Economics

Prereq.: 15.012
Year: G (1, 2)
3-0-6

Analysis of the structure of American industry centering on concentration of sales, control of entry by economies of scale or artificial barriers such as licenses, certificates, or patents. Relationship between structure and industry performance as measured by price levels, price discrimination, advertising, and profitability. Effect of government regulation on the performance of companies, including effect of price controls, profitability controls, quality controls, or safety legislation. Conclusions formulated on the efficiency criteria used to evaluate the largest industries in the US and to evaluate the performance of government in controlling these industries. Some attention paid to the relative efficiency of public enterprise.
R. L. Schmalensee, T. M. Stoker, E. R. Berndt

15.014 Macroeconomic Problems and Policies

Prereq.: 15.012
Year: G (2)
3-0-6

Intermediate level subject in macroeconomics, with emphasis on design and analysis of macroeconomic policy, both for short-term stabilization and long-term economic growth, and on interrelationship between industry behavior and macroeconomic performance. Specific aspects of macroeconomic structure studied in some detail, including determination of national income, behavior of the monetary sector, dynamics of wage-price inflation, and mechanism of long-term economic growth in context of resource scarcity. Policy problems include the design and impact of monetary and fiscal policy, as well as the macroeconomic impact of government controls on specific industries.
J. J. Rotemberg

15.016 Public Sector Economics and Finance

Prereq.: 15.012
Year: G (2)
3-0-6

Applications of economics and analytic methods to problems of evaluation and choice in the public sector, and to the study of phenomena that lead to "public" problems. Analysis of government expenditures, taxes, and transfers; problems of market failure; and role of

Operations Research/Statistics

government enterprises. Emphasis on applied empirical analysis in such areas as energy and natural resources, pollution, medical care, crime, welfare, and tax reform.
H. D. Jacoby, D. M. Holland

15.017 Economics of Government Regulation

Prereq.: 15.011 or 15.012
Year: G (1)
3-0-6

Considers rationale, origin, and effects of the major forms of government regulation of firms and markets. Experience in the US used to illustrate principles and problems. Economic and political foundations, ideal and actual public utility regulation, utility regulation applied to competitive markets, new policies aimed at health, safety, consumer protection, and environmental preservation.
R. L. Schmalensee

15.018 Economics of International Business

Prereq.: 15.012
Year: G (1, 2)
3-0-6

International trade and finance for students of management. Pure and applied theory of trade and of trade policy. International monetary system and balance of payments. International investment and multinational firm. Offered in two sections, one emphasizing role of multinationals and institutions affecting that role, the other emphasizing theory and institutions of international trade and monetary systems.
P. R. Krugman, S. S. Alexander

15.019 Energy Economics and Policy

Prereq.: 15.011 or 15.012
Year: G (1)
3-0-6

Surveys recent work in energy economics and management, paying particular attention to US energy situation. Analytical methods developed, and use of research tools and results in public and private sector decision making stressed. Topics: international aspects of energy policy, domestic price controls, energy and the environment, demand modeling and management, new energy technologies, and interactions between energy sectors and the macroeconomy.
M. B. Zimmerman, H. D. Jacoby, D. O. Wood

15.024 Economics and Finance: Principles and Policies

Prereq.: —
Year: G (S)
4-0-9

Introduction to the determination of national income and its fluctuations; composition and pricing of output; determination of factor prices and inputs; industrial economics, relations of government and business, and current problems of applied economics; and general economic policy. (Restricted to Sloan Fellows.)
Staff

15.031 Quantitative Approaches to Economic and Management Policy (A)

Prereq.: 15.012; 15.013 or 15.014 or 15.016
Year: G (1)
3-0-6

Analysis of public and corporate policy problems. Emphasis on approaching and solving complex problems, often drawing upon a variety of quantitative tools and techniques. Students work through five or six actual policy problems during semester. Examples: a decision to import liquefied natural gas under a long-term contract, design of an optimal strategic stockpile of crude oil for the US, and financing of a new copper venture in a less developed country. Although solution of these problems might involve a variety of techniques (simulation models, forecasting techniques, and optimization methods), problems all share in common the need for analytical reasoning at the outset.
R. S. Pindyck

15.053 Introduction to Management Science

Prereq.: 18.02, *18.700*
Year: U (1, 2) SD
4-0-8

Introduction to management science with emphasis on basic deterministic models and their optimization. Formulation and solution of linear optimization models for management applications. Simplex method, duality theory, sensitivity analysis. Introduction to networks, dynamic programming, integer programming, and nonlinear programming. Solving problems by computer and interpreting the results.
J. D. C. Little

15.058 Applied Mathematical Programming (New)

Prereq.: 18.02, *18.700*
Year: G (1, 2)
4-0-8

Introduction to management science with emphasis on basic deterministic models and their optimization. Formulation and solution of linear optimization models for management applications. Simplex method, duality theory, sensitivity analysis. Introduction to networks, dynamic programming, integer programming, and nonlinear programming. Solving problems by computer and interpreting the results. Subject is more advanced than 15.062 and substitutes for it.
J. D. C. Little

15.061 Statistics for Management

Prereq.: 18.01
Year: G (1, 2)
4-0-8

Introduction to probability and statistical data analysis with emphasis on applications in management. Topics: basic probability, sampling and data collection, exploratory data analysis, inference and diagnostics for linear regression models, statistical computing and simulation. (Restricted to Sloan School of Management graduate students; others admitted by permission of instructor.)
A. I. Barnett, M. A. Wong

15.062 Decision Models for Management

Prereq.: 18.01
Year: G (1, 2)
4-0-8

Introduction to mathematical programming and decision analysis emphasizing applications to management problems. Formulation and solution of linear optimization models. Simplex method, duality theory, sensitivity analysis. Transportation and network flow problems. Introduction to dynamic programming, integer programming, and branch-bound methods. Decision trees and Bayes theorem.
J. B. Orlin

15.065 Decision Analysis (A)

Prereq.: Permission of Instructor
Year: G (1, 2)
3-0-6

Basic theory of decision making under uncertainty. Topics: decision trees, quantification of judgments and preferences, the value of information, Bayes theorem, the structuring of complex decisions, and multi-attributed utility theory.
G. M.. Kaufman

15.066 Statistical Decision Theory (A)

Prereq.: 6.041 or 18.440
Year: G (2)
3-0-6

An introduction to the Bayesian approach in statistics. Topics: subjective probability, probabilistic utility, posterior and preposterior analysis of sampling processes, point and interval estimation, Bayesian treatment of multivariate linear regression models.
G. M. Kaufman, R. E. Welsch

15.071 Management Decision Support Models

Prereq.: —
Year: G (S)
3-0-6

Model-based approach to modern managerial analysis. Introduction to various techniques that support managerial decision making, including decision analysis, simulation, statistics, and linear programming. Emphasis on basic understanding and evaluation of techniques and their application rather than technical expertise. (Restricted to Sloan Fellows.)
T. L. Magnanti

15.073J Introduction to Stochastic Processes (A)

(Same subject as 18.445J)
Prereq.: 18.313 or 18.440 or 6.041
Year: G (1, 2)
4-0-8

Introduction to theory and application of stochastic processes. Examples of empirical phenomena for which stochastic processes provide mathematical models. Random walk, gambler's ruin, recurrent events, discrete-time Markov chains, Branching processes, Poisson processes, nonhomogeneous Poisson processes, compound Poisson processes, renewal theory. Continuous-time Markov chains, birth and death processes, queueing theory and Brownian motion. Time permitting, additional topics chosen from: semi-Markov processes, Markov renewal processes, Markov decision process, inventory theory, and Gaussian processes.
Term 1: *Staff*
Term 2: *A. I. Barnett*

15.075 Statistics for Applications (A)

Prereq.: 18.440
Year: G (1, 2)
3-0-6

Introduction to statistical data analysis concentrating on specific techniques used in management science. Topics: exploratory and graphical data analysis, smoothing, regression models and diagnostics, statistical inference for linear models, sampling and data collection. (Open to qualified undergraduates.)
R. E. Welsch

15.076J Statistics for Model Building (A)

(Same subject as 18.457J)
Prereq.: 15.075 or 18.443 and 18.700
Year: G (2)
3-0-9

Designed to be an advanced subject in statistical data analysis for those interested in model building, calibration, and validation. Topics: linear and nonlinear regression analysis with emphasis on detection and correction of model violations, robustness, selection of variables, models with categorical data. Introduction to multivariate methods and statistical computing.
R. E. Welsch, H. Chernoff

15.077 Bayesian Analysis Studies (A)

Prereq.: 15.065
Year: G (1)
3-0-6

Primary emphasis on Bayesian methods in multivariate problems. Content varying from year to year. Typical topics: the multivariate normal distribution, best of several processes problem, stratified sampling, bias, extended natural conjugate analysis of the normal process, multiple regression, multivariate regression, simultaneous equation systems, Bayesian interpretation of standard multivariate inference statements. Term paper on selected multivariate statistical problems.
G. M. Kaufman

15.078J Logistical and Transportation Planning Methods (A) (Revised Content and Unit)

(Same subject as 1.203J, 6.281J, 11.526J, 13.665J, 16.76J, TPP 43J)
Prereq.: 6.431, 15.075
Year: G (1)
3-0-6

Quantitative techniques of operations research with emphasis on applications in transportation systems analysis (urban, air, ocean, highway, pick up and delivery systems) and in the planning and design of logistically oriented urban service systems (e.g., fire and police departments, emergency medical services, emergency repair services). Unified study of functions of random variables, geometrical probability, multi-server queueing theory, spatial location theory, network analysis and graph theory, and relevant methods of simulation. Discussion of implementation difficulties. Examples of applications: design of ambulance systems having both specialized and general-purpose vehicles; emergency response to oil spills; estimation of energy consumption by commuters in a metropolitan area; design of dial-a-ride transportation systems; controlling randomness in mass transit systems; evaluation of technologies for vehicle location, routing and control.
A. I. Barnett, R. C. Larson, A. R. Odoni, H. N. Psaraftis

Health Management

15.079 Workshop in Applied Statistics (New)

Prereq.: Permission of Instructor
Year: G (1, 2)
Arr.

Presentations by faculty, students, and guest speakers concerned with research in applied statistics, data analysis projects related to management, statistical consulting, and statistical computing. Discussions of recent literature dealing with subjects of special interest to participants. (Primarily for Doctoral students.)
R. E. Welsch

15.081J Introduction to Mathematical Programming (A)

(Same subject as 6.251J)
Prereq.: 18.700
Year: G (1, 2)
3-0-9

A first subject in mathematical optimization emphasizing methodology. Linear programming, simplex method, duality, sensitivity analysis, geometric view. Transportation and network flow problems. Elements of integer programming. Introduction to generalized and nonlinear programming.
J. B. Orlin, S. K. Mitter

15.082 Network Optimization (A)

Prereq.: 15.081J
Year: G (2)
3-0-9

Network models for industrial logistics systems, transportation systems, communication systems, and other applications. Emphasis on algorithms and their efficiency; algorithms for shortest routes, minimum cost flow, minimal spanning trees, traffic equilibrium, vehicle routing and the traveling salesman problem, facility location and network design, matching. Implementation issues.
T. L. Magnanti

15.083 Combinatorial Optimization (A)

Prereq.: 15.081J
Year: G (1)
3-0-6

Devoted to integer programming and related topics. Group optimization methods and integer programming duality theory. Benders' method for mixed integer programming. Introduction to combinatorics including matroids, properties of integer polyhedra, theory of computational complexity, optimization of submodular functions.
J. F. Shapiro

15.084J Nonlinear Programming and Discrete-Time Optimal Control (A)

(Same subject as 6.252J)
Prereq.: 18.700, *18.100*
Year: G (2)
3-0-9

Unified approach to mathematical programming and discrete-time optimal control. Convex analysis. Global and local duality theory for nonlinear programming. Discrete maximum principle of optimal control. Unconstrained minimization methods. Algorithms for nonlinear programming. (Knowledge of 15.081J/6.251J useful but not required.)
J. F. Shapiro, S. K. Mitter

15.085 Topics in Optimization (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-6

Seminar devoted to current literature and advanced topics in optimization theory and practice. Topics such as game theory, fixed point theory, analysis of heuristics, multicriteria optimization, and infinite dimensional optimization varying from year to year.
T. L. Magnanti

15.089 Workshop in Operations Research (New)

Prereq.: Permission of Instructor
Year: G (1, 2)
Arr.

Presentations by faculty, students and guest speakers of ongoing research concerned with current issues in Operations Research. Typical topics: reports of research projects, proposed or in progress, informal discussions of recent literature dealing with subjects of special interest to participants. (Primarily for Doctoral students.)
T. L. Magnanti

15.121 Seminar in Health Management (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-6

15.122 Seminar in Health Management (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Study of selected organizational and management issues facing managers of health services, health education, and health research institutions as discussed by invited guests who are experienced managers. (Primarily for members of the Health Management Executive Development Program. Other Sloan Fellows and a limited number of graduate students with background or concentration in health management admitted by permission of instructor.)
N. S. Stearns, E. B. Roberts

15.132 Management of Change in Complex Health Organizations (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Designed for persons in line management or key staff positions in health institutions who manage the human and other resources involved in major institutional change. Topics: large system diagnosis — theory and methods; goal setting and change planning; managing the transition state; intervention strategies and technologies; evaluation of planned change efforts; managing the stabilization phase; maintenance of organization flexibility. (Primarily for members of the Health Management Executive Development Program. Others admitted by permission of instructor.)
R. Beckhard

15.136 Health Technology (A) (New)

Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Research seminar in the development, evaluation, and dissemination of medical technologies and practices. Strategies for management of basic and applied biomedical research. Communication channels for research results among researchers and from researchers to users. Analytic methods for evaluation of efficacy and social impact. Examination of factors influencing commercial development of new health technology.
S. N. Finkelstein

International Business

15.141J Comparative Health Systems (A)

(Same subject as 17.228J)
Prereq.: Permission of Instructor
Year: G (1)
3-0-6

Organization and major issues facing health systems in the US and selected other countries considered from a variety of perspectives, including those of the physician, manager, and policy analyst. Cost, quality, access, and technology considered in depth in nonprofit, proprietary, and government elements of the systems.
S. N. Finkelstein, H. M. Sapolsky

15.144 Analytical Methods for Health Policy and Management (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Applications of analytical methods to health policy and management problems. Consideration of incidence, prevalence, cost, and other characteristics of disease and ill health having significant management or public policy implications. Review of public and private initiatives in disease control, prevention, and research.
S. N. Finkelstein

15.149 Special Studies in Health Management (A)

Prereq.: Permission of Instructor
Year: G (1, 2)
Arr.

For graduate students who desire to do advanced work or research on a health management problem not specifically covered elsewhere. Readings, conferences, fieldwork, and reports.
E. B. Roberts

15.215 International Dimensions of Management

Prereq.: —
Year: G (2)
3-0-6

Theory and practice of international business, with special emphasis on strategy selection in selected areas (for example, production, labor, management, and ownership) and on corporate organizational response to the changing international environment. (Restricted to Sloan Fellows.)
R. D. Robinson, Staff

15.221 International Business Management I (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-6

Theory of, and institutional restraints acting on, international business, with emphasis on the pressure to effect harmonization of a firm's objectives with those of foreign business associate or customer, host government, and parent government. Discussion of historical flows of trade and investment and impact of such flows on host and parent societies. Coverage of institutional restraints in the legal, informational, financial, and commercial areas. Problem areas: sources of foreign market information and evaluation of same, conflict of law regarding property and rights of aliens, taxation of international income, antitrust law, adjudication of international business disputes, investment guarantees, foreign exchange controls, financing of foreign trade, trade agreements and trading areas. Term project: an analysis of a foreign market for a specified product and firm.
R. D. Robinson

15.222 International Business Management II (A)

Prereq.: 15.221
Year: G (2)
3-0-6

A policy-oriented working seminar open only to students who have command of material covered in 15.221. After a series of introductory discussions on environmental analysis and decision making within the international firm and its organizational evolution, seminar focuses on two or three major strategic corporate issues and their public policy implications, such as international corporate regulation, global production/marketing strategy within a given sector, corporate response to changes in industrial relations and to national differences, etc. Term project: leadership of the seminar in the discussion of one or more policy options and the preparation of the relevant materials.
R. D. Robinson

15.223 International Business Environments (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-6

In-depth examination of sociocultural, political, economic, and legal environments of international business. Topics: industrialization and social change, demography, cross-cultural communication, comparative management, imperialism, political development, the international political system, and models and methods available for environmental analysis by the firm. Objectives: to provide a more sophisticated understanding of the international environment and to develop a familiarity with analysis of the investment environment. Subject is interdisciplinary in nature, drawing on a wide range of literature and case material. Term project: in-depth analysis of the investment environment of a given country for a firm.
Staff

15.224 Intercultural Communication I (A)

Prereq.: 15.221
Year: G (2)
3-0-6

15.225 Intercultural Communication II (A)

Prereq.: 15.224
Year: G (1)
3-0-6

Subjects designed as a sequence of experiences providing in-depth exposure to a culture with which student has not had significant prior contact. Requirements for each student: development of a working proficiency (oral) in a major language of target area; completion of a background reading course under supervision of a faculty member; three months investigating line of inquiry within student's target area subject to approval of reading course instructor and the instructor in charge of subject; a working paper reporting on experience abroad. Defrayment of expenses for language training (if MIT facilities inadequate) and expenses incurred by reason of residence and travel abroad are the student's liability. Normal time for overseas experience is during the summer between a student's first and second years. A required working paper in 15.225, as well as consultations with the two instructors involved. (Required for Ph.D. students offering international management as their major ap-

History and Environment

Organization Studies

plied field. Requirements for Ph.D.: an article-length report of publishable quality; passing an oral examination measuring understanding of the foreign culture, including relevant language.)
R. D. Robinson

15.227 International Technology Transfer (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Designed for those seeking careers in international industrial development, whether within context of public developmental institutions or international corporations. Focus on specification of technological needs in various societies, range of alternative technologies, choice of appropriate technology given varying environmental conditions, incentives, and disincentives to technology transfer (e.g., the impact of various financial, legal, and organizational factors); transfer mechanisms, the diffusion or internalization of technology, social/political impact of rapid technological change, marketing of technology.
K. N. Rao, R. D. Robinson, D. Leonard-Barton

15.228J Ocean Engineering and Law Seminar (A)

(Same subject as 13.94J)
Prereq.: 13.96 or 13.92
Year: G (2)
3-0-6

An interdisciplinary research seminar which examines selected problems involving law and ocean engineering. Analysis of implementation of new technological systems in the ocean under evolving legal regimes. Students expected to participate in interdisciplinary team exercises on such matters as establishment of traffic separation schemes and administration of extended jurisdiction zones. A research paper required on a problem involving law and ocean engineering. Covers international and municipal legal policy, applied economics, and technical aspects. Offered jointly with Harvard Law School. ***(Not offered 1981-82.)***
J. D. Nyhart, J. T. Kildow

15.268 Readings in Power and Responsibility (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-6

A study of managerial power and responsibility in relation to today's world. Examination of conflicts between power and moral responsibility, of the value-complexes which underlie modern Western society, and of the major political and economic stances available to leadership in coping with current problems.
W. F. Bottiglia

15.301 Managerial Psychology Laboratory

Prereq.: —
Year: U (1, 2) LAB
2-6-4

Core subject for students majoring in management. Survey of individual and social psychology and organization theory interpreted in the context of the managerial environment. Laboratory involves projects of an applied nature in behavioral science. Emphasis on use of behavioral science research methods to test hypotheses concerning organizational behavior.
T. J. Allen

15.304 Complex Organizations

Prereq.: 15.301
Year: U (2)
3-0-6

Introductory examination of various perspectives by which complex organizations may be viewed. Emphasis placed on such features as conflict, control, authority, deviance, leadership, and decision making as useful dimensions for understanding both organizational behavior and individual behavior within structured environments. Subject combines field observations of a goal-oriented social process with a survey of empirical findings related to complex organizations.
J. E. Van Maanen

15.306 Behavioral Science Research Methods

Prereq.: *15.304*, 18.05
Year: U (1)
3-0-9

Introduction to methods of behavioral science research. General strategy of behavioral research (quantitative vs. qualitative analysis, hypothesis formulation, the probabilistic nature of data, etc.); research design (purposes, variance control, control of extraneous variables, use of control groups, randomized designs, factorial designs, two-group, multigroup, and correlated-groups designs). Specific technologies of various designs (questionnaire construction, sampling, interviews, systematic observation). Theory and research findings. Ethical issues involved in social research. Organization and development of research project.
R. Katz

15.307 Behavioral Science Research Practicum

Prereq.: 15.306
Year: U (2)
2-8-8

Development and completion of research project planned in 15.306 during previous term. Interpretation and application of research findings in management environment. Experimentation with such techniques as field survey work, laboratory experimentation, computer simulation, field consulting of relationships. (Restricted to undergraduates in the Sloan School of Management who are in the Behavioral Science Program.)
R. Katz

15.311 Individuals, Groups and Organizations

Prereq.: —
Year: G (1)
3-0-6

Examination of the interpersonal and human side of both public and private enterprise. Emphasis on managerial applications of social science concepts and research findings. Uses experiential learning modes and case analyses as well as lectures and discussions. Class materials cover both micro concerns (i.e., individuals and small groups), and macro issues (i.e., organizational interrelations, culture, and learning). (Restricted to first-year Sloan School of Management graduate students.)
L. Bailyn

15.312 Managerial Leadership, Motivation, and the Nature of Work (A)

Prereq.: 15.311
Year: G (1)
3-0-6

In-depth examination of effective managerial behaviors within organizations. Topics include conflict management, decision making, performance analysis and appraisal, time management, work design, and supervisory-subordinate relationships. Additional coverage given to issues of managerial succession, managing new and long-term individuals, and managerial requirements in complex organizational structures. Analysis of different theories of leadership and motivation; utilization and discussion of self-assessment and training programs in managerial skills. Based on current research programs, subject is designed as an elective for Master's students wishing to look at managerial roles from their own perspective as future organizational leaders.
R. Katz

15.313 Interpersonal Dynamics and the Management of Groups (A)

Prereq.: 15.311
Year: G (2)
3-0-6

Examination of basic concepts of how people relate to each other and how groups work from both a psychological and sociological perspective. Through lectures, discussion, fieldwork, weekly learning group exercises, and written assignments students learn not only the concepts but also how to improve their own communication and group membership.
E. H. Schein

15.314 Organization Design and Development (A)

Prereq.: 15.311
Year: G (2)
3-0-6

Topics: character and characteristics of effective organizations; designing organization structures; managing change; managing organization transitions; organization/environment relationships; managing interface. Class activities include lectures, seminars, practice cases, films, and some team projects.
R. Beckhard

15.317 Comparative Studies of Organizations (A)

Prereq.: 15.311
Year: G (2)
3-0-6

Seminar examining studies of management of organizations in various parts of the world. Determination of which management styles are most appropriate in different countries and whether any general principles of management are valid internationally. Beginning with basic theoretical and empirical work in organization studies, seminar continues with an examination of findings about non-US organizations, and concludes with an examination of cross-cultural aspects of technical assistance. Each student encouraged to become an expert on organizational studies in a particular country. Topics: motivation of workers and managers, power and control, communications, the generality of participative approaches such as Theory Y or System IV, and organizational development.
R. D. Robinson

15.318 Organizational Behavior, Policy and Practice (A)

Prereq.: 15.311
Year: G (2)
3-0-6

Study of organizational theory as it applies to actual organizational behavior. Specific examples of organizational behavior problems analyzed at policy level: how policy, explicit and implicit, affects behavior in the total organization. Discussion of selected organization research studies, papers, cases. (Enrollment limited to 20 students; admission only by permission of instructor.)
P. P. Gil

15.321 Theories of Planned Change (A)

Prereq.: 15.311
Year: G (1)
3-0-6

A comprehensive exposure to major theories and conceptual literature on planned change of individuals, groups, and organizations. Material related to current strategies employed in systematic change efforts, so that participants can increase their ability to apply these theories in an organizational setting as a manager or as a consultant. Subject developed around seven important, tested perspectives or theories of change: 1) cognitive input: use of ideas, information, constructs, persuasion; 2) modeling and imitation: social learning theory; 3) participation, involvement, and catharsis; 4) expectancy and the instillation of hope, vision, aspiration; 5) selective reinforcement; 6) coercive power; and 7) structural rearrangement: changing organizational variables. (Enrollment limited to 30 students; admission only by permission of instructor.)
E. C. Nevis

15.322 Organizational Psychology (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-6

Analysis — through lectures, discussions, and class exercises — of management of human resources in industry. (Restricted to Sloan Fellows.)
E. H. Schein

15.332 Administrative Theory and Practice (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-6

Selected significant administrative areas with emphasis upon organization and its operational problems. Comparative study of current practice and relevant research findings. Typical areas include productivity and morale, manager development, personnel practices, communication, appraisal, motivation and performance, ethics and morality. Readings, case problems, term papers, and outside speakers where appropriate.
L. B. Moore

15.333 Management of Industrial Change (A)

Prereq.: Permission of Instructor
Year: G (2)
3-3-3

Examination of the improvement function in management. Review of literature on creativity as it affects innovation in industrial operation. Human relations problems in industrial change. Role of the manager in fostering improvement. Use of the conference as an improvement tool. Fieldwork in comparative analysis of representative improvement programs.
L. B. Moore

15.334 Managing Planned Change I (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-6

Examination of approaches to planning and managing change in complex organizations. Emphasis on methods and models of diagnosis of organization conditions. Class participation in a series of live consultations with "real" clients using models of diagnosis and strategy planning. Designed for graduate students interested in the problems involved in effective implementation of either technological, structural, or human resource based planned change efforts.
R. Beckhard

15.335 Managing Planned Change II (A)

Prereq.: 15.334
Year: G (2)
3-0-6

Continuation of 15.334 designed for students who intend to pursue careers as applied behavioral science specialists in personnel, training, organization development, management development, industrial relations, etc. Emphasis on skills and issues of intervening in a system. Topics: process of intervention, consultation skills, organizational diagnosis, design of interventions. Each class member works on a two-three person team project at a local organization; this practicum experience is a major part of the subject. (Permission of instructor required.)
E. C. Nevis

15.337 Sociology of Work and Organizations (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Review of key concepts and research findings from sociology which illuminate the nature of work, how organizations evolve, and managerial process. Practice in use of sociological methods for studying work and organizations both in public and private sector. Designed for Master's students concentrating in organization studies and Doctoral students. (Alternate years with 15.339. ***Offered 1981-82.***)
J. E. Van Maanen

15.339 Social Psychology of Work and Organizations (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Review of key concepts and research findings from social psychology which illuminate the nature of work, functioning of organizations, and managerial process. Issues in use of social psychological methods for studying work and organizations both in public and private sector. Designed for Master's students concentrating in organization studies and Doctoral students. (Alternate years with 15.337. ***Not offered 1981-82.***)
L. Bailyn

15.344 Doctoral Seminar on Career Development and Adult Socialization (A)

Prereq.: Permission of Instructor
Year: G (2)
2-0-7

Seminar for doctoral students in organization studies, covering the topics of career choice, career paths in organizations, career crises, personal changes induced by occupational career, and organizational factors such as recruitment, training, and management development. Emphasis on research and theory. ***(Not offered 1981-82.)***
E. H. Schein

15.345 Doctoral Seminar in Organization Studies I (A)

Prereq.: Permission of Instructor
Year: G (1, 2)
2-0-7

15.346 Doctoral Seminar in Organization Studies II (A)

Prereq.: 15.345
Year: G (1, 2)
2-0-7

Seminar covering the basic fields of social psychology, individual psychology, and sociology and organization theory for purposes of preparing the doctoral candidate for his or her doctoral examinations. Basic concepts, theories, and research methods serving as focus for the seminar. (Restricted to doctoral candidates.)
Staff

15.347 Doctoral Seminar in Research Methods (A)

Prereq.: Permission of Instructor
Year: G (2)
4-0-8

Introduction to the process of social research, with particular emphasis on issues in conceptualization and the logic of data analysis. Students expected to actually perform all research procedures using a common data base provided for the class.
L. Bailyn

15.348 Workshop in Research Methods (A)

Prereq.: 15.347
Year: G (1)
3-0-6

Special topics in research. Students may work on their own data.
L. Bailyn

15.349 Issues of Work and Family in the Management of Human Resources (A)

Prereq.: Permission of Instructor
Year: G (2)
2-0-7

Seminar dealing with the interaction of work and family in the pursuit of organizational careers. Discussion of issues arising from changes in individual life-styles and in the values surrounding work and success; consideration of implications of these developments for management of human resources in organizations.
L. Bailyn

Management of Innovation

15.351 Research and Development Management (A)

Prereq.: 15.311 or 15.515
Year: G (1)
2-0-7

Presentation and integration of research findings on R & D management. Topics: laboratory management; project management; R & D interfaces to users, marketing, and manufacturing; technological entrepreneurship; project selection; technological forecasting; flow of technical information; management of technical personnel.
E. A. von Hippel

15.357 Management of the Innovation Process (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Focus on understanding and managing the industrial innovation process. Review of research studies on the process as a whole. Review of research on key factors such as project selection methods, economics of innovation, industrial buying behavior, organizational responses to innovation, 'nature' of the entrepreneur. Examination and evaluation of the various organizational contexts in which innovation is supposed to occur — corporate R & D, new enterprises, etc.
E. A. von Hippel

15.361 Managing Professionals (New)

Prereq.: —
Year: G (1)
3-0-6

Similar to 15.311, but with emphasis on professional (especially scientific and engineering) individuals, groups, and organizations. (Primarily for members of the Joint Program in the Management of Technology. Others admitted by permission of instructor.)
R. Katz

15.363 Managing Product Development (A) (New)

Prereq.: 15.311 or 15.361
Year: G (1)
2-1-6

Presentation and integration of research findings on the management of product-oriented research, development and engineering work. "Market-pull" vs "technology-push" as sources of initiation. Role of incremental improvement vs major breakthrough. Alternative organization structures for product development. Student project work on product conceptualization and development issues. (Primarily for members of the Joint Program in the Management of Technology. Others admitted by permission of instructor.)
E. A. von Hippel

15.365J Manufacturing/Technology Interface (A) (New)

(Same subject as 3.565J, 13.685J)
Prereq.: 15.361 or 15.363
Year: G (1)
3-0-6

Focus on the management of process innovation. Economic and other influences on manufacturing process change. Interactions between research, development and engineering activities, and manufacturing operations. Transfer of new product developments into manufacturing.
J. M. Utterback

15.367 Marketing/Technology Interface (A) (New)

Prereq.: 15.361 or 15.363
Year: G (1)
3-0-6

Market inputs to product research, design, and development. Market research techniques for new product development. User role as source of innovations in industrial goods. Marketing of advanced technology products and systems. (Primarily for members of the Joint Program in the Management of Technology. Others admitted by permission of instructor.)
E. A. von Hippel, D. Leonard-Barton

15.369 Corporate Strategies for Managing Research, Development, and Engineering (A) (New)

Prereq.: 15.363 or 15.365 or 15.367
Year: G (2)
2-0-7

Joint seminar with the Harvard Business School technology management group. Strategic issues in managing research, development, and engineering. Consideration of corporate research laboratories, new venture organizations, and integration of RD & E into corporate strategy. Lecture sessions by faculty of both schools and by invited speakers from government and industry. Independent study and preparation of reports by individual students or teams of students.
E. B. Roberts

15.371 Technical Problem-Solving and Communication (A) (New)

Prereq.: 15.311 or 15.361
Year: G (2)
3-0-6

Presentation of research findings on intra- and interorganizational communication of technical information. Role of interpersonal, organizational, and architectural factors in affecting technology flows. Differences between scientific and engineering fields.
T. J. Allen

15.375 New Technical Ventures (A) (New)

Prereq.: 15.515, 15.363
Year: G (2)
2-1-6

Organization and management of technology-based companies, and technology-based new business ventures in existing corporations. Financing of new enterprises through private, corporate and public capital sources. Joint ventures between new and old companies. Corporate venture capital activities. Preparation of cases by study of operation of local companies and detailed development of plans for launching a new venture. (Enrollment limited. Admission by permission of instructor.)
E. A. von Hippel

Finance

15.411 Financial Management (A)

Prereq.: 15.511, 15.024, 15.071
Year: G (1)
3-0-6

Survey of what an organization invests in and how much it invests: where and how funds for investment are obtained; how financial institutions and financial markets operate. A framework of principles developed that applies to operations of a corporation in context of our contemporary capital market place; a set of decision rules derived that is designed to enhance profitability and value of the enterprise. Topics: management of short-term assets and liabilities; capital budgeting and investment program decision making; functions and operations of the capital markets; valuation theory; long-term financial instruments and financing decisions; capital structure and dividend policy. (Restricted to Sloan Fellows.)
Staff

15.412 Financial Management (A)

Prereq.: 15.001 or 15.011 or 15.012
Year: G (1, 2)
4-0-8

Survey and analysis of problems facing the financial manager including a theoretical introduction to financial institutions, financial instruments, and the capital markets; theory of efficient markets; portfolio theory and valuation theory; capital investment decisions; the firm's cost of capital; long-term financing decisions; including questions of dividend policy and capital structure; and overall financial planning. (Primarily for students not concentrating in finance.)
S. C. Myers

15.413 Topics in Corporate Financial Management (A)

Prereq.: 15.412
Year: G (1, 2)
3-0-6

An in-depth treatment of specific topics in the management of corporate finance, extending and further applying the concepts and techniques covered in 15.412. In particular, topics to be covered: asset acquisition strategies, capital market responses to corporate financial strategies, investment and financing policies under inflation, international investment planning, and international capital markets.
T. A. Marsh

15.414 Business Forecasting (A)

Prereq.: 15.061
Year: G (1, 2)
3-0-6

Designed for students interested in applied econometric methods and business forecasting. Emphasis on problems typically encountered in conducting empirical econometric research, in evaluating results and testing hypotheses, and in constructing forecasts. Term paper required. Problem sets involve working with econometric models and the computer.
E. R. Berndt, E. Kuh

15.415 Finance Theory (A)

Prereq.: 15.011 or 15.012
Year: G (1, 2)
Arr.

Extensive analysis and in-depth study of capital markets extended over two terms. First term: study of the functions and operations of capital markets, analysis of consumption-investment decisions of investors, analysis of investments in common stocks, bonds, and other risky assets; portfolio construction and diversification, equilibrium pricing of assets, valuation theory, efficient market theory, cost of capital and effects of firm's capital structure. Introduction to the theory and relevant empirical testing of the theory. Second term: emphasis on firm's financial decisions. Topics: capital budgeting and investment decision making, management of short-term assets and liabilities, estimation and determinants of the firm's cost of capital; effects of capital structure decisions on investment and cost of capital; financial instruments, evaluation of mergers and acquisitions and overall financial planning. Emphasis on models for financial management, and on the models' assumptions, logical structure, and relation to capital market theory. (Primarily for Sloan graduate students concentrating in finance; others admitted only by permission of instructor.)
R. C. Merton, R. S. Ruback

15.418 Taxation and Business Management (A)

Prereq.: 15.412 or 15.415
Year: G (1)
3-0-6

Analysis of effect of taxation on conduct of business. Concentration on major decisions in which taxes impinge on the firm or its managers; concern with both theory and relevant empirical evidence. Among topics covered: the "double-taxation" of dividends; the effect of capital gains taxation; tax incentives; compensation planning; the effect of taxation on effort; alternatives to income taxation.
D. M. Holland

15.419 Finance for International Managers (A)

Prereq.: 15.221, 15.412
Year: G (2)
3-0-6

Analysis of international financial decisions of corporations and financial institutions from a management perspective. Survey of financial factors which distinguish international from domestic setting. Emphasis on specific management problems including foreign exchange transactions, measurement and control of foreign exposure, working capital management, tax management, special accounting and financial control problems, capital budgeting, financing, strategies, and financial aspects of alternative forms of participation in foreign ventures. (Primarily for students concentrating in International Management. Credit not given for both 15.419 and 15.436.)
D. R. Lessard

15.423 Financial Markets and Institutions (A)

Prereq.: 15.415
Year: G (2)
3-0-6

Application of the theory of finance to specific financial markets and institutions. Special emphasis on stock markets, corporate finance, underwriting, trading, investment companies, options markets, banks, and international financial markets.
F. Black

Accounting and Control

15.432 Capital Markets and Financial Institutions (A)

Prereq.: 15.415
Year: G (2)
3-0-6

Role and functioning of the capital and money markets as a device for the allocation of resources, the channeling of investable funds, and the reallocation of risk. Function of financial intermediaries operating in these markets.
F. Modigliani

15.433 Advanced Capital Market Theory (A)

Prereq.: 15.415
Year: G (1, 2)
3-0-6

Advanced topics in investment with strong emphasis on theory and empirical testing of hypotheses. Continuation of portfolio theory including treatment of intertemporal decision making under uncertainty, and general dynamic models and their use in evaluation of investment performance and capital asset prices. Extensive analysis of the pricing of financial securities such as options, warrants, debt, convertible bonds, and loan guarantees; and the relationship between corporate decision variables and the capital markets. Other areas covered: current empirical research on capital asset pricing, information and the efficiency of the capital markets.
R. C. Merton, T. A. Marsh

15.434 Advanced Financial Administration (A)

Prereq.: 15.415
Year: G (2)
3-0-6

Advanced topics in application of finance theory to problems of corporations and government. Theory and applications of models in the general areas of cash management, capital budgeting, cost-benefit analysis, and short-term and long-term financial planning. Specific topics: financial applications of mathematical programming models; estimating the cost of capital; developing decision rules for decentralized investment decision making; risk analysis in capital budgeting; and empirical work relevant to financial administration.
R. S. Ruback

15.436 International Managerial Finance (A)

Prereq.: 15.018, 15.415
Year: G (1)
3-0-6

Application of financial and economic theory to international financial decisions of corporations, financial institutions, and individual investors. Roughly equal emphasis on identification and analysis of factors which distinguish international from domestic setting and on modeling of specific applications. A background in international economics assumed, but further attention given to topics of exchange rate behavior, theory of portfolio and direct investment flows, and extensions of modern capital market theory to international context. Applications include foreign exchange transactions, exposure and working capital management, tax management, international portfolio investment, capital budgeting, financial structure decisions. (Primarily for students concentrating in finance. Credit not given for both 15.419 and 15.436.)
D. R. Lessard

15.441 Research Seminar in Finance (A)

Prereq.: 15.415
Year: G (1)
3-0-6

Presentation and analysis of original research in finance. (For Sloan School doctoral candidates in finance. Others admitted only by permission of instructor.)
F. Modigliani

15.501 Financial and Cost Accounting

Prereq.: —
Year: U (1, 2)
3-0-6

Introduction to basic concepts and techniques of collecting, processing and reporting financial information generated by a business. Emphasis on basic financial and cost accounting concepts, and methods of financial analysis. Examination of the financial goal structures and decision-making processes which give rise to information needs. The orientation is towards providing information to parties external to a business.
R. T. S. Ramakrishnan

15.511 Financial and Management Accounting Systems

Prereq.: —
Year: G (S)
3-0-6

Study of the basic concepts of financial accounting and the accounting principles underlying financial statements. Viewpoint is that of the users of accounting information (especially managers) rather than the preparer (the accountant). Emphasis on use of accounting information in decision making, performance evaluation, and control in organizations. (Restricted to Sloan Fellows.)
J. M. McInnes

15.515 Financial and Cost Accounting

Prereq.: —
Year: G (1, S)
3-0-6

Introduction to basic concepts and techniques of collecting, processing and reporting financial information generated by a business. Examination of the financial goal structures and decision-making processes which give rise to information needs. Introduction to the methods of financial analyses, with goal of enabling students to understand, and use, corporate financial statements. The orientation is towards providing information to parties external to a business. (Restricted to Sloan School of Management graduate students. Others admitted only by permission of instructor.)
J. S. Hekimian, H. D. Sherman, P. Brownell

15.516 Financial and Management Accounting (A except XV)

Prereq.: Permission of Instructor
Year: G (1, 2)
3-0-6

A one-semester, self-contained introduction to the basic concepts and techniques of financial and managerial accounting for students desiring a single subject in the field. Viewpoint is that of a user of accounting information rather than the preparer. Enables students to understand the use of financial data from two perspectives: first, the perspective of parties external to a firm, and second the perspective of the decision-making and control requirements of a firm's managerial organization.
H. D. Sherman, T. S. Ramakrishnan

15.521 Management Accounting and Control (A)

Prereq.: 15.501 or 15.511 or 15.515 or 15.516
Year: G (1, 2)
3-0-6

Examination of management accounting and related analytical methodologies for decision making and control in profit-directed organizations. Budgetary control systems for planning, coordinating and monitoring the performance of a business and its functional components; methods for controlling capital expenditures and working capital funds. Principles of measurement. Development of a framework for assessing behavioral dimensions of control system design; impact of different managerial styles on motivation and performance in an organization.
P. Brownell, J. S. Hekimian

15.522 Planning and Control in Nonprofit Organizations (A)

Prereq.: 15.501 or 15.511 or 15.515
Year: G (2)
3-0-6

Principles of planning and control systems used in managing organizations not having a profit orientation. Emphasis on medical, educational, and cultural organizations and on tying together strategic planning and management control systems. Issues discussed: environmental analysis, program budgeting, consideration of organizational size, budgeting procedures, output measurement, the influence of professionals in these organizations, and public responsibility. Focus on the evaluation of existing planning and control systems and the design of new systems. (Content of 15.521 relevant but not required.)
H. D. Sherman

15.525 Theory and Problems of Financial Accounting (A)

Prereq.: 15.501 or 15.511 or 15.515 or 15.516
Year: G (1)
3-0-6

In-depth examination of theories of accounting, fundamental issues and emerging shifts in the financial accounting area. Advanced analysis and interpretation of financial statements and pronouncements of various agencies concerned with financial accounting (FASB, SEC, etc.).
M. F. van Breda

15.532 Planning and Control Systems (A)

Prereq.: 15.521
Year: G (1, 2)
3-0-6

Development of a framework for analyzing an organization and its environment to provide basis for designing information systems and procedures to support the management of strategic development and operating performance of an organization. Goal formation and direction setting, long-range planning, budgeting and monitoring systems. Design of responsibility accounting systems in relation to strategy; problems of multi-dimensional measurement. Coordination of responsibility centers, and transfer pricing mechanisms. Management of uncertainty and risk in resource allocation process. Design of reward systems to reinforce goal-directed behavior in an organization.
J. M. McInnes

15.535 Planning and Control Systems (A) (New)

Prereq.: 15.511
Year: G (1)
3-0-6

Design of information systems and procedures to facilitate the management of an organization in relation to its environment. Systems to support goal formation, direction setting and the strategic development of an organization. Profit planning, budgeting, monitoring and performance analysis systems. Design of responsibility accounting systems in relation to strategy; corrdination of responsibility centers and issues off transfer pricing. Management of the resource allocation process under conditions of uncertainty and risk. Design of measurement and reward systems to sustain goal-directed behavior in an organization. Consideration of political factors and managerial style as they impact the implementation of planning and control systems. (Restricted to Sloan Fellows.)
A. C. Hax

15.541 Computer-Based-Models for Planning and Control (A)

Prereq.: 15.532
Year: G (2)
3-0-6

Investigation of fundamental concepts and methods for analysis and design of planning and control systems from a formal point of view. Formulation and implementation of computer-based models, use of on-line interactive systems as part of the planning and control process, discussion of modeling packages, and managing the implementation, subsequent modification, and updating of systems.
J. M. McInnes

15.545 Advanced Topics in Planning and Control (A)

Prereq.: 15.532
Year: G (2)
3-0-6

Focus on evolving a unified theory of planning and control by analysis and synthesis of concepts from diverse disciplines. Discussion of a selection of research studies. Emphasis on theoretical foundations underlying the conceptual constructs and paradigms, and on methodological issues in conducting research in the area.
M. F. van Breda

15.549 Workshop in Accounting and Control (New)

Prereq.: Permission of Instructor
Year: G (1, 2)
Arr.

Presentations by faculty, Doctoral students and guest speakers of ongoing research concerned with current issues in financial and managerial accounting, and in planning and control systems in organizations. Topics: reports of research projects, proposed or in progress, and discussions of recent literature in the area. Selection of specific topics is geared to interests of participants. (Primarily for Doctoral students.)
J. M. McInnes, M. F. van Breda, P. Brownell

Management Information Systems

15.561 Introduction to Computers, Programming, and Information Systems

Prereq.: —
Year: G (1, 2)
0-6-0

Introductory concepts in computer hardware, software, and management information systems. Emphasis on programming using high-level languages, specifically PL/1. Familiarization with computer resources available at MIT which may be useful in subsequent subjects, research, or thesis work. (Restricted to Sloan graduate students.)
J. A. Ghani, J. A. Meldman

15.562 Principles of Management Information Systems (A)

Prereq.: 1.00 or 6.030 or 15.561
Year: G (1, 2)
3-0-6

Introductory examination of issues related to the effective use of computer-based information systems in organizations. Topics: frameworks for analyzing need for information systems in an organization; methods for designing and implementing systems for effective use; management of the information system life cycle and computer professionals; overview of computer technology and economics; and business practices in the computing industry (vendors' product and pricing strategies, marketing, distribution and service arrangements, competition). (Credit not given for both 15.562 and 15.568. Limited enrollment)
M. L. Markus, J. A. Meldman

15.564 Management Information Technology I (A)

Prereq.: 2.10 or 6.030 or 15.561
Year: G (1, 2)
3-0-6

Introduction to the basic principles of computer systems and computer systems programming. Emphasis on program planning and organization. Topics: machine language, assemblers, compilers, and operating systems. Algorithms presented for translation from programming languages to machine languages, table processing, searching, sorting, and storage management. Students required to prepare and test several programs written in System/360 Assembly Language and PL/I.
J. J. Donovan, S. E. Madnick

15.565 Management Information Technology II (A)

Prereq.: 15.564
Year: G (1, 2)
3-0-6

Subject provides technical background in and a framework for integrating the concepts essential to analysis and development of computer-based information systems: data management software techniques, telecommunications, and performance evaluation. Development of student's understanding of computer technology to enable its use in new and creative ways in an organization. Examples of the implementation and use of actual management information systems discussed.
J. J. Donovan, S. E. Madnick

15.568 Management Information Systems (A)

Prereq.: 15.564, *15.565*
Year: G (1, 2)
3-0-6

Concepts, frameworks, tools, techniques and processes which assist management in its interaction with and direction of computer-based information systems today. Emphasis on understanding major transaction processing systems of the firm as well as those systems used primarily for managerial information. Topics: survey of existing frameworks for planning for such applications; design and computer system implementation of data processing applications; organization and human behavior realities in implementation and use of such systems; methods for controlling the implementation and evaluating the result. Lectures, case studies, and a group project. (Credit not given for both 15.562 and 15.568.)
J. F. Rockart, P. G. W. Keen

15.569 Decision Support Systems (A)

Prereq.: 15.562 or 15.568
Year: G (2)
3-0-6

Focus on issues and techniques involved in development of computer-based systems designed to support manager's decision-making and problem-solving processes. Topics: assessment of the technology available; development of frameworks and techniques with which to analyze and organize key decisions and a manager's decision-making process; and discussion of the design and implementation of such systems in on-going organizations. Lectures, cases, projects, and analysis of existing decision support systems.
P. G. W. Keen

15.571 Advanced Computer Systems (A)

Prereq.: 15.564
Year: G (1, 2)
3-0-6

Advanced study of real-time systems and operating systems based on the framework of resource management. Emphasis on separating issues of mechanisms from policies. Key computer resources studied: memory, processors, I/O devices, and information. Topics: I/O programming, asynchronous processing, multiprogramming, virtual memory, file systems, and protection. Case studies drawn from advanced operating systems, such as Multics, CTSS, OS/360 and VM/370. Students required to design, implement, and test actual operating system components using the MIT computer system.
Staff

15.572 Systems Simulation (A)

Prereq.: 15.061, 15.561
Year: G (2)
3-0-6

Introduction to discrete simulation and model building methodology using high-speed digital computers. Focus on event-oriented as opposed to continuous systems. Emphasis on simulation language and model building. Consideration of the issues of proper experimental design, statistical analysis of results, effects of random number generation techniques and validation. Some discussion of typical applications.
Staff

15.581 Information Systems and Law (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Examination of interlocking technological and legal issues that arise in the operation of computer-based information systems in society. Emphasis, in class discussions and in term projects, on interdisciplinary definition, analysis, and solution of specific problems. Continuing effort toward improving and integrating technical, social, and legal concepts of information. Topics: security and privacy in databanks, computer infringement of copyright, protection of proprietary rights in software, jurimetrics.
J. A. Meldman

Law

15.599 Workshop in Management Information Systems (New)

Prereq.: Permission of Instructor
Year: G (1, 2)
Arr.

Presentations by faculty, Doctoral students and guest speakers of ongoing research concerned with current issues in management information systems as well as discussions of key research papers in the field. Specific topics determined by the interest of participants and by new and important directions in information systems. Background readings and active participation by students expected. (Primarily for Doctoral students.)
S. E. Madnick

15.612 Structure of American Law

Prereq.: —
Year: G (2)
3-0-6

Examination of how law is made and evolves in the US. Case material utilized to analyze the roles of Congress, administrative agencies, and courts in law-making process. Major attention given to powers and limitations of administrative agencies, such as NLRB, FTC, and EPA; the procedural requirements that govern their rule-making and decision-making processes; and the role of the courts in reviewing administrative action. Students encouraged to argue opposing positions on current controversial issues such as reverse discrimination, pollution control, and state action restricting interstate commerce in the light of Supreme Court precedents. Review of the current scope of antitrust law as set forth in decisions of Federal Trade Commission and Supreme Court.
G. F. Bloom

15.616 The American Legal System (A)

Prereq.: 14.01 or 15.012
Year: G (1)
3-0-6

Analysis of American legal system as a process for ordering our society. Consideration of selected legal problems to reveal the operation of the major component elements of the system: judicial, legislative, administrative, and private law-making power. Consideration of substantive law primarily from standpoint of the process for generating and modifying legal policy. Extensive reading of case law as well as textual materials and legal essays. Research projects involving use of a law library.
J. A. Meldman

15.625 Labor Law (A)

Prereq.: 15.616
Year: G (1)
3-0-6

Legal structure of labor-management relations. Review of evolution of labor relations law in the 20th century and intensive study of the current Federal labor legislation. Among subject areas examined from the legal standpoint are organization of labor, negotiation and administration of the collective agreement, status of economic weapons (strikes, boycotts, lockouts, etc.), relations between the individual and unions, and role of federalism in the law of labor relations. Extensive use of case materials, including tape recorded cases.
Staff

15.631 Corporate Law for the Modern Manager (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-6

Examination of legal and ethical obligations that arise between the individual (employee, manager, officer, director), the corporation, and the world. Among other topics, seminar covers the formation and legal organization of various types of businesses, with particular emphasis on corporations; obligations of corporation to outside world based on the activities of its employees, managers and owners; obligations of individuals serving in those capacities to corporation and outside world; corporate securities; and regulation of corporate ownership and control by state and Federal government.
J. F. Vittek, Jr.

15.632 Seminar on Regulatory Law and Its Impact Upon Business (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Study of problems of government intervention in business developed through examination of legal framework and underlying philosophy of administrative law. Topics: processes by which regulation comes about and is carried out, with emphasis on contrasts between theoretical model and actual experience; evaluation of changes under way in the regulatory process; society wide versus industry regulation; control of increased costs; legal management of complex scientific, technological, and medical issues. Study of substantive administrative law areas includes those under EPA, NLRB, FTC, and OSHA. Guest speakers from business and government present conflicting viewpoints concerning regulation. Subject satisfies environment requirement for Sloan Master's program.
J. D. Nyhart, G. F. Bloom

Industrial Relations

15.635 International Law and Regulatory Order (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Issues of jurisdiction, sources, and nature of international law, with special attention to international economic law, extension of US domestic regulatory policies beyond US territory, and the problems of obtaining consistency among nations' regulation of transborder business. Basic foundation in international law applying to private sector manager. Examination of theoretical and empirical emergence of international regulation of transportation, communications, trade, ocean use, finance, food and health standards, and multinational corporations.
J. D. Nyhart

15.662 Collective Bargaining and Public Policy (A)

Prereq.: 15.612
Year: G (1)
3-0-6

An analysis of industrial relations systems, with particular emphasis on the US Labor movement, the process of collective bargaining, and current issues. Public policies affecting labor-management also considered. A collective bargaining game used, and visiting speakers also scheduled. (Restricted to Sloan Fellows.)
R. B. McKersie

15.663 Labor-Management Relations

Prereq.: —
Year: G (1, 2)
3-0-6

Structure and functioning of management and unions in handling of industrial relations; union policies; problems likely to arise. Reconciliation of union and management policies. Public policy in labor-management relations. A collective bargaining game used. (Restricted to Sloan School of Management graduate students; others admitted only by permission of instructor.)
T. A. Barocci, J. W. Driscoll, P. A. Wallace

15.664 Management of Human Resources (A)

Prereq.: 15.663
Year: G (2)
2-0-7

Seminar with emphasis on managerial responsibilities and policies in the effective utilization of people in organizations. Topics: managers and their personnel concepts, management organization for personnel administration, organization planning and management development, manpower planning and personnel budgets, recruitment and selection, promotion and transfer, training, performance appraisal, discipline, managing change, and wage and salary administration. Field research on selected problems.
J. W. Driscoll

15.671J Labor Economics (A)

(Same subject as 14.671J)
Prereq.: 14.64 or 15.663
Year: G (1)
3-0-6

Primary emphasis on structure of labor markets and determinants of wage levels, unemployment, distribution of income and employment opportunity. Special attention given to the impact of unions on both wage and non-wage elements of collective bargaining in light of the characteristics and objectives of particular unions. Other special topics growing out of recent research in labor economics.
Staff, M. J. Piore

15.672J Public Policy on Employment and Industrial Relations (A)

(Same subject as 14.672J)
Prereq.: 14.64 or 15.663
Year: G (2)
3-0-6

Major trends in legislation and other government activities affecting the work place. Topics: wage and price controls, equal employment opportunity, and government regulation of union organization, collective bargaining, industrial disputes, wages and hours of work, and workplace health and safety. The broad economic and social questions raised by these trends also explored.
H. C. Katz, H. S. Farber

15.674J Comparative Systems of Industrial Relations and Human Resource Development (A)

(Same subject as 14.674J)
Prereq.: 14.64 or 15.663
Year: G (1)
3-0-6

International and comparative analysis of industrial relations systems and systems of human resource development. Concentration on an examination of selected issues involving the nature and functions of labor and management organization in different contexts; role of the state in establishing procedures and in shaping the substance of industrial relations; manpower and economic growth in the context of comparative systems of human resource development; worker participation in management, and other topics.
M. J. Piore

Operations Management

15.675 Equal Employment Opportunity and Management of Human Resources (A)

Prereq.: 14.64 or 15.663
Year: G (1, 2)
3-0-6

Issues and policy consequences of governmental action related to management and development of human resources, especially equal employment opportunities for minorities and women; labor market participation of women. Examination of extensive and recent literature, including court decisions.
P. A. Wallace

15.691J Research Seminar in Industrial Relations (A)

(Same subject as 14.691J)
Prereq.: 15.671J or 15.672J
Year: G (1)
3-0-6

15.692J Research Seminar in Industrial Relations (A)

(Same subject as 14.692J)
Prereq.: 15.691J
Year: G (2)
3-0-6

Discussion of important areas for research in industrial relations, frameworks for research, research techniques, and methodological problems. Centered mainly on staff research and the thesis research of advanced graduate students and invited guests.
Staff

15.761 Operations Management (A)

Prereq.: 15.053 or 15.062, 15.061 or 6.041
Year: G (1, 2)
3-0-6

Study of practical problems involved in designing and implementing model-based systems to assist managers in planning, controlling, and improving efficiency of production operations. Topics: demand forecasting methods, facility design decisions, capacity planning decisions, inventory control, production scheduling, and network-based management systems (PERT/CPM and extensions). Emphasis on integrated approach to management decision making. Applications from public and private sectors illustrating and extending material introduced. (Open to qualified undergraduates.)
A. C. Hax, H. C. Meal, S. C. Graves

15.763 The Practice of Operations Management (A)

Prereq.: 15.761
Year: G (1)
3-0-6

An applied subject designed to provide students with an opportunity to learn how to diagnose complex problems, structure relevant solutions to those problems, and deal with issues of implementing those solutions. Use of case analyses and projects to extend the student's understanding of, and ability to deal with, operating management situations. Projects undertaken in local manufacturing and service organizations. Emphasis on integrative approach using methodologies drawn from operations research, management information systems, and organizational design.
S. C. Graves, H. C. Meal

15.764 The Theory of Operations Management (A)

Prereq.: 15.761
Year: G (2)
3-0-6

Focus on theoretical work for studying operations planning and control problems. Topics: inventory theory, sequencing theory, aggregate production planning, production scheduling, large-scale system methodology, decomposition theory, and aggregation methods. Research on heuristic methods.
S. C. Graves

15.765 The Operating Manager (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Development of the operating skills of a manager through case analyses and discussions. Cases drawn primarily from manufacturing situations and designed to improve the manager's ability to analyze an operating situation, define the operating task, and accomplish that task. Primary emphasis is on accomplishment — policy implementation, changes in operations, etc.
H. C. Meal

15.766 Innovation and Industrial Development (A)

Prereq.: 15.761
Year: G (1)
3-0-6

Recognition of regularities in the pattern of product and process change, types of change required, and likely sources of change in different industry and national settings (e.g., continuous processes, consumer durables, mass-produced consumer goods, assembled industry products, in US, Japan, and Brazil). Familiarity with evolution of design criteria and product planning requirements as technical market uncertainties change. Practice with basic management and design process change. Discussion of current research findings and case materials. Designed to help those who must manage and implement a change in either an existing or a new business. (Open to qualified undergraduates.)
J. M. Utterback

15.767 Industrial Project Evaluation (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Subject organized to familiarize student with methodologies and applications related to Project Evaluation. Several actual industrial and governmental projects analyzed. Methodologies related to capital budgeting, cost-benefit analysis, financial management, strategic planning, and operations management covered.
G. R. Bitran, A. C. Hax

Marketing

15.768 Operations Management in the Service Industry (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-6

Analysis of managerial problems in the service industry. Illustration of the use of systems analysis techniques in the design, production, and delivery of services. Cases used to illustrate applications.
G. R. Bitran

15.795 Seminar in Operations Management (A)

Prereq.: 15.761 or 15.915
Year: G (2)
3-0-6

Examination of studies from current literature devoted to formal methods for analyzing operations management problems. Discussion of case studies as time permits.
Staff

15.799 Workshop in Operations Management (New)

Prereq.: Permission of Instructor
Year: G (1, 2)
Arr.

Presentations by faculty, Doctoral students and guest speakers of ongoing research concerned with current issues in operations management. Topics; reports of research projects, proposed or in progress, and informal discussions of recent literature dealing with subjects of special interest to participants. (Primarily for Doctoral students.)
S. C. Graves

15.811 Marketing (A)

Prereq.: 15.071, 15.511
Year: G (1)
3-0-6

Analysis of elements of marketing strategy which can be utilized by business, governmental, and social organizations to meet needs of their clientele. Examination of major constraints imposed by governmental and judicial action on marketing decisions. Review of contributions of management science in providing new techniques for solution of marketing problems. Utilization of case method to sharpen analytical tools for dealing with various problems faced by typical marketing manager. (Restricted to Sloan Fellows.)
Staff

15.812 Marketing Management (A)

Prereq.: 15.061 or 6.041 or 14.30 or 18.05
Year: G (1, 2)
3-0-6

Develops problem-identification and problem-solving skills in formulating and appraising marketing strategies and policies for consumer and industrial goods and services. Topics: marketing strategy and corporate planning, buyer behavior and market analysis, product strategy and development, advertising and promotion, personal selling, pricing, distribution, and regulation. Concepts useful for structuring marketing problems presented as are empirical findings bearing on relevant behavioral phenomena and examples of the use of marketing research methods and planning models. Lectures including outside speakers and case discussions.
Staff

15.813 Marketing Issues in Public Systems (A)

Prereq.: 15.061 or 6.041 or 14.30 or 18.05
Year: G (1)
3-0-6

Intended as an alternative to 15.812 for students interested in public systems management. Marketing-like problems of politicians, government agencies, hospitals, universities, and other institutions serving the public. Exploration of the application of management science and behavioral science to the relationship between public organizations and their clienteles. Specifically, consideration of the design, communication, and distribution of services so as best to serve the public. Emphasis on normative applications of information systems and models. Typical areas: family planning, political campaigns, citizen feedback systems, and medical systems.
G. L. Urban, R. P. Bagozzi

15.824 Marketing Communications (A)

Prereq.: 15.812
Year: G (2)
3-0-6

Focus on management problems that arise when attempting to communicate with and influence a market or other public in an organization's environment through advertising and related mass media and promotion campaigns. Topics: marketing strategy and communication program planning, expenditure policy, communication processes and response measurement, copy development and testing, media planning, advertising agencies, regulation, and public policy issues. Exposure to current management practices and the available behavioral and model-based decision-support technology in this field. Lectures, case discussions, projects.
A. J. Silk

15.825 Marketing Models (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Basic modeling approaches. Models for specific decision areas: price, promotion, advertising, distribution, and sales force. Integrative models; the marketing mix, new products. Special issues of industrial marketing.
J. D. C. Little, J. R. Hauser

15.826 Industrial Marketing (A)

Prereq.: 15.812
Year: G (2)
3-0-6

Focus on marketing goods and services to organizations for resale to other industrial customers or for use in the goods and services they. in turn, produce. Literature on organizational buying behavior provides the foundation of the subject. Topics: industrial marketing analysis, product planning, distribution and channel decisions, promotion and advertising, sales force decisions. Emphasis on using models and research results to solve industrial marketing problems. Lectures, case discussions, research project.
Staff

System Dynamics

15.828 Marketing New Products (A)

Prereq.: 15.812
Year: G (2)
3-0-6

Identification, structuring, and analysis of marketing issues associated with new product development and introduction. Study of the four stages of new product development: 1) search for new product ideas, 2) screening of alternative product concepts, 3) analyzing new ideas and 4) introduction of new products. In each stage, the decision is structured, the existing state of knowledge presented, and marketing concepts developed. Term project required. Projects deal with marketing in new product situations; projects may be related to the MIT Innovation Center and outside firms.
J. R. Hauser, G. L. Urban

15.832 Measurement for Management (A)

Prereq.: 15.061
Year: G (1)
3-0-6

Focus on methods for collecting and analyzing behavioral data applicable to a variety of measurement problems in management. Research and sampling design. Development of questionnaires, scaling and psychometric methods for measuring perceptions, attitudes, and preferences. Statistical techniques for analyzing these types of data.
A. J. Silk

15.834 Marketing Strategy (A) (New)

Prereq.: 15.812 or 15.813
Year: G (1, 2)
3-0-6

Examination of marketing aspects of strategy formulation. Study of market phenomena that are foundations of strategy. Analysis of management science models for brand, product line, strategic business unit, and corporate marketing strategy. Topics: approaches to marketing strategy; life cycle; experience curve and dominance; market selection and product differentiation; market definition and segmentation; product strategy; product line policy; growth and development strategy; strategic business unit analysis; corporate marketing strategy; PIMS model; organization; strategic planning and control. Lectures, cases, guest speakers. Term project required.
G. L. Urban

15.838 Research Seminar in Marketing (A)

Prereq.: 15.812
Year: G (1, 2)
3-0-6

Seminar on current marketing literature and current research interests of faculty and students. Topics such as the theory of consumer behavior, simulation of consumer product markets, marketing experimentation, and the development of behavioral models from consumer panel data.
Staff

15.839 Workshop in Marketing (New)

Prereq.: Permission of Instructor
Year: G (1, 2)
Arr.

Presentations by faculty, Doctoral students and guest speakers of ongoing research concerned with current issues in marketing. Topics: reports of research projects, proposed or in progress, and informal discussions of recent literature dealing with subjects of special interest to participants. (Primarily for Doctoral students.)
A. J. Silk

15.852 Principles of Dynamic Systems I

Prereq.: —
Year: U (1, 2) SD
3-0-9

Introduction to principles for modeling dynamic social and industrial systems. Emphasis on building intuitive understanding of feedback structures underlying growth, stagnation, and cyclical fluctuation. Focus on system dynamics as one approach to understanding behavioral characteristics of complex systems. Student exercises treat feedback system behavior, reasons for shifting modes of behavior, and model formulation. Modeling assignments illustrate applicability of basic concepts to biological, economic, ecological, industrial, and urban systems.
P. M. Senge

15.872 Principles of Dynamic Systems I (A)

Prereq.: Permission of Instructor
Year: G (1, 2)
3-0-9

Introduction to principles for modeling dynamic social and industrial systems. Emphasis on building intuitive understanding of feedback structures underlying growth, stagnation, and cyclical fluctuation. Focus on system dynamics as one approach to understanding behavioral characteristics of complex systems. Student exercises treat feedback system behavior, reasons for shifting modes of behavior, and model formulation. Modeling assignments illustrate applicability of basic concepts to biological, economic, ecological, industrial, and urban systems.
P. M. Senge

15.873 Principles of Dynamic Systems II (A)

Prereq.: 15.872
Year: G (2)
3-0-9

Continuation of the philosophy and methods of 15.872 with purpose of expanding student's ability to analyze behavior arising from complex dynamic feedback systems. Topics: translating qualitative observations on real systems into quantitative models; methods for relating system structure to system behavior; common errors in model construction and policy design.
N. J. Mass, P. M. Senge

General Policy and Special

15.874 Industrial Dynamics (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Introduction to modeling of corporate and industrial systems. Examination of the separate functional areas of production planning, labor management, capital investment, marketing, finance and accounting. Functional area models pieced together to analyze the cause of such corporate problems as production and employment instability, loss of market share, unstable market growth, and declining profitability. Development of skills in portraying complex managerial systems, and deriving understanding through quantitative modeling and computer simulation.
J. D. W. Morecroft

15.875 Applications and Implementation of Industrial Dynamics (A)

Prereq.: 15.872 or 15.874
Year: G (2)
3-0-6

Project-based subject applying methods of Industrial Dynamics to real corporate problems. Class divided into groups that act as consultants to local corporations. Meetings with corporate managers and staff to obtain information for model construction; instructor provides advice and guidance on model formulation and testing. Final report on work done and recommendations.
J. D. W. Morecroft

15.876 Dynamics of Health Service Systems (A)

Prereq.: 15.852 or 15.872 or 15.874
Year: G (2)
3-0-6

Application of system dynamics to the management, organization, and policy problems of health care delivery. Review in depth of models developed during past 10 years in areas of community mental health, heroin addiction, ambulatory care, comprehensive health planning, and other areas. Major collaborative class projects to apply System Dynamics to new problem areas in health field.
E. B. Roberts

15.878 Economic Dynamics (A)

Prereq.: 15.872
Year: G (2)
3-0-6

Introduction to system dynamics modeling of economic systems. Combines lectures, exercises, and a term project on subject of student's choice. Topics: economic cycles; inflation and unemployment; capital investment and monetary policy.
N. J. Mass

15.879 Seminar in System Dynamics Policy Analysis (A)

Prereq.: 15.872
Year: G (1)
3-0-6

Research seminar focusing on development of student projects to illuminate important aspects of policy analysis. Each exercise designed to give students direct experience with some problem in policy analysis and the issues involved in resolving or handling that problem. Topics vary from year to year. Typical examples from past years: projects dealing with problems in designing policies based on forecast, problems with use of leading and lagging indicators on policy inputs, value of information and importance of analyzing feedback effects of corporate policies on behavior.
N. J. Mass

15.880 System Dynamics (A)

Prereq.: 15.071
Year: G (1)
3-0-3

Introduction to system dynamics modeling of managerial policy issues in public and private organizations. Emphasis on building intuitive understanding of feedback structures underlying growth, stagnation, and cyclical fluctuation. Development of skills in causal-loop diagramming of complex situations, and in the techniques needed for quantitative modeling and computer simulation. Study of previous system dynamics applications in business and human delivery organizations, with focus on factors affecting implementation of changes in policy and structure. (Restricted to Sloan Fellows.)
E. B. Roberts

15.915 Information and Decision Systems

Prereq.: 15.515
Year: G (S)
4-0-8

Introduction to functional fields of finance, marketing, and operations. Exposure to a number of major problems in these fields with special emphasis on the interdependence of the functions. Not an exhaustive treatment but enough depth in each field to serve as a basis for further study, with overview and integration to provide context for further study. Development of skills in defining problems, creating alternatives, assessing consequences of alternatives, and developing criteria for choice of alternatives.
Staff

15.921 Business and Social Pressures (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-6

Case studies of interrelationships of corporate, individual, and social values in decision situations, including the various conflicting loyalties, tradeoffs, and ambiguities involved. Corporate policy and decision making under conditions of social pressure; examination of the dilemmas of corporate ethics; external pressures for changes in corporate governance and evolving responses; role of the individual in influencing organizational decisions. (Enrollment limited; admission only by permission of instructor.)
L. L. Banks

15.922 Business and the Media (A)

Prereq.: Permission of Instructor
Year: G (2)
2-0-4

Study of interrelationships of business and the media, to provide managers with a realistic understanding of journalistic reporting and interpretation as it affects corporate practice. Subject is divided into sessions dealing with editorial viewpoints as reflected in the media, discussions with appropriate editors and correspondents, and corporate responses obtained from published reports and meetings with corporate public affairs officers from major firms. (Restricted to Sloan Fellows and second-year graduate students.)
L. L. Banks

15.931 Corporate Strategy, Policy and Planning (A)

Prereq.: 15.012, 15.062, 15.311
Year: G (1, 2)
3-0-6

Subject dealing with approaches to general management problems affecting all facets of the enterprise. Discussions and readings tracing strategy practice, methodology, and theory, including a field study. Attempt to develop the integrative ability to use knowledge gained in core subjects. Preparation for launching careers in management with a balanced understanding of the organization as an entity.
E. H. Bowman, M. Horwitch, Z. S Zannetos, G. B. M. Walker, Jr.

15.932 Policy and Strategy for Technology-based Entrepreneurship (A)

Prereq.: 15.931
Year: G (2)
3-0-6

Study of innovation process. Characteristics of entrepreneurship and its role in generation of new products and services. Contributions of the large vs. the small firm to productivity and to local and regional economic development. Role of the university in innovation process. Methods for effecting a linkage between the knowledge and developments within educational institutions and the small technology-based firm. Evaluation of alternative government policies affecting innovation, entrepreneurship, and the linkage between educational institutions and the technology-based small firm. (Permission of instructor required.)
Z. S. Zannetos

15.933 Financial Strategy (A)

Prereq.: 15.412, 15.931
Year: G (1)
3-0-6

Applications of concepts and material of 15.931 to the area of corporate finance. Analysis of impact of finance theory and various legal and institutional constraints on financial strategy. Topics: capital budgeting, long-range planning, financial reporting and auditing, mergers and acquisitions, taxation (both domestic and international), SEC regulations, capital structure, organization structure, capital markets, and financing methods.
Z. S. Zannetos

15.934 Research Seminar in Corporate Strategy (A)

Prereq.: 15.931
Year: G (1, 2)
3-0-6

Seminar built around published theoretical and empirical research in corporate strategy. Students share leadership of seminar using journal articles focusing on the study of particular strategic issues or problems. Articles drawing on theory and/or methodology may come from current literature in economics, the behavioral sciences, or management science. Articles and topics change each term.
E. H. Bowman, Z. S. Zannetos

15.935 Seminar on Corporate Strategy and Structure (A)

Prereq.: 15.931
Year: G (2)
3-0-6

Use of framework and methodology of 15.931 to analyze the strategic decisions facing industries (such as oil, electronics, data processing) and the firms within such industries. Combination of lectures and student research presentations on such issues as determinants and consequences of industry structure, firm characteristics, pricing strategies, innovation organization structures, and diversification.
Z. S. Zannetos, E. H. Bowman

15.937J Economics of Ocean Transportation (A)

(Same subject as 13.661J)
Prereq.: 14.120 or 15.012 or CTS 110J
Year: G (2)
3-0-6

Study of the economics of the principal ocean transportation markets and of resource allocation to ocean transportation. Structure of markets and of industries involved; barriers to entry and competition; theory of international trade; spot and term freight rate formation in the tanker, dry bulk and tramp shipping markets; analysis of risks facing the industry, charter market operators, and charterers; world petroleum transportation network; relationship between oil prices and tanker rates; liner shipping rate making; impact of maritime policies and regulations on private and national income. Economic implications of alternative strategic decisions and policies of those who operate in the ocean transportation markets.
Z. S. Zannetos, H. N. Psaraftis

15.939 Advanced Topics in Policy and Strategy (A)

Prereq.: 15.931
Year: G (1, 2)
Arr.

Directed research and study of advanced topics in corporate policy and strategy as well as public policy relating to the private sector. (Primarily for doctoral students in Management; others admitted by permission of instructor.)
E. H. Bowman, M. Horwitch, Z. S. Zannetos

15.951 Special Studies in Management

Prereq.: —
Year: U (1, 2)
Arr.

Special tutorial arrangement with a faculty member for guided reading, research, laboratory, or teaching experience.
J. A. Meldman

15.961 Special Studies in Management (A)

Prereq.: —
Year: G (1, 2)
Arr.

For graduate students who desire to do advanced work or to carry out some special investigation of a management problem not specifically covered elsewhere and not qualifying as a thesis. Readings, conferences, laboratory and fieldwork, and reports.
Staff

15.962-15.969 Special Seminars in Management (A)

Prereq.: —
Year: G (1, 2)
Arr.

Opportunity for group study by graduate students on current topics related to management not otherwise included in curriculum.
Staff

15.976 Seminar in Administration

Prereq.: —
Year: G (1)
2-0-1

Study of managerial decision making and styles through unstructured seminars with successful managers, including Senior Executives, Sloan Fellows, and alumni. (Restricted to students in the Sloan School Accelerated Master's Program.)
P. W. Turner

15.977 Seminar in Management

Prereq.: —
Year: G (1, 2)
2-0-1

Investigation of effective management through informal meetings with executives representing a range of industries and functions in both public and private sectors. Examination of managerial philosophies, practical problems of management, personal career paths, enabling students to develop skill in asking questions.
P. B. Cronin

15.978 Seminar in Administration (A)

Prereq.: 15.511
Year: G (1)
3-0-6

15.979 Seminar in Administration (A)

Prereq.: 15.511
Year: G (2)
3-0-6

Study of fundamental economic, financial, organizational, and administrative relationships analyzed and discussed by experienced leaders in business, labor, and public administration. Examination of managerial philosophies and practices in the field and in seminar discussions. (Restricted to Sloan Fellows.)
A. F. White

16 Aeronautics and Astronautics

16.UR Undergraduate Research

Prereq.: —
Year: U (1, 2)
Arr.

Undergraduate research opportunities in Aeronautics and Astronautics. For further information contact Departmental Coordinator:
E. E. Larrabee.
Staff

16.001 Unified Engineering I

Prereq.: 8.01, *18.03*
Year: U (1) SD
4-3-5

Simultaneous registration with 16.002 required, except by permission of instructor
J. Dugundji, W. M. Hollister, M. Martinez-Sanchez, L. Trilling, H. Y. Wachman

16.002 Unified Engineering II

Prereq.: 8.01, *18.03*
Year: U (1)
4-3-5

Principles and methods of engineering presented in a format of lecture, recitation, and design. Basic disciplines presented with the unifying themes: forces and their interaction with solids and fluids; energy and energy transfer; systems control and information handling. Topics: mechanics of solids and fluids, forces, stresses, geometry of motion, conservation of mass and momentum, properties of solids and fluids; principles of measurement and control; temperature, thermodynamic properties and states. First Law of thermodynamics; conservation of energy. Applications include: particle dynamics, stress and strain in simple structures; low speed flow; lift, drag, and thrust; loads and design criteria in aerospace systems. Laboratory exposure to empirical methods in engineering; illustration of principles and practice. Design of a typical aircraft or spacecraft element. Provides a sound basis for a wide variety of careers in engineering.
J. Dugundji, W. M. Hollister, M. Martinez-Sanchez, L. Trilling, H. Y. Wachman

16.003 Unified Engineering III

Prereq.: 16.001, 16.002
Year: U (2)
4-3-5

Simultaneous registration with 16.004 required, except by permission of instructor.
J. Dugundji, W. M. Hollister, A. R. Odoni, M. Martinez-Sanchez, L. Trilling, H. Y. Wachman, H. P. Whitaker

16.004 Unified Engineering IV

Prereq.: 16.001, 16.002
Year: U (2)
4-3-5

Concepts, principles, and methods of engineering, presented in a format of lecture, recitation, laboratory, and design, with special emphasis on unified presentation of disciplines as in 16.001-2, structured by application to high-technology devices and aerospace systems. Topics: dynamics of rigid and deformable bodies; center of mass, rigid body motion, inertia tensor; Second Law of thermodynamics, entropy, irreversibility; high-speed flow, shock waves, stresses in fluids, heat transfer; interaction between component devices, signal flow, feedback and stability in control. Applications include: strain energy and principles in structural analysis, failure modes in structures, fracture, fatigue, plasticity; beams, plates, shafts; airfoil theory, flow over bodies, channel flow, boundary layers; thermal cycles, chemical-to-thermal conversion, aircraft and rocket engines. Techniques presented for analysis and optimization of systems. Experiments in: mechanics, strength of materials, subsonic and supersonic flow, rockets and turbomachinery; system dynamics and control, analog simulation of control system. Design and evaluation of an aircraft or spacecraft component. Provides sound basis for a wide variety of careers in engineering.
J. Dugundji, W. M. Hollister, A. R. Odoni, M. Martinez-Sanchez, L. Trilling, H. Y. Wachman, H. P. Whitaker

16.005 Introduction to Aerospace Engineering (New)

Prereq.: —
Year: U (2)
2-2-5

Presents a broad review of the steps involved in the development of aerospace systems from preliminary design to production. Drafting techniques, weight and performance estimation, control, structural design, cost estimating, manufacturing processes, certification, and service engineering discussed in the context of an aerospace vehicle which each student designs. Four laboratory tests support the design process. (Recommended for freshmen.)
R. H. Miller, J. W. Mar

16.006 Aerospace Graphics

Prereq.: —
Year: U (1, 2)
2-1-3

Lectures, demonstrations, and practice in graphic techniques of the aerospace industry. Two-dimensional representation of three-dimensional objects: orthographic projections, isometric projections, and perspective drawing. Computer drafting. Curve plotting. Airfoil and wing geometry. Rotor geometry. Aircraft and spacecraft geometry. Preparation of formal illustrations. Construction of demonstration and display models.
E. E. Larrabee

16.008 Computer Models of Physical and Engineering Systems (Revised Unit)

Prereq.: 18.02, 8.01
Year: U (1) SD
3-0-9

Reduction of physical and engineering systems to simplified physical and mathematical models; representation using networks; graphs and finite element methods. Process simulations using random variables (Monte-Carlo techniques) and Linear and Dynamic Programming. Manipulation of the resulting models using algorithms on digital computers. Examples drawn from fields primarily of interest to scientists and engineers, with some attention to styles of problem solving. Extensive "hands-on" computing experience. (Working knowledge of FORTRAN expected.) This subject is an Engineering School-Wide Elective.
B. Schumacker, R. Kaplow, K. J. Bathe

16.02 Aerodynamics

Prereq.: 16.004 or 2.20 or 1.05
Year: U (1, 2)
4-0-8

Molecular and continuum description of a gas. Length and time scales as basis for geometric, velocity, and altitude subdivisions of fluid flow regimes of aeronautical interest. Thermodynamic and kinematic foundations. Viscous flow fields, thin shear layer concept, skin friction, heat transfer, flow separation. Transition and turbulence. Incompressible potential fields for lifting airfoil sections. Large and small aspect ratio limit approximations for wings of finite span. Pressure distributions, control surfaces,

and stability implications. Similarity concepts for subsonic, transonic, and supersonic compressible fields. Introduction to supersonic flows.
J. R. Baron, E. E. Covert, W. L. Harris

16.023 Introduction to Computational Fluid Dynamics

Prereq.: 16.02 or 2.21 or 18.354
Year: U (2)
3-1-8

Introductory subject in modern computational techniques for inviscid and viscous flow field calculations. Emphasis is on finite-difference methods for solving one- and two-dimensional, linear and nonlinear model equations. Fundamentals of consistency, stability, convergence, iteration methods, and truncation error effects are introduced for elliptic, hyperbolic, and parabolic partial differential equations. Applications of the methods to fluid flow problems are stressed through computational problem sets. Surface singularity methods and computer architecture are introduced. Requires knowledge of FORTRAN.
E. M. Murman, W. T. Thompkins, Jr.

16.025 Numerical Fluid Dynamics (A)

Prereq.: 16.02, *18.075*
Year: G (1)
3-0-9

Concepts and techniques used in the computational evaluation of flow fields by means of panel and lattice methods, finite-element descriptions, and primarily finite-difference procedures. Algorithm fundamentals related to discrete element modeling of the partial differential equation field descriptions governing a continuous media, such as numerical stability, induced dispersion, and diffusion phenomena, with and without physical viscosity. Associated linear algebra, relaxation, iterative, marching, and discontinuity considerations. Applications selected from subsonic, transonic, and supersonic flow regimes for airfoil, body, and channel geometries. Assignments requiring use of digital computer.
J. R. Baron

16.026 Advanced Computational Fluid Dynamics (A)

(16.542)
Prereq.: 16.025
Year: G (2)
3-0-9

Advanced computational methods for two- and three-dimensional compressible inviscid and viscous calculations introduced with particular emphasis on calculation schemes for systems of mixed hyperbolic-parabolic equations. Potential, Euler, and Navier-Stokes equations treated in general nonorthogonal, curvilinear coordinates using finite-difference and finite-volume methods. Coordinate system generation, boundary layer solution schemes, and time-splitting techniques also covered in detail while turbulence modeling and computer architecture considerations are introduced. Applications drawn from internal and external flow problems in aerospace vehicles. Assignments requiring use of digital computer.
W. T. Thompkins, Jr., E. M. Murman

16.028 Special Topics in Computational Fluid Dynamics (A) (New)

Prereq.: 16.026
Year: G (1)
1-0-2

A seminar for students specializing in Computational Fluid Dynamics. Topics vary with interests of the class but are drawn from emerging discretization techniques (finite-volume, spectral, vortex methods), boundary condition treatment, solution methods (direct solvers, multigrid, Alternating Direction Implicit, advanced computer architecture, and CFD applications. (Alternate years. ***Offered 1981-82.***)
E. M. Murman, W. T. Thompkins, Jr., J. R. Baron

16.03 Aerospace Heat and Mass Transfer

Prereq.: 16.004
Year: U (2)
4-0-8

Heat transfer by conduction and convection. Free and forced convection. Effects of Reynolds number and Mach number. Relation of skin friction to convective heat transfer. Reference temperature concept for high-speed flows. Identification of essential physical properties and dimensionless parameters. Radiation heat transfer. Mass transfer: significant physical properties; ablation and transpiration cooling. Similarities between temperature profiles and concentration profiles. Practical aerospace applications explored in detail. Examples drawn from aerodynamic heating of the space shuttle during re-entry, turbojet and rocket engine heating, solar power in space, electronic package thermal protection, etc. Examples emphasized vary from year to year.
M. Finston

16.035 Fluid Mechanics (A)

Prereq.: 16.02, 18.075
Year: G (1)
4-0-8

Prepares students for graduate study in fluid mechanics and aerodynamics, and some of its applications in science and engineering. Discusses the basic concepts of continuous fluid mechanics, shows how they underlie the properties of particular flow fields such as potential and rotational constant density inviscid and viscous flows. Shows applications to flow past airfoils and wings, vortex flows, and some geophysical flows. Special attention given to boundary layers and their transition to turbulence. (Any undergraduate subject in fluid mechanics or aerodynamics accepted for 16.02.)
M. T. Landahl, L. Trilling

16.041 Aerodynamics of Viscous Fluids — Boundary Layer Approximation (A)

Prereq.: 16.035
Year: G (2)
3-0-9

Boundary layers in viscous, compressible, heat conducting fluids as an approximation to the solutions of exact equations of motion of fluids. Influence of various dimensionless parameters on steady and unsteady flows with primary emphasis on incompressible flows. Survey of experimental and theoretical methods for estimating quantities of interest in aeronautical applications. Introduction to turbulent flows.
E. E. Covert

16.042 Aerodynamic Heating (A)

Prereq.: 16.041, 18.076
Year: G (1)
3-0-9

Extension of discussion in 16.041 to include thermodynamic aspects. Kinetic heating at high speeds; heat transfer through boundary layers; discussion of methods of reducing surface temperatures. Application to hypersonic aircraft and re-entry bodies, including real gas effects at high temperatures.
M. Finston

16.044J Turbulence and Random Processes in Fluid Mechanics (A)

(Same subject as 19.65J)
Prereq.: 1.612 or 2.20 or *16.035* or 18.350
Year: G (1)
3-0-9

Development of descriptions of random fields. Response of systems and fields to random inputs, with examples from waves. Sources of turbulence, hydrodynamic stability, equations, spectra, equilibrium, and decay. Shear flow turbulence, turbulent boundary layers. Methods of observation, measurement, and analysis. Discussion of problems of current interest.
M. T. Landahl, E. L. Mollo-Christensen

16.051 Gas Dynamics (A)

Prereq.: 16.035
Year: G (2)
3-0-9

Dynamics of a perfect gas, primarily inviscid. Potential and rotational flow fields for subsonic, transonic, and supersonic flight applications. Exact and approximate methods for two- and three-dimensional flows including characteristics, similarity, small disturbances, blast analogy, integral and Newtonian concepts. Near and far field shock propagation. Examples drawn from wing and body configurations and test facility requirements.
J. R. Baron

16.052 Real Gas Dynamics (A)

Prereq.: 16.035
Year: G (1)
3-0-9

Dynamics of a real gas. Equilibrium and nonequilibrium gas processes and relaxation coupling with fluid dynamics under high temperature and rarefied conditions. Vibrational excitation, translational, chemical, and radiative nonequilibrium. Wave propagation, dispersion, similarity, shock phenomena, surface reaction coupling. Application to mass transfer, viscous layers, blunt entry vehicles, test facilities, wakes, and gas dynamic lasers. (Alternate years. ***Not offered 1981-82.***)
J. R. Baron

16.06 Space Gas Dynamics (New)

Prereq.: 16.004, 8.03, 18.075
Year: U (2)
3-0-9

Nature of the space environment; review of elements of thermodynamics and gas dynamics. Study of the kinetics of molecular gas flows: notion of free path and velocity distribution; free molecule and transition flows past bodies. Surface phenomena in space flight: accommodation, adsorption, condensation, and surface deposition. Applications to the aerodynamic performance of space vehicles and to the effectiveness of its sensing surfaces.
L. Trilling, H. Y. Wachman

16.065 Surface and Gas-Surface Problems in Aerospace Engineering (A)

(16.060)
Prereq.: 16.004 or 2.40
Year: G (2)
3-0-9

Consideration of problems associated with solid surfaces and gas-solid interfaces in aerospace engineering. Reviews of structure of surfaces, fundamentals of kinetic theory of gases and of thermodynamics as applied to processes of adsorption and desorption, condensation, and evaporation, satellite drag, and free molecular heat transfer. Experimental methods for analysis of surface properties: atomic and microstructure, adsorbate population, roughness. Behavior of surfaces in a space environment including consideration of outgassing, contamination, impact, and radiation damage, sputtering and spalling.
H. Y. Wachman

16.07 Aerodynamics of Wings and Bodies (A)

Prereq.: 16.035, 18.075
Year: G (2)
3-0-9

Coordinated presentation of theoretical methods useful for predicting performance and stability of thin lifting surfaces and slender flight vehicles. Review of fluid mechanics, with emphasis on potential aerodynamics. Constant-density flow and procedures for indirectly introducing real fluid effects. Application of method of inner and outer solutions as a framework for analyzing cases such as: slender bodies or wing-body combinations, thin air-foils, and thin planar wings in subsonic and supersonic flight. Other special topics selected in light of currently important aeronautical problems. (Alternate years. ***Not offered 1981-82.***)
W. L. Harris

16.081J Principles of Acoustics (A)

(Same subject as 2.060J, 13.81J)
Prereq.: 2.03J or 16.004, 18.075
Year: G (1)
3-0-9

Emphasizes acoustics of fluid; derivation of basic equations, radiation of sound, diffraction and scattering and acoustics of ducts and rooms. Acoustic, thermal, and vorticity fluctuations as first order perturbation of equations of fluid dynamics; energy density and intensity. Multipole expansions of source fields, spherical harmonics, radiation impedance and directivity. Scattering and diffraction of sound by obstacles. Natural modes of sound propagation in ducts; excitation and reverberation of sound in rooms.
S. E. Widnall, R. H. Lyon, P. Leehey

16.082J Flow Noise (A)

(Same subject as 2.065J, 13.84J)
Prereq.: 16.02 or 2.20, 16.081J
Year: G (1)
3-0-9

Elements of aerodynamic and hydrodynamic sound. Subsonic and supersonic jet noise. Jet noise suppression. Vortex sound and feedback resonance effects. Propeller, compressor, and helicopter rotor noise and noise suppression techniques. V/STOL noise. Boundary layer noise: Mach wave radiation, structural response and re-radiation. (Alternate years. ***Offered 1981-82.***)
S. E. Widnall, P. Leehey

16.09 Nonlinear Wave Propagation (A)

Prereq.: 18.075, 2.271 or 13.02 or 16.035
Year: G (2)
3-0-9

Physical description and mathematical treatment of nonlinear effects occurring in wave propagation in fluid continua. Particular examples discussed taken from water waves, finite amplitude acoustic waves in the ocean, and gas dynamics. Topics: water waves — Gerstner-Rankine waves, Stokes finite amplitude waves, conoidal waves, finite amplitude capillary waves, nonlinear dispersive waves; nonlinear underwater acoustics — Fubini's solution for plane waves, Burger's equation, Keck and Beyer's solution, cylindrical and spherical wave propagation modeling; gas dy-

namics — propagation of shock waves in nonuniform media, sonic boom theory, Lick's method, internal shock wave structure. Other topics of interest.
W. L. Harris

16.105 Applied Aerodynamics

Prereq.: 16.004
Year: G (1)
3-0-6

Survey of current analytic and experimental techniques appropriate to industrial applied aerodynamics. Characteristics of the atmosphere. Calibration of aircraft air data systems. Wind tunnels and wind tunnel measurements. Determination of airfoil section characteristics. Induced drag. Skin friction drag. Estimation of wave drag and sonic boom pressure signatures. Propeller theory, sizing and efficiency. Aircraft power plant characteristics. Flight mechanics, including trajectory analysis and classical performance calculation. Longitudinal dynamics of a rigid airplane. Flight test techniques.
E. E. Larrabee

16.15 Advanced Flight Vehicle Stability and Control (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Analytic solutions for nonlinear problems in flight mechanics. Linear approximations to flight vehicle dynamics, including: classical airplane stability theory, stability derivative estimation, dynamic similarity laws, gust response, inertial cross coupling and spinning. Dynamics of simple aircraft-controller combinations. Analysis of flight test dynamic stability data. Some background in introductory applied aerodynamics required. (Alternate years. ***Not offered 1981-82.***)
E. E. Larrabee

16.20 Structural Mechanics (Revised Unit)

Prereq.: 16.004 or 2.01 or 13.001
Year: U (1, 2)
5-0-7

Application of solid mechanics to analysis of high technology structures. Plane stress, plane strain problems. Bending, shear, torsion of rods and thin wall beams. Introduction to energy principles and computer-oriented structural analysis such as matrix and finite element methods. Applications to statically indeterminate structures and solid continua. Buckling of column and stability phenomena. Theories and modes of structural failure. Principles in optimal structural design.
E. A. Witmer

16.21 Plates, Stability and Thermoelasticity (A)

Prereq.: 16.20
Year: G (2)
3-0-9

Analysis of anistropic plates typical of laminated composite structures. Coupling of and duality in bending and stretching of plates, transverse shear effect. Large deflections of plates. Theory of stability of structures and applications to buckling of plates. Equations of thermal elasticity. Heat transfer and thermal stress analysis for supersonic and hypersonic aircraft.
J. W. Mar

16.22 Shell Structures (A)

Prereq.: 16.20
Year: G (1)
3-0-9

Elements of tensor analysis. General formulation of elasticity in curvilinear coordinates. Introduction to differential geometry. Development of shell equations in tensor form. Membrane behavior of thin shells. Bending behavior of thin shells. Shallow shells, shells of revolution, edge zones. ***(Not offered 1981-82.)***
J. W. Mar

16.23 Structural Design of Gas Turbine Engines (A)

Prereq.: 16.20, 16.54
Year: G (2)
3-0-9

Overall structural design and layout of modern gas turbine engines. Emphasis on the unique aspects induced by the high temperatures and high rotation speeds. Review of thermodynamic cycle analysis and aerodynamic environment to determine operating loads. Both stationary structural components such as blades, disks and shafts analyzed. Topics: thermal stresses, creep, low cycle fatigue, rotor dynamics, aeroelasticity and crack growth. Materials, structural testing and retirement of components discussed. Throughout subject, design tradeoffs between performance, and lifecycle cost and durability considered. (Alternate years. ***Not offered 1981-82.***)
E. F. Crawley, D. J. Jordan, Staff

16.24 Plasticity, Viscoelasticity and Creep (A)

Prereq.: 16.20
Year: G (1)
3-0-9

Plastic stress-strain relations of materials. Yield conditions, flow rules and strain-hardening rules. Limit and shakedown analysis. Characterization of linear viscoelastic behaviors, creep compliance and relaxation modulus, discrete element models, spectrum and dynamic representations. Viscoelastic stress analyses, corresponding principle and integral equation solutions. Nonlinear creep laws. Structural analyses in presence of creep. Creep buckling. (See 2.073. Consult advisor.)
T. H. H. Pian

16.251 Structural Design for Longevity (A)

Prereq.: 16.20
Year: G (1)
3-0-9

Longevity is the most difficult of all the structural integrity requirements for aerospace vehicles. Examines the many aspects of longevity such as: frequency of loads, fatigue of materials, growth of cracks, safe-life philosophy, fail-safe philosophy, damage tolerance, stress concentrations, scatter factors, testing, etc. Emphasis on application of theory to practice. A portion devoted to study of case histories with examples drawn from past, present, and future vehicles. Guest lecturers bring their experiences for discussion.
J. W. Mar

16.253J Advances in Fracture Research (A)

(Same subject as 3.40J)
Prereq.: 2.30 or 2.31, 2.32 or 2.301, 3.39
Year: G (1)
2-0-4

Discussion of recent advances in the understanding of phenomena, mechanics and mechanisms of fracture in structural alloys under service conditions. An integrated selection of topics including nucleation and growth of cracks under fully plastic conditions, in both rate insensitive as well as in creeping alloys, under both steady loading as well as cyclic loading, discussed by experts in the field from points of view ranging from phenomenological to detailed and mechanistic. ***(Not offered 1981-82.)***
T. H. H. Pian, A. S. Argon, R. M. N. Pelloux

16.261J Structural Mechanics in Nuclear Power Technology (A)

(Same subject as 1.565J, 2.084J, 3.82J, 13.14J, 22.314J)
Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Structural components in nuclear power plant systems: their functional purposes; mechanical, thermal, and nuclear operating conditions; mechanical-structural design requirements. Mechanics of continuous media are combined with models of material behavior to determine adequacy of component design. Effects considered include: mechanical loading, hydraulic forces, elevated temperatures, and neutron irradiation; normal operation, accident situations, and seismic effects. Lectures given by several members of Institute faculty and by guest lecturers from the nuclear power industry.
T. H. H. Pian, J. E. Meyer, A. S. Argon, O. Buyukozturk, P. C. Xirouchakis, R. M. N. Pelloux

16.27 Finite Element Method (A)

Prereq.: 16.20
Year: G (1)
3-0-9

Formulation of finite element method through use of variational principles and the principle of virtual work for structural mechanics and continuum mechanics, assumed displacement and assumed stress models. Tools in numerical analyses, interpolation and integration. Problems treated include plane stress and plane strain, plate bending and three-dimensional solids. Emphasis on the practical ways of constructing and assembling the element matrices and on methods of solving large systems of algebraic equations by modern computers. Students required to carry out actual solutions using the digital computer.
T. H. H. Pian

16.28 Advanced Finite Element Method (A)

Prereq.: 16.27
Year: G (2)
3-0-9

Generalized variational principles in solid mechanics and related finite element models. Incremental formulations of elastic-plastic, large deflection, and creep analyses. Superposition of analytical and finite element solutions. Applications to shells of revolution, fracture mechanics, finite element in time and nonstructural problems. Current development of finite element method.
T. H. H. Pian

16.29 Design with Filamentary Composite Materials (A)

Prereq.: 16.20
Year: G (2)
3-0-9

Study of the behavior of the filamentary composite materials composed of boron, graphite, and Kevlar fibers embedded in a matrix. Material properties of fibers and matrices. Anisotropic elasticity, micromechanics, interlaminar stresses, failure modes. Design concepts. Study of tooling and production methods. Cost-effective applications.
J. Dugundji

16.30 Principles of Automatic Control

Prereq.: 18.03
Year: U (1, 2)
3-0-9

Fundamental physical and analytical principles used in the design of automatic control systems. Emphasis on a sound foundation in the classical control techniques upon which more advanced subjects can build. Use of digital computer program in the solution of illustrative homework problems. Compensation techniques and design examples to meet performance specifications.
H. P. Whitaker

16.31 Principles of Instrumentation and Control (A)

Prereq.: 16.30
Year: G (1)
3-0-9

Introduction to the state space description of dynamic systems. Multiple-input, multiple-output systems. Modeling of dynamic systems. Design and compensation of feedback systems to achieve desired response. Principles of analysis and design of feedback control systems incorporating nonlinear components. Describing function and phase plane techniques, the stability criteria of Lyapunov and Popov.
M. Bowles

16.32 Principles of Optimal Control (A)

Prereq.: 16.31, 16.37
Year: G (2)
3-0-9

Study of the principles of deterministic optimal control. Pontryagin's maximum principle. Applications of the theory including optimal feedback control, time optimal control, and others. Dynamic programming, numerical techniques. Optimal estimation and control in the presence of uncertainties.
M. Bowles

16.33 Computer Control of Dynamic Systems (A)

Prereq.: 16.30
Year: G (1)
3-0-9

Basic graduate subject in the control of linear dynamic systems by linear control laws implemented in digital computers. Elements of linear discrete-time system theory: state description, interconnection of discrete and continuous systems, state transition matrix, stability, z-transform analysis of time-invariant systems, controllability, observability, canonical forms. Analysis of linear discrete-time control systems: stability, integral squared error performance criterion, sensitivity. Synthesis of state feedback computer control systems: stability improvement, deadbeat controllers, minimum quadratic cost optimal regulators. Control of systems with incomplete state measurements: observers, properties of observer-regulator computer controllers. Computer hardware considerations: input and output interfaces, memory, speed, precision.
W. S. Widnall

16.34 Automatic Control of Flight Vehicles (A)

Prereq.: 16.30
Year: G (2)
3-0-9

Application of design techniques and principles to advanced automatic control systems for air and space vehicles. Synthesis of control systems from standpoint of meeting mission specifications. Analysis of adaptive control systems; their use in meeting performance requirements over widely changing environments encountered by high-speed aircraft and manned spacecraft. Typical engineering problems associated with design of control equipment, considering limitations and uncertainties

of components, random input effects, mass cross-coupling effects, etc. Parameter optimization as a design technique using digital computer programs.
H. P. Whitaker

16.351J Quantitative Physiology: Sensory and Motor Systems

(Same subject as 2.793J, 6.023J, HST 543J)
Prereq.: 2.02 or 6.003 or 16.30
Year: U (2)
3-2-7

Studies of sensory and motor physiology with objectives of establishing quantitative models. Peripheral signal processing in eye, ear, and vestibular systems. Physiology and psychophysics of audition, vision, orientation, and body stabilization. Organization of neuromuscular and proprioceptive systems at level of spinal cord reflex. Postural control and kinetics of movement. Supplemented by laboratory exercises. (6.021J recommended background.)
L. R. Young, L. S. Frishkopf, R. W. Mann

16.352J Sensory-Neural Systems (A)

(Same subject as 6.532J)
Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Detailed consideration of a number of sensory-neural systems with respect to anatomy, physiology, and mode of operation. Reading of relevant papers and critical discussion of the methods and results described. Topics selected on the basis of their current research interest with emphasis on systems in which physical input and sensory cell-neuron output can be quantitatively related. Examples from vertebrate and invertebrate species including mechanical, visual, and other modalities. (Alternate years. ***Not offered 1981-82.***)
C. M. Oman, L. S. Frishkopf

16.353 Visual Signals and Systems (A) (New)

Prereq.: Permission of Instructor
Year: G (1)
3-0-6

Selected topics on the physical, physiological, and psychophysical bases of visual communication. Structure and function of the retina. Signal to noise considerations in vision. Ideal detectors and optimal processing models. Acuity and hyperacuity. Compression and reduction of information rate. Mach bands and models of automatic gain control. Spatio-temporal modulation transfer functions. Models of spatio-temporal frequency channels and matched filters in vision. Eye movements and vision.
Y. Y. Zeevi

16.355J Man-Machine Systems (A)

(Same subject as 2.18J)
Prereq.: Permission of Instructor
Year: G (2)
3-3-6

Introduction to modeling, design and evaluation of human-operated systems. Relevant theories of communication, decision, and control. Readings from the human factors engineering literature. Design of displays and controls, as applied to aircraft and space vehicles, undersea and industrial robotics, nuclear power plants and various person-computer interactions. Illustrative laboratory experiments and demonstrations using human subjects. An understanding of elementary dynamics assumed. Text: Sheridan and Ferrell, *Man-Machine Systems.*
T. B. Sheridan, Y. Y. Zeevi

16.356J Biomedical Signal Processing (A)

(Same subject as HST 582J)
Prereq.: HST 580J
Year: G (2)
3-3-6

Principles of processing and enhancing physiological information for use in medicine. Emphasis on understanding characteristics of present and experimental medical technology available to the physician. Areas of signal processing include: cardiology, radiology, neurophysiology, computer-aided diagnosis, etc. Basic principles and algorithms used in data processing concerning each system included. A general knowledge of control theory, computer hardware and software, and instrument transducers expected.
R. V. Kenyon

16.36 Flight Simulation (A)

Prereq.: 18.03 or 18.031, 16.30 or 6.003 or 2.14
Year: G (1)
3-6-3

Purposes and practice of simulation of aircraft research and pilot training. Conversion of aircraft equations of motion and data package into a digital computer model. Simplified transfer functions and modal analysis. Physiological and psychological principles of vision relevant to out-the-window displays. Software and hardware aspects of display generation. Implementation of CRT, model board and point light source displays. Cockpit motion requirements, motion washout, artificial control and feel and high-g cuing devices. Students participate in actual simulator problems including simplified aircraft dynamics, elementary scene graphics, and motion generation in the lab sessions. Familiarity with FORTRAN programming assumed.
R. V. Kenyon, L. R. Young, M. Connelly, K. A. Stevens

16.37 Statistical Problems in Automatic Control (A)

Prereq.: 16.30
Year: G (1)
3-0-9

Statistical problems of importance to control system engineers. Review of probability theory with application to such problems as system reliability and multidimensional random errors. Measurement of the statistics of random variables and processes. Extensive treatment of random processes in linear systems using both transfer function and state space descriptions. Design of optimum filters according to Wiener and Kalman.
W. E. Vander Velde

16.371 Estimation and Control of Stochastic Processes (A)

Prereq.: 16.37
Year: G (2)
3-0-9

Fundamental concepts and theory for the analysis and design of optimal estimators and stochastic controllers. Stochastic processes: general concepts, mean square calculus, Wiener process, white noise, Gaussian processes, Markov processes. Stochastic nonlinear differential equations: Ito stochastic calculus, Wang and Zakai modeling theorem, Kolmogorov's equations. Introduction to nonlinear filtering theory: estimation criteria, evolution of the conditional density. Linear filtering and smoothing theory: Kalman filter derivations, optimal smoother, filter stability, steady state properties, sensitivity to model errors. Application of linear filter theory: extended Kalman filter, filter divergence, adaptive noise estimation, numerical considerations, square-root formulations. Approximate nonlinear filters: Gaussian second-order filter. Optimal control of stochastic linear systems: state feedback stochastic optimal regulator, output feedback optimal controller, separation theorem.
W. S. Widnall

16.381J Optics and Optical Electronics (A)

(Same subject as 6.631J)
Prereq.: 6.014 or 8.07
Year: G (1)
3-0-9

A first-year graduate subject on fundamental concepts and techniques of modern optics and quantum electronics. Review of Maxwell's equations and the vector properties of light. Interference and interferometers. Temporal and spatial coherence. Scalar diffraction theory and the Fresnel and Fraunhofer approximations. Propagation of spherical and Gaussian-spherical beams. Lenses, imaging and spatial filtering. Resonant and nonresonant scattering. Nonlinear optics; electrooptic effect. Thin film and "fiber" waveguides. Modulators and deflectors. Additional topics selected from: switches, frequency conversion, and detectors.
S. Ezekiel, H. A. Haus

16.382 Lasers and Optics for Applications (A)

Prereq.: 16.381J
Year: G (2)
3-0-9

Resonant and nonresonant interaction of radiation with atoms and molecules. Spontaneous and stimulated emission. Conditions for laser oscillation. Rate equations. Homogeneous and inhomogeneous gain media. Laser resonators. Single frequency selection. Frequency stabilization and tuning. Optics of laser beams. Survey of gas, liquid, solid, and semiconductor lasers. Design of tunable single frequency dye lasers. Q-switching, mode locking, harmonic generation and mixing. Brief discussion of important laser applications.
S. Ezekiel

16.39 Algorithms for Function Minimization and Optimal Control (A)

Prereq.: 18.076 or 18.085
Year: G (2)
3-0-9

Development of techniques for seeking the minima of functions and optimal control histories for dynamic systems. Presentation based on fundamentals of function optimization and optimal control theory, with introductions given to variational calculus, the maximum principle dynamic programming. Unconstrained and constrained problems considered. Comparison of the complexity and performance of different optimum-seeking algorithms. Computer time available to the class for voluntary experiments with these methods. (Alternate years. ***Offered 1981-82.***)
W. E. Vander Velde

16.40 Principles of Flight Guidance

Prereq.: 16.30
Year: U (2)
3-1-8

Introduction to navigation and guidance of flight vehicles. Basic concepts of position and velocity determination using celestial, inertial, and radio techniques. Guidance strategy for aircraft and spacecraft applications. Steering laws for rocket-powered flight, atmospheric reentry, and air traffic control. Familiarity with rigid body dynamics and elementary automatic control theory desirable.
W. M. Hollister

16.41 Inertial Engineering I (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Consideration of origins of inertial space concepts and application to interpretation of measured data. First half treats generalized theory of linear and angular acceleration and velocities of bodies in motion with respect to inertial space, gyroscopic instrument theory, gimbal systems, Schuler tuning, and the design of the three principal inertial navigation systems. Second half introduces practical aspects of inertial instruments and systems. Single and two degree of freedom systems; laser, electrostatic, and dry-tuned gyros and their errors are discussed. Hands-on experience with hardware, by the students, in testing state-of-the-gyroscopes and accelerometers and verifying their error sources is a major portion of the second half. The instrumentation of gimbal and strapped-down systems discussed. Students obtain a thorough understanding of inertial space concepts and associated hardware instrumentation.
W. R. Markey, P. K. Chapman, J. S. Sinkiewicz

16.42 Inertial Engineering II (A) (Revised Unit)

Prereq.: 16.41
Year: G (2)
3-0-9

Continuation of system design concepts presented in Inertial Engineering I. Error analysis of a local geographic coordinate system and extension to the general case of six other configurations. Role of geodesy and gravimetry in system design. Limitation of Kalman Filtering. Radio inertial hybrid system design. Throughout the term seminars are held by staff members of the Charles Stark Draper Laboratory on topics chosen primarily by the class.
W. R. Markey

16.43 Strapped-Down Inertial Systems (A)

Prereq.: 16.41
Year: G (2)
3-0-9

Development of the concept of inertial attitude reference systems and inertial navigation systems utilizing instruments mounted directly on the vehicle, rather than being isolated from vehicle angular motion by a gimballed platform as in conventional inertial systems. Derivation of errors in strapped-down systems, especially those induced by the rotation environment. Derivation of computer algorithms to maintain an orientational reference and comparison among alternate approaches. Introduction of algorithms to perform inertial navigation in several coordinate frames. (Alternate years. ***Not offered 1981-82.***)
W. E. Vander Velde

16.46 Astronautical Navigation (A)

Prereq.: 18.03
Year: G (1)
3-0-9

Fundamentals of astrodynamics; two-body and n-body approximate and precision orbit determination. Fundamentals of space vehicle navigation with particular emphasis on self-contained methods; statistical error analysis. Topics: universal orbital variables, recursive algorithms, variation of parameters, state space methods, maximum likelihood estimates, numerical integration, optimum measurement strategies, correlated measurement errors. Techniques of linear perturbation theory, numerical methods, probability theory, vector and matrix algebra are developed as needed and freely applied. Selected applications from the Apollo and Space Shuttle programs.
R. H. Battin

16.47 Astronautical Guidance (A)

Prereq.: 16.46
Year: G (2)
3-0-9

Fundamentals of the two-body orbital boundary value problem with applications to space vehicle guidance for both powered flight and mid-course maneuvers. Topics: Lambert's problem and methods of solution, one-way and round-trip orbit determination to the moon and planets, orbital adjustment and transfer,

linearized and explicit techniques for fixed and variable time of arrival guidance, velocity to be gained methods, hodograph analysis and application of optimization principles.
R. H. Battin

16.491 Selected Topics in Celestial Mechanics (A)

Prereq.: 8.03, 18.076
Year: G (1)
3-0-6

Review of the two-body problem. Variational principles in dynamics, leading to Lagrange's equations, the canonical equations, and canonical transformations. The Hamilton-Jacobi equation, with solution for the Kepler problem, leading to canonical perturbation methods, Delaunay variables, and Lagrange's variational equations. Gravitational potential of a planet and rotational motions of the earth and moon. First order theory of the orbits of artificial satellites, including the effects of atmospheric drag.
J. P. Vinti

16.492 Selected Topics in Celestial Mechanics (A)

Prereq.: 16.491
Year: G (2)
3-0-6

Brouwer-Von Zeipel method and method of Lie transforms, with applications to the orbits of artificial satellites and lunar orbiters. Separable problems, including the spheroidal method, Staeckel systems and effects of general relativity on orbit of a planet or satellite. Selected topics from the three-body problem, planetary and lunar theory, resonant motions, periodic orbits, and stability theory.
J. P. Vinti

16.52 Energy Conversion (New)

Prereq.: 16.004, or 2.20, 2.40; or 10.301, 10.13
Year: U (1)
3-0-9

Fundamentals of energy conversion of fossil fuels. Thermodynamics and fluid mechanics aspects of various types of dynamic and direct energy converters discussed. Principal power cycles: Carnot, Rankine, Brayton, Otto, and Diesel discussed and their attributes examined. Chemical reactions: combustion, gasification, and liquefaction processes examined. Environmental factors including chemical pollution, particulate pollution, and thermal pollution considered. Finally, the principal fossil fuel energy systems in use and under development (fluidized bed, gas turbine, MHD, and fuel cell systems) discussed. Emphasis on system integration of conversion processes.
J. F. Louis

16.53 Rocket Propulsion

Prereq.: 16.004
Year: U (2)
3-1-8

Velocity requirements for orbital and interplanetary flight. Available velocity increments and staging. Rocket systems involving liquid, solid, and hybrid propellants treated, with reference to: nozzle flows, thermochemistry, real gas effects, losses and heat transfer, structural constraints, propellant feed, and combustion. Simple vehicle optimization. Laboratory demonstrations.
E. M. Greitzer

16.531 Space Propulsion and Power Generation (A) (New)

Prereq.: 16.53, 8.03
Year: G (2)
3-0-9

Review of rocket propulsion fundamentals, followed by a discussion of advanced thruster concepts, ranging from airbreathing boosters to electric propulsion. Particular emphasis on physics and engineering of small thrusters for station-keeping and attitude control. Survey of methods and concepts for electric power generation in space, with attention to photovoltaic, solar, thermal, and nuclear systems, as well as to various conversion schemes. Power transmission and reception.
M. Martinez-Sanchez

16.54 Aircraft Engines and Gas Turbines

Prereq.: 16.004
Year: U (1)
3-1-8

Performance and characteristics of aircraft engines and industrial gas turbines, as determined by thermodynamic and fluid mechanic behavior of components; inlets, compressors, combustors, turbines, nozzles. Discussion of various engine types including turbojet, turbofan, and turboprop. Limitations imposed by material properties and stresses. Emphasis on factors which determine future design trends, including noise, pollutant formation, fuel consumption, and weight.
W. T. Thompkins, Jr., D. J. Jordan

16.541 Aircraft Turbine Engines (A)

Prereq.: 16.54
Year: G (2)
3-0-9

Fluid mechanics, thermodynamics, and solid mechanics of aircraft turbine engines. Emphasis on physical concepts which have key roles in determining the basic features of an aircraft gas turbine engine. Steady two-dimensional and three-dimensional flow theories of compressors and turbines. Unsteady flow and noise production in turbomachinery and in complete engines. Operational limitations, and instabilities including flutter, rotating stall, surge. Stress and associated temperature limits in turbines. Influence of blade cooling techniques. Thermodynamic and performance analysis of gas turbine engines.
E. M. Greitzer, D. J. Jordan

16.543 Internal Flows in Turbomachines (A)

Prereq.: 16.035 or 2.25
Year: G (2)
3-0-9

General features of internal flows with particular application to turbomachinery. Fundamental concepts of rotational flows, inherent unsteadiness of turbomachinery aerodynamics, boundary layers, wakes, and losses in turbomachines. Simplified models: axisymmetric swirling flows, blade element theory, and experimental information. Effects of viscosity and compressibility in internal flows. Computational methods. Turbines vs compressors. Multiple stages and their interactions. Secondary flows: examples and effects, experimental evidence. Flow instabilities in turbomachines. Importance of vorticity in swirling flows. Selected topics of recent developments such as nonaxisymmetric flows and three-dimensional effects.
E. M. Greitzer, J. E. McCune

16.544J Advanced Gas Turbines Utilizing Ceramics

(Same subject as 3.78J)
Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Utilization of low cost gas turbines in automobiles and other ground vehicles offers promise of improved efficiencies but requires improved designs and higher temperature materials to obtain satisfactory performance over a range of output power. Issues involved in designing and fabricating advanced engines utilizing ceramic materials addressed; these include cycle efficiencies, component design considerations, design philosophy for using brittle materials,

and effects of materials properties and fabrication limitations. Subject is interdisciplinary and involves lecturers from industry or government.
R. M. Cannon, Staff

16.55 Ionized Gases (A)

Prereq.: 8.211
Year: G (1)
3-0-9

Describes physical properties and behavior of low temperature plasmas as encountered in applications such as: Magnetohydrodynamic and thermionic energy conversion, plasma propulsion, gas lasers, etc. Equilibrium description of ionized gases: energy states, statistical mechanics, and ionization equilibrium. Kinetic theory: motion of charged particles in magnetic fields, distribution function, collisions, Boltzmann equation, characteristic lengths and times, cross-sections, transport properties. Gas surface interactions: thermionic emission, surface ionization, sheaths, probe theory. Radiation in plasmas, diagnostics.
M. Martinez-Sanchez

16.551 MHD Power Generation (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Motion of fluids interacting with electric and magnetic fields. Conversion of mechanical and electrical energy with Lorentz forces. Detailed study of magnetohydrodynamics with emphasis on power generation: simple inviscid and compressible flows, electric conductivity, Hall effect, ion slip, non-equilibrium electronic heating. Application to Faraday, Diagonal, and Hall generators. MHD interaction in channel, viscous effects, effects on nonuniformities, end effects, time-dependent MHD performance. Theoretical methods of channel flow analysis. Discussion of engineering aspects of MHD generators includes channel construction, combustion of coal for MHD conditions, materials utilization, and superconducting magnet.
J. F. Louis

16.56 Noise Control Engineering (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Detailed account of the various aspects of noise and vibration control engineering, with focus on mechanisms of noise generation, transmission and absorption, and techniques for reducing noise. Comprehensive account of aerodynamic noise and its reduction and a study of acoustically induced flow instabilities and fatigue failures in valves and structures. Covers measurements and analysis of noise, effects of noise on humans, noise rules and criteria, and system considerations of noise control. Case histories of timely problems selected for analysis. Examples: development of aircraft duct liner technology, noise control of devices such as compressors, turbines, pumps and valves, and of facilities such as gas turbine power plants (jet engine driven) and nuclear power plants.
K. U. Ingard

16.59J Introduction to Plasma Physics II (A) (Revised Content)

(Same subject as 6.652J, 8.614J, 22.612J)
Prereq.: 6.651J or 8.613J or 22.611J; 18.075
Year: G (2)
3-0-9

Linear waves and instabilities in magnetized plasmas; solutions of Vlasov-Maxwell equations in homogeneous and inhomogeneous plasmas; conservation principles for energy and momentum; negative energy waves; absolute and convective instabilities. Quasi-linear theory and conservation principles; evolution of unstable particle distribution functions. Collisional transport theory; Fokker-Planck equations; particle diffusion, thermal conductivity, and viscosity in magnetized plasmas.
J. E. McCune, A. Bers, R. C. Davidson, K. Molvig

16.60 Advanced Special Project (A)

Prereq.: —
Year: G (1, 2, S)
Arr.

Study, original investigation, or lab project work of graduate level by qualified students. Topics selected in consultation with instructor.
H. Y. Wachman

16.601 Advanced Special Subject (A)

Prereq.: —
Year: G (1, 2)
Arr.

Organized lecture or laboratory subject consisting of graduate-level material not available in regularly scheduled subjects.
H. Y. Wachman

16.602 Advanced Special Subject

Prereq.: —
Year: G (1, 2)
3-0-6

Organized lecture or laboratory subject consisting of graduate-level material not available in regularly scheduled subjects.
H. Y. Wachman

16.605 Special Projects

Prereq.: —
Year: U (1, 2, S)
Arr.

Study or laboratory project work of undergraduate level by qualified students. Topics selected in consultation with the instructor.
E. A. Witmer

16.606 Selected Topics in Aeronautics and Astronautics

Prereq.: —
Year: U (1, 2)
Arr.

Study at the undergraduate level by qualified students. Topics selected in consultation with the instructor.
E. A. Witmer

16.61 Microcomputer Laboratory (New)

Prereq.: 6.071 or 6.002; 2.10 or 6.030
Year: U (1, 2)
2-8-2

Laboratory devoted to understanding the operation of microcomputers and methods of interfacing digital and analog devices to microcomputers. Machine language programming. Use of cross-assemblers. Analysis of monitor or operating system environment. Parallel and serial digital interfaces. Digital to analog and analog to digital conversion. Input-output operations with timing and interrupts. Control of real-time events and physical systems. The use of compiler languages and their limitations in real-time applications. Project: design, construction, programming, and testing of a system that includes a microcomputer. (Limited enrollment.)
W. S. Widnall, J. E. Thomas

16.62 Experimental Projects

Prereq.: 16.004
Year: U (1, 2) LAB
2-6-4

Designed to help the student gain practical insight and understanding of the scientific principles as applied to "project" experiments. Emphasis on preparation of project goals, planning and conducting details for the necessary apparatus, conducting of the experiment, and relation of the experimental results to the initial goals. Provides an opportunity for the student to assemble and apply the knowledge gained, and provides a link between theory and practice. (Limited to Avionics Option, Co-op, and transfer students.)
W. R. Markey

16.621 Experimental Projects I

Prereq.: 16.004
Year: U (1, 2)
1-1-1

Introduction to laboratory experimental techniques. Principles of reliable measurements. Techniques for the design and construction of components and apparatus. Use of basic machine and hand tools. Soldering techniques. Laboratory safety. Instruction in effective report writing and oral presentation. Selection and detailed planning of an individual research project, including design of components or equipment. Preparation of a detailed proposal for the selected project (which is carried through to completion under 16.622).
W. R. Markey

16.622 Experimental Projects II

Prereq.: 16.621
Year: U (1, 2) LAB
1-7-4

Designed to help the student gain practical insight into and an improved understanding of engineering experimentation through design and execution of "project" experiments. The student (in 16.621) will have selected an appropriate individual project, defined specific goals, and planned and designed in detail (and procured) the experimental apparatus and instrumentation. Now in 16.622 the student builds and tests the necessary equipment. Then, systematic experimental measurements of the phenomena in question are made; next, the data are analyzed. Also, appropriate theoretical predictions are compared with the experimental results. The entire project including conclusions and recommendation of steps to resolve any remaining problems are described by the student in a written final report and in a formal oral presentation. Provides valuable link between theory and practice.
W. R. Markey

16.64 Flight Measurement Laboratory

Prereq.: 16.002
Year: U (1, 2)
2-2-2

Opportunity to see aeronautical theory applied in real-world environment of flight. Students assisted in design and execution of simple engineering flight experiments in light aircraft. Projects encouraged which demonstrate aeronautical phenomena previously studied in classroom. Typical investigations include determination of stability derivatives, verification of performance specifications, and measurement of navigation system characteristics. May be taken in conjunction with a 16.62 project. Approximately two hours of flying as an observer required. (Limited to students in Aeronautics and Astronautics.)
W. M. Hollister

16.65 Experimental Techniques in Aerodynamics (A)

Prereq.: 16.02
Year: G (1)
3-0-9

Foundation for experimentation, including characteristics of instrumentation, selection of transducers and sensors, signal processing, and computer-aided experimentation. Attention given to practical aspects of experimentation. (Offered alternate years. ***Not offered 1981-82.***)
E. E. Covert

16.671J Invention

(Same subject as 2.941J, 6.935J, 10.802J, 13.77J)
Prereq.: —
Year: G (1)
3-0-6

Process of invention is analyzed with intention of enhancing the skill of the student inventor. Instructions include the following phases of the process: a) technology observation to increase the technology background of potential inventor; b) need analysis to define clearly the requirements and limitations of needed inventions; c) parameter analysis, to focus the attention of inventor on the important parameters of the problem and on potential solutions; d) creative step, to develop techniques for providing innovative solutions. Students are encouraged to provide innovative solutions to invention needs of their own choice.
D. G. Jansson, A. D. Carmichael, W. C. Flowers, J. B. Howard

16.672 Entrepreneurship

Prereq.: —
Year: G (2)
4-0-5

Introduction to the various issues faced by technical innovators interested in becoming entrepreneurs. Lectures and discussions are held on concept evaluation, patents, licensing, contract negotiation, marketing, business planning, financing, accounting, and small business management. Students encouraged to use their own innovative ideas as the object of study topics. This subject is an Engineering School-Wide Elective (open to undergraduates by permission of instructor.)
D. G. Jansson

16.673 Inventions and Patents (New)

Prereq.: 14.02
Year: U (1)
3-0-6

History of private and public rights in scientific discoveries and applied engineering leading to the development of worldwide patent systems. The classes of invention protectable under the patent laws of the US, including the procedures in protecting inventions in the Patent Office and in the courts. Reviews of past cases involving inventions and patents in a) the chemical process industry and medical field, b) devices in the mechanical, ocean exploration, civil, and/or aeronautical fields, c) the electrical and electronic areas including key radio, solid-state, and computer inventions. This subject is an Engineering School-Wide Elective.
R. H. Rines

16.675 Invention Development Laboratory

Prereq.: —
Year: U (1, 2)
Arr.

Objective is to heighten student's understanding of social needs and improve existing solutions through introduction of an innovative design or process together with skillful utilization of certain material or components to bring forth an identifiable invention. Further strengthened through an examination of market surveys, patent searching, analytical evaluation, model building and testing. Project completed with a business plan to be presented to the Innovation Co-op outlining pro-

posed further development, marketing strategy, potential pilot production model construction, field testing, budgeting, and return of investment. A project undertaken need not be the student's invention. Approval by the Innovation Education Council is required to evaluate the pace and scope of each project to meet the Institute Laboratory Requirement. Registration must be a minimum of 6 units.
D. G. Jansson

16.676 Internship in New Enterprise Development

Prereq.: —
Year: U (1, 2)
Arr.

Students acting as project coordinators for Innovation Co-op projects may receive lab credit by registering for this subject. Function of coordinator involves an intimate association with the decision-making process of each project, such as technology transfer from laboratory model to finished product, specification revision, alternative material, manufacturing process and tolerances, trouble shooting, marketing strategy, budgeting, licensing arrangement, new venture capital exploitation, and various legal problems. Students must adjust to the pace of the product development of the Co-op and may register consecutively for several terms to follow a product from its conceptual stages to its maturity. Normal load may be 6 units per term. Project supervised by one faculty member of the Innovation Education Council in coordination with the General Manager of the Co-op may meet the Institute Laboratory Requirement.
D. G. Jansson

16.701 Principles of Systematic Policy Analysis

Prereq.: Permission of Instructor
Year: G (1)
3-0-6

Introduction to the systematic analysis of policy choices, with emphasis on approaches, concepts, and techniques employed. Main focus on cost effectiveness as a means of choosing between major project alternatives. Study of time-streams of benefits and costs. Pertinent operations research techniques including linear and dynamic programming, analysis of uncertainty, project scheduling. Introduction to the basic ideas of decision analysis and utility theory. A few case studies also discussed.
A. R. Odoni

16.703 Introduction to Aerospace Management

Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Identifies and analyzes major principles of modern corporate and government agency management related to the aerospace and air transportation industry. Designed to provide technical and scientific professionals with an understanding of what management entails and how it is accomplished. Material should help students to analyze and evaluate the data, reports, and recommendations on which managerial decisions can be based. Lectures supplemented with seminar presentations by speakers from the industrial and financial communities and government agencies.
J. T. Kneafsey

16.704J Seminar in Air Transportation Analysis and Planning

(Same subject as 1.233J)
Prereq.: —
Year: G (1)
1-0-5

A review of current issues facing the airline industry in operational, economic, financial, regulatory, and institutional areas. Seminars are presented on alternative weeks by leading speakers from airlines, aircraft manufacturers, major airports, regulatory agencies, and national and international aviation organizations. Preparatory lectures precede each seminar. Opportunity for students to conduct studies on particular topics with readings guided by staff. Term paper required.
C. O. Carey, H. S. Marcus, A. R. Odoni

16.711 Introduction to Probability and Statistics

Prereq.: Permission of Instructor
Year: G (1)
3-0-6

Introduction to probabilistic concepts and statistical methods with strong emphasis on applications to management, engineering, and administrative problems. Elements of probability theory consist of sample space and points, probability rules and use of binomial, normal, and poisson distribution tables. Basic material on statistics consists of sampling theory, estimation, hypothesis testing, and regression analysis.
D. F. X. Mathaisel, N. K. Taneja

16.712 Regression Forecasting Methods (A)

Prereq.: 16.711
Year: G (2)
3-0-6

Application of regression analysis to forecast air transportation activity. Introduction to regression analysis with emphasis on applications. Topics: ordinary least squares procedure; in-depth analysis of the underlying assumptions with focus on multi-collinearity, auto-correlation, and heteroscedasticity; residual analysis; and multi-equation systems. Students use the available computer-based systems and are not expected to write their own programs. Elementary knowledge of probability and statistics required. (Permission of instructor required.)
D. F. X. Mathaisel, N. K. Taneja

16.72 Air Traffic Control (A)

Prereq.: 6.071 or 16.40
Year: G (2)
3-0-6

Introduction to the various aspects of present and future Air Traffic Control systems. Descriptions of the present system: systems analysis approach to problems of capacity and safety; surveillance including NAS and ARTS; navigation subsystem technology; aircraft guidance and control; communications; collision avoidance systems; sequencing and spacing in terminal areas; future directions and development; critical discussion of past proposals and of probable future problem areas.
A. L. Elias, R. W. Simpson

16.73 Airline Management (A)

Prereq.: 16.74
Year: G (2)
3-6-3

Introduction to airline management with consideration given to marketing, managerial economics, and regulatory environment of both domestic and international airline industry. Primary emphasis on interactions between the diverse aspects of product planning, market forecasting, and market shares including fleet planning and the financial, economic, and performance selection criteria of aircraft. Particular importance placed on strategic planning issues. Students participate in teams managing simulated airlines using a large-scale computer simulation on an air transportation network, and are expected to apply concepts presented in the lectures.
A. L. Elias, R. W. Simpson

16.74 Air Transportation Economics (A)

Prereq.: 14.001
Year: G (1)
3-0-6

Introduction to fundamental concepts and analysis of air transportation economics. Focuses on composition and pricing of air transport services and supply and demand analysis under Federal regulation. Emphasis on applications such as break-even point analysis, determination of optimal load factor and schedule decision making under various cost analyses for both passenger and freight transportation.
R. W. Simpson

16.751 Flight Transportation (A)

Prereq.: 16.30
Year: G (1)
3-0-6

Integrated discussion covering basic concepts and operational characteristics of flight transportation systems. Methods of predicting vehicle performance, anticipating future design trends, and determining operating costs; airport design and functional layout; guidance and control techniques, both in terminal area and en route; communication and radar system performance.
R. H. Miller

16.752J International Air Transportation

(Same subject as 17.334J)
Prereq.: —
Year: G (1)
3-0-6

Introduction to problems of international air transportation with emphasis on political and legal aspects. Topics: international civil aircraft industry; types of airline ownership, characteristics of air transport in North and South America, Europe, the Middle East, Asia, Africa, China, and the Soviet Union, world route patterns, bilateral negotiations, international air transport organizations, problems of air transport in developing nations, unlawful interference with aircraft, restrictive governmental practices on airlines, and international charter and cargo operations. Classwork supplemented by guest lecturers. Term paper required.
B. R. Gidwitz, R. W. Simpson

16.76J Logistical and Transportation Planning Methods (A) (Revised Content and Unit)

(Same subject as 1.203J, 6.281J, 11.526J, 13.665J, 15.078J, TPP 43J)
Prereq.: 6.431 or 15.075
Year: G (1)
3-0-6

Quantitative techniques of operations research with emphasis on applications in transportation systems analysis (urban, air, ocean, highway, pick up, and delivery systems) and in the planning and design of logistically oriented urban service systems (e.g., fire and police departments, emergency medical services, emergency repair services). Unified study of functions of random variables, geometrical probability, multi-server queueing theory, spatial location theory, network analysis and graph theory, and relevant methods of simulation. Discussion of implementation difficulties. Examples of applications: design of ambulance systems having both specialized and general-purpose vehicles; emergency response to oil spills; estimation of energy consumption by commuters in a metropolitan area; design of dial-a-ride transportation systems; controlling randomness in mass transit systems; evaluation of technologies for vehicle location, routing, and control.
A. R. Odoni, A. I. Barnett, R. C. Larson, H. N. Psaraftis

16.77 Flight Transportation Operations Analysis (A)

Prereq.: 1.143 or 15.081
Year: G (2)
3-0-6

Study of application of linear programming and network flow theory to operational problems in flight transportation systems. Review of graph theory. Network flow theory. Integer programming and branch and bound methods. Dynamic programming. Review of implementation of computerized mathematical programming systems. Application of the theory to scheduling, aircraft and crew routing, timetable optimization, passenger traffic flow, flight planning, etc. Student use of computer to solve large-scale problems and for term project.
R. W. Simpson, D. F. X. Mathaisel

16.781J Planning and Design of Airport Systems (A)

(Same subject as 1.231J)
Prereq.: Permission of instructor
Year: G (2)
3-0-6

Emphasizes equally current practice and advanced concepts. Airport location and planning with full consideration of economics, environmental, and other impacts. Examination of techniques for predicting demands. Determination of capacity of airfield and terminal facilities, estimation of levels of congestion and consideration of their optimal design. Configuration and design of terminals. Role of airports in the aviation and transportation system. Airport access problems. Optimal configuration of air transport networks and implications for airport development. Economics of the airport. Financing and institutional aspects. Special attention to advanced concepts for the design and operation of airport systems in the US and in Europe and the insight they provide for the planning and design of future airport systems. Illustration through cases in airport master planning, site selection, and expansion planning.
A. R. Odoni, R. de Neufville

16.783J Engineering Policy Thesis Seminar (A)

(Same subject as 1.980J, TPP 13J)
Prereq.: Thesis Registration
Year: G (1, 2)
2-0-1

A weekly seminar designed to assist students in formulating research topics, designing their investigation, executing analysis, and writing the thesis itself. It thus also serves as preparation for general examinations. Students required to present work for general discussion by faculty, research staff, and their colleagues.
A. R. Odoni, R. de Neufville, Staff

16.784 Engineering Systems Analysis (A) (New)

Prereq.: Permission of Instructor
Year: G (1)
3-0-6

Synthesis of the analytic procedures for the identification and selection of optimal systems. Review of the economic framework for analysis. Systematic survey of theory and applications of mathematical optimization to engineering problems. Evaluation procedures for single and multiattributed problems covering utility theory and decision analysis in addition to standard procedures. The application of this material to real problems in planning and design stressed throughout the term. (Open to qualified undergraduates. Knowledge of prob-

ability, microeconomics, and computer systems at an undergraduate level required.) This subject is an Engineering School-Wide Elective.
R. de Neufville, J. P. Clark

16.792 Introduction to Technology and Law

Prereq.: —
Year: U (1)
3-0-9

Introduction to basic principles and functions of law, using legal cases and materials arising from scientific and technical issues. Provides an understanding of the law and legal processes as they impact upon the work of engineers and scientists. Study of judicial law making focuses on elementary civil procedure and how change in legal doctrine takes place. Examination of statutory law making shows how Federal and state power to govern grows as technology grows. Administrative law making focuses on the regulatory agencies' role in controlling and supporting technology as well as the extent and curbs on their power. Study of law cases, using so-called "Socratic method," and of legal processes and doctrines provides insight into the lawyer's working methods. Law's task of resolving conflicts found in scientific and engineering alternatives sensitizes students to choice of values questions. This subject is an Engineering School-Wide Elective. ***(Not offered 1981-82.)***
J. D. Nyhart

16.794 Engineering Risk-Benefit Analysis (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Risk evaluation and cost-benefit analysis techniques for the assessment of engineering projects involving risks. Emphasis on public sector. Balancing risks and benefits with concern for financial uncertainties, environmental risks, and especially, issues of human safety. Introduction to decision analysis, the value of information, problems with multiple goals and issues related to collective decisions. Issues of public policy and regulation. Case studies with attention to the nature of public discussion. Cases drawn from dam safety, safety of nuclear reactors, transport and storage of liquefied natural gas, seismic risk problems, and off-shore oil exploration. Some background in elementary probability assumed. (This subject is intended mainly for graduate and upperclass students in the School of Engineering, and is an Engineering School-Wide Elective.)
M. E. Paté, A. W. Drake

16.80 Industrial Practice

Prereq.: —
Year: U (2)
0-8-0

Seven months of engineering practice carried out by the cooperative students at the plants of organizations participating in the cooperative program.
R. H. Miller

16.801 Engineering Internship

Prereq.: —
Year: U (1, 2, S)
0-6-0

A summer of work experience as part of the Engineering Internship Program. Students register for this subject twice receiving the grade "J" for the first registration. Two work assignments must be completed in order for credit to be awarded. (Enrollment limited to students registered in Course XVI-C.)
W. E. Vander Velde

16.802 Advanced Engineering Internship

Prereq.: 16.801
Year: G (1, 2, S)
0-6-0

A consecutive seven-month period of work experience as part of the Engineering Internship Program. Students register for this subject in two terms receiving the grade "J" for the first registration. (Enrollment limited to students registered in Course XVI-C who have been admitted to the Graduate School.)
W. E. Vander Velde

16.821 A Management View of Engineering Seminar

Prereq.: —
Year: G (1)
2-0-4

Directed toward the student whose objective is a career in engineering. Provides opportunities to examine management topics related to the conduct of engineering activities in the industrial environment. A case approach employed to look at management interfaces between engineering and other corporate functions such as marketing, finance, manufacturing, quality, etc. Special attention given to role of engineer in the acquisition of new business, as well as the treatment of management of large projects. Consideration also given to technical and business aspects of starting new ventures within corporate environment.
J. Yamron

16.83 Automotive Vehicles

Prereq.: 16.002
Year: U (2)
3-0-6

Analytical approach to vehicle performance, handling and riding qualities. Design of body, chassis, suspension, engine, and transmission to meet vehicle requirements. Individual study of a special problem related to automobile design. Demonstrations of vehicles and components. (Alternate years. ***Not offered 1981-82.***)
E. E. Larrabee

16.84 Flight Vehicle Engineering

Prereq.: 16.02
Year: U (2)
2-3-7

Design of an atmospheric flight vehicle to satisfy stated performance, stability, and control requirements. Emphasis on individual initiative, application of fundamental principles, and the compromises inherent in the engineering design process.
N. D. Ham

16.85 Space Systems Engineering

Prereq.: 16.20
Year: U (1)
4-0-8

Review of fundamental principles used in engineering development of space systems and application to their analysis. Optimization of a complete system including trajectory analysis, entry dynamics, propulsion systems, structural design, thermal protection, weight estimation, environmental control, support systems, and cost estimates. Design of a complex space system, including mission analysis, design tradeoffs, optimization and systems integration. Students participate in teams, each responsible for one of several subsystems, providing experience in project organization, interaction between disciplines, and methods by which individuals and teams work together.
R. H. Miller

16.851 Satellite Engineering (A)

Prereq.: —
Year: G (1)
3-0-9

Fundamentals of satellite engineering design. Study of orbital environment. Analysis of problems of station keeping, attitude control, communications, power generation, structural design, thermal balance, and subsystem integration. Review of available technology in materials, sensors, and actuators. Consideration of tradeoffs among weight, efficiency, cost, and reliability. Discussion of choice of design

parameters such as size, weight, power levels, temperature limits, frequency, bandwidth, etc. Examples taken from current satellite systems. Background knowledge of topics helpful but not assumed.
W. M. Hollister

16.87 VTOL Aircraft (A)

Prereq.: 16.02
Year: G (1)
3-0-6

An analytical discussion of the fundamental performance, stability, and control characteristics of vertical take-off and landing aircraft, including helicopters and ducted fan, rotor-propeller, jet vectored-lift, and jet vertical-lift aircraft. (Alternate years. ***Not offered 1981-82.***)
N. D. Ham

16.88 Aerodynamics, Structural Dynamics, and Aeroelasticity of Wind Turbines and Rotorcraft (A)

Prereq.: 16.02
Year: G (1)
3-0-6

An analytical discussion of fundamental aerodynamic, structural dynamic, and aeroelastic characteristics common to wind turbines and rotorcraft. Included in the discussion are the horizontal-axis and vertical-axis types of wind turbine, and the helicopter and tilting rotor-propeller types of rotor-craft. (Alternate years. ***Offered 1981-82.***)
N. D. Ham

16.91 Structural Dynamics (A)

Prereq.: 16.20
Year: G (1)
3-0-9

Vibrations of simple and complex structures: bars, strings, rods, beams, plates; emphasis on physical concepts. Analysis of continuous and multimass systems. Formulation and application of diverse methods: finite element, finite difference, Galerkin, integral equation, and numerical collocation. Variational principles in dynamics: Hamilton's Principle and Lagrange's equations. Transient response solution by modal superposition and direct numerical integration techniques. Mode shape and frequency evaluation by modern computing techniques for large and small systems. Examples and interpretation of transient response of *linear* systems. Introduction to self-excited vibrations: divergence and flutter of aircraft, power transmission lines, buildings, suspension bridges, etc. (See 2.032. Consult advisor.)
E. F. Crawley

16.92 Advanced Aeroelasticity (A)

Prereq.: 16.004, 16.91
Year: G (2)
3-0-9

Presentation of field of aeroelasticity from unified viewpoint applicable to flight structures as well as buildings, suspension bridges, and other structures. Static aeroelastic and flutter instabilities of simple and complex structures. Similarity lows and wind tunnel modeling. Responses to gusts and random excitation. Derivation of unsteady airloads. Simple nonlinear aeroelastic behavior.
E. F. Crawley

16.94 Advanced Structural Dynamics (A)

Prereq.: 16.91
Year: G (2)
3-0-9

Review of transient response of linear systems. Emphasis on *nonlinear* vibrations and transient response of structures; elastic and inelastic material behavior and large deflections. Formulation and use of finite element, finite difference, and assumed mode methods. Analysis by modal and modern direct numerical timewise integration techniques. Accuracy, stability, efficiencies, merits, and deficiencies of various current techniques. Transient acceleration, strain, and displacement responses, and permanent deformation. Impact and the propagation of both elastic and intense inelastic stress waves in solids; boundary effects and spall fracture. Nonlinear geometric vibratory responses of elastic structures from forced and parametric excitation; limit cycle predictions from numerical, harmonic balance, and perturbation techniques. ***(Not offered 1981-82.)***
T. H. H. Pian

16.991 Aeronautics and Astronautics Seminars

Prereq.: —
Year: U (1, 2)
2-0-0

Speakers from campus and industry discuss current activities and advances in aeronautics and astronautics. (Restricted to Course XVI students.)
W. R. Markey

16.992 Seminar

Prereq.: —
Year: G (1, 2)
2-0-0

Discussion of current interest topics by staff and guest speakers. (Restricted to Course XVI students.)
W. R. Markey

16.993 Management in Engineering

Prereq.: —
Year: U (1)
3-0-9

Introduction to the concepts of management of the engineering function, as found in a variety of industrial and non-industrial settings. Aim is to help the student acquire 1) recognition of role of engineering and its relationship to other functions in getting a job done, 2) familiarity with some of the managerial tools and concepts employed in engineering organizations, 3) practice in dealing with both short- and long-term managerial problems in a range of real-life circumstances, and 4) incentive to develop a career strategy relevant to engineering training. Topics: financial principles; management of innovation; engineering project planning, scheduling and control; human factors; career planning; contracts; patents; and technical strategy for firms. Taught, in part, by case method, which emphasizes student participation in discussion. (Intended for juniors, seniors, or graduate students; others should consult the instructor in charge.) This subject is an Engineering School-Wide Elective.
R. T. Lund, D. P. Hoult, H. S. Marcus

17 Political Science

Political Philosophy/Social Theory

17.101 Revolution and the Theory of Politics

Prereq.: —
Year: U (1) HUM-D
3-0-9

Subject in political theory focusing on certain political problems during three periods of crisis: English Revolution, French Revolution, and the socialist revolutions. Explores range of alternative solutions to problems of authority, obedience, representation, and social justice in works of such theorists as Locke, Hobbes, Rousseau, Burke, and Marx. ***(Not offered 1981-82.)***
S. Berger

17.103 Socialism

Prereq.: —
Year: U (2) HUM-D
3-0-6

Analysis of issues and values that gave rise to the Socialist movement in the wake of the Industrial Revolution and that in the contemporary world continue to shape political action and thought. Readings, lectures, and discussion focus on theories of Socialism and history of Socialist movement in various countries. By considering differences between countries — and why Socialism has not developed in the USA — subject emphasizes the ways in which different national traditions and different routes to industrialism and modernity shape politics and political theory. Exploration of changes in industrial society that led to changes in Socialism with analysis of the case of "Eurocommunism" as an example of the adaptation of Socialism to contemporary industrial societies.
S. Berger

17.105J Political Philosophy

(Same subject as 24.233J)
Prereq.: One Philosophy Distribution subject
Year: U (1)
3-0-9

Freedom and the social order. An analysis of central works of modern political philosophy focusing on their efforts to develop political theories based on the idea of freedom. Readings from Hobbes. Rousseau, Marx, and Mill. (Meets concurrently with 17.152. ***Not offered 1981-82.)***
J. Cohen

17.107 Introduction to Political Theory: Individual and Community

Prereq.: —
Year: U (1) HUM-D
3-0-6

Basic introduction to the study of politics focusing on selected works in classical, medieval, and early modern political thought. The claims to freedom of the individual as they encounter demands of the community for order, justice, and obedience. Questions of differences in social status, wealth, intelligence, or talent, existing between individuals as they affect how a society is organized and governed. Extent to which political society is justified in shaping the lives and consciousness of its members. Foundations of political authority. Readings include: Socrates, Plato, Aristotle, St. Augustine, St. Thomas, Machiavelli, and Luther.
B. H. Smith

17.109 Modern Political Theory: Democracy and Freedom

Prereq.: —
Year: U (2)
3-0-6

Introduction to the study of politics focusing on selected works in modern political thought. Issues of freedom and democracy in context of the historical developments which shape modern society. Study of theories of social contract as basis of the state, property rights and liberalism, representative vs. direct democracy, conservatism, the French and industrial revolutions and their promise. Readings include Locke, Rousseau, Marx, Lenin, and Arendt.
Staff

17.111 Introduction to Sociology

Prereq.: —
Year: U (1)
3-0-6

Introduction to basic sociological concepts, theories, and analytic approaches including the nature of organizations, systems of stratification, social institutions and social change. Readings and discussion emphasize issues of public policy and social change, and include detailed empirical studies and evaluations of the consequences of public policies.
R. Neuman

17.150 Basic Concepts of the Social Sciences (A)

Prereq.: —
Year: G (1)
3-0-9

A workshop in which the basic concepts used in the building of modern social science theories are systematically identified and reviewed. Basis of workshop is extensive reading in the classic works of modern social and political science.
L. W. Pye

17.152 Political Philosophy (A) (Revised Content)

Prereq.: Some previous subject in Modern Political Philosophy
Year: G (2)
3-0-9

Considers the implications for an understanding of the democracy of two traditions of modern political thought: individualist, rational choice theory, and theories of the general will. Readings include Hobbes, James Mill, Arrow, Downs, Rousseau, Habermas, Rawls.
J. Cohen

17.154J The Rise of the Modern State (A)

(Same subject as STS 510J)
Prereq.: Permission of Instructor
Year: G (1)
3-0-9

The theory of the state. Focuses on three stages in the development of the modern state: political absolutism, the property-contract stage, and the corporate-welfare state. In each section close attention given to key texts in political theory and to their relationship to the corresponding historical period.
C. F. Sabel, J. Cohen

17.156J Political Economy I: Theories of the State and the Economy (A)

(Same subject as 14.781J)
Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Critical analysis of liberal, neoclassical, and Marxist perspectives on modern society. Alternative theories of economic growth, historical change, the state, classes, and ideology.
S. Berger, M. J. Piore

American Politics/Public Policy

17.158 Topics in Political Economy and Political Sociology (A)

Prereq.: 17.701
Year: G (2)
3-0-6

Review of selected topics in political economy and political sociology with special emphasis on social, economic, and political trends in advanced capitalist societies. Topics: economic conditions and electoral outcomes; the politics of macro-economic policy (the political business cycle); economic and political conflict in advanced industrial societies; theories of the state; critical problems of industrial, capitalist nations (unemployment, inflation, protest against the welfare state).
J. Freeman

17.160 Topics in the Sociology of Bureaucracy (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Central theme is the relation between rule making, administrative efficiency, and the exercise of power. Discussion developed through readings of contemporary studies of bureaucratic organization. This framework applied to consideration of relations between the state apparatus and society. Topics: Absolutism and the rise of state authority, Legalism and Corporatism as techniques of Social Compromise and Bonapartism. Readings for bulk of subject are historical and comparative; but where possible, reading selections chosen to facilitate discussion of the contemporary role of the bureaucracy in the US. Students required to write one seminal-length paper. ***(Not offered 1981-82.)***
C. F. Sabel

Public Policy

17.200 Field Seminar in American Politics and Public Policy (A) (New)

Prereq.: Permission of Instructor
Year: G (2)
Arr.

Review of issues in theory and research in American Politics, Public Policy and Urban Politics in preparation for the general qualifying examinations.
Staff

17.201J Politics and Public Policy

(Same subject as 11.007J)
Prereq.: —
Year: U (1, 2) HUM-D
3-0-9

Introduction to political aspects of public policy making. First section considers philosophical rationales for government action and the evolution of government regulation in American history. Second section examines basic strategies of government control: market controls, performance standards, legal instruments, and mass persuasion techniques. Final section introduces ways of analyzing the impacts of public policies — social indicators, cost/benefit analysis, evaluation of distributive equity, and unintended consequences.
M. Lipsky, D. A. Stone, G. Marx

17.203 Evaluation Research Laboratory

Prereq.: —
Year: U (1) LAB
3-5-4

Introduction to the field of public policy evaluation. Acquaints student with the concepts and methods of evaluation research and aids the student in developing skills used in conducting evaluation studies. Topics: the concept of interventionary public policy programs, research designs for public policy evaluatives, alternative analytic methodologies (quantitative and qualitative), and the politics, problems, and policy utilization of evaluative studies. Individual evaluation projects are carried out as part of subject. (May *not* be counted toward Humanities Requirement. ***Not offered 1981-82.***)
S. M. Meyer

17.205 Bureaucracy and Public Policy

Prereq.: —
Year: U (2)
3-0-6

Study of the structure of public organizations and the politics of bureaucracy in the United States. Examination of major theories of bureaucracy and public administration with reference to specific cases involving policy making, policy execution, and the relationship among elected and appointed officials.
H. M. Sapolsky

17.207 Seminar on Health Policy

Prereq.: —
Year: U (1)
3-0-6

Assesses the health system, its politics and its technology. Considers the "health" problem from a variety of policy perspectives. Emphasis on the ways of controlling professional bureaucracies in the health field including both those which develop new technologies and those which deliver services. (Meets with 17.228J.)
H. M. Sapolsky, S. N. Finkelstein

17.211J Distribution of Income and Employment Opportunity

(Same subject as 14.41J)
Prereq.: 14.001
Year: U (1)
3-0-6

Analysis of public policies deriving from concerns about the equality of the distribution of income and employment opportunities in the United States. ***(Not offered 1981-82.)***
Staff

17.213 Regulation

Prereq.: —
Year: U (2)
3-0-6

Analysis of factors that influence the design of regulatory policy, with examples drawn from health and the environment. The full range of policy instruments examined (e.g., taxes, information disclosure, standards, control on market entry, etc.) Addresses economic, political, and administrative considerations in evaluating both regulatory problems and regulatory alternatives. (Meets concurrently with 17.230.)
D. A. Stone

17.215 Public Policy Implementation

Prereq.: —
Year: U (2)
3-0-6

Public policy implementation is concerned with the relationship between the articulation and formulation of policy and what actually happens when policy is "delivered" or received at the point of impact. Examines stages of the implementation process, different policy arenas in which implementation takes place, and different approaches to studying implementation processes. ***(Not offered 1981-81.)***
M. Lipsky

17.217 Media and Public Policy

Prereq.: 17.255
Year: U (2)
3-0-6

Deals with the relationships among politics, policy, and the mass media. Specific case studies of the political uses of television, magazines, and newspapers drawing upon materials from current Executive-Congressional-Press relations. Attention given to the media's role in "tipping" the balance of power toward or away from the Presidency. (Limited enrollment. Permission of instructor required.)
E. Diamond

17.220J The Policy-Making Process (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

An overview of the ways in which public policy evolves, with special emphasis on the interactions of politics and policy analysis. Examines the ways in which cultural, economic, and technological factors have combined with politics and analysis to shape welfare, regulatory, and economic promotional programs in the US and other industrialized democracies. Also considers recent literature on the roles of formal policy analysis in the political process.
A. A. Altshuler

17.222 Research Seminar on Bureaucratic Politics and Institutional Analysis (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Seminar intended for students planning dissertations involving a bureaucratic politics component or stressing institutional analysis. Review of major studies and current work. Discussion of research methods and problems. Presentation of research plans.
H. M. Sapolsky

17.226 Energy Policy (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Projections of energy demand and supply. Macropolicy questions for the US and other major industrial countries, including issues of dependence and interdependence. The economics, risks, health effects, and environmental consequences of alternative energy options, particularly oil, coal, and nuclear. The role of the government in R & D and pricing.
G. W. Rathjens

17.228J Comparative Health Systems (A)

(Same subject as 15.141J)
Prereq.: Permission of Instructor
Year: G (1)
3-0-6

The organization and major issues facing health systems in the US and selected other countries considered from a variety of perspectives, including those of the physician, the manager, and the policy analyst. Cost, quality, access, and technology considered in depth in nonprofit, proprietary, and government elements of the systems. (Meets concurrently with 17.207.)
H. M. Sapolsky, S. N. Finkelstein

17.230 Regulation (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Analysis of factors that influence the design of regulatory policy, with examples drawn from health and the environment. The full range of policy instruments examined (e.g., taxes, information disclosure, standards, control on market entry). Addresses economic, political, and administrative considerations in evaluating both regulatory problems and regulatory alternatives. (Meets concurrently with 17.213.)
D. A. Stone

17.232J International Food and Nutrition Policy (A)

(Same subject as 20.411J)
Prereq.: 20.410J or Permission of Instructor
Year: G (2)
2-0-7

Considers the manner in which the issues of food and nutrition are handled at the macropolitical level. Focuses first on the domestic and foreign policy elements of concern to governments in formulating policy on these matters. Attention then directed to the major policy impacts of bilateral and multilateral approaches to food and nutrition issues between developed and developing nations. Concludes with an examination of the political effectiveness of international institutional mechanisms established to deal with problems such as malnutrition and insufficient food availability.
M. B. Wallerstein

17.234 Business and Government (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Explores business-government relations as they affect management of corporations, formulation of public policy, and legitimization of private sector's role in US society. Topics: the growth of government, public aid for ailing corporations, corporate response to regulation, business involvement in electoral politics, attempts to use business in implementing public policy, and the changing ideology of business. Although stress is on the current US situation, some comparative and historical materials are explored.
H. M. Sapolsky

American Politics

17.241 Introduction to the American Political Process

Prereq.: —
Year: U (1, 2) HUM-D
3-0-9

Study of the functioning of the American national governmental system emphasizing the theoretical and historical background of the Constitution, the Congress, the Presidency, and the Judiciary. Particular attention devoted to diffusion of power in national government, role of the political party, and how institutions of national government help fulfill the goals of a just and democratic society.
T. Ferguson, L. Menand

17.243 American Politics and Social Change

Prereq.: —
Year: U (2) HUM-D
3-0-9

A central paradox in American society is that the political system appears to be very stable, while at the same time vast changes occur in some social and economic relationships. This subject provides some framework for understanding dilemmas of social change in the US by focusing on explanations of stability and orientations toward change, including perspectives drawn from the study of public opinion and underlying cultural values, governmental institutions and electoral politics, "consciousness" movements, and mass struggle and protest.
T. Ferguson

17.245 The Supreme Court and Constitutional Processes

Prereq.: —
Year: U (1)
3-0-9

An interpretation of constitutional rights, processes, and concepts of limited government in light of Supreme Court decisions and of Executive and legislative initiatives.
L. Menand

17.247 The Evolution of American Politics

Prereq.: 17.241 or 17.249 or 17.245 or 17.251
Year: U (2)
3-0-6

Designed to provide students with historical background for understanding growth and change in American national political structures and processes to their present state. The approach, however, oriented at least as much to social science perspectives as to those of more conventional history. Topics: the evolution of Congress, the Presidency, and electoral politics, with attention to changes in behavior, structure, and performance. Primary emphasis placed on developments in the 20th century, and some collateral attention paid to changes in the role of the Supreme Court in the national policy process.
W. D. Burnham

17.249 Political Parties

Prereq.: 17.241
Year: U (1)
3-0-6

Analysis of political parties and their role in decision making in the political system. Primary attention to the American party system, national party organization, Presidential nominating conventions, electoral strategies, and especially the dynamics of American voting behavior. Comparison with parties and electoral behavior in other political systems, especially those of Western Europe. Attention paid to extremist political movements and the behavior of electorates under acute stress.
W. D. Burnham

17.251 Congress and the American Political System

Prereq.: —
Year: U (2)
3-0-6

Focuses both on the internal processes of the House and Senate and on the place of Congress in the American political system. Attention given to committee behavior, leadership patterns, and informal organization. Relations between Congress and other branches of government considered, as well as relations between the two houses of Congress itself. (Meets concurrently with 17.262.)
T. Ferguson

17.253 Executive Leadership: Presidents, Governors, and Mayors

Prereq.: 17.241
Year: U (1)
3-0-9

An examination of the role of chief executives — presidents, governors, and mayors — in the American political process. Focuses on the nature of executive leadership and on the environment in which chief executives make decisions. Students expected to do research on one or more political executives who interest them. (Meets concurrently with 17.268.)
M. W. Weinberg

17.255 Politics, Television, and the News

Prereq.: —
Year: U (1)
3-0-6

The role of television, considered by some the most powerful mass medium in shaping American public attitudes toward elections and issues, especially national and international policies. Focus on TV but newspapers and magazines also discussed. Topics include the influence, if any, of political coverage on elections and policies: news "management" by both government and the media; Presidential access to media; economics and assumptions about audience. Particular attention given to the media's coverage of the New Reagan administration. (Limited enrollment. Permission of instructor required as is attendance at Recitations.)
E. Diamond

17.260 Graduate Seminar in American Politics (A)

Prereq.: 17.241
Year: G (1)
3-0-9

Analysis of the American political system with primary emphasis on the national level. Examination of American political culture, federalism, American party system, representation and public policy, and major institutional components of the national policy process. Special attention to contemporary and comparative research on American politics and government. Discussion also includes some reference to the explicit and implicit theoretical assumptions of such work, as well as critiques of these assumptions.
W. D. Burnham

17.262 Research Seminar on Congress (A)

Prereq.: 17.241
Year: G (2)
3-0-9

Exploration of major issues in the literature on Congress. Focus both on internal processes of Congress and on relationships with other parts of the American political system. Emphasis on independent research projects. (Meets concurrently with 17.251.)
T. Ferguson

17.264 Dynamics of Electoral Politics (A)

Prereq.: 17.241
Year: G (2)
3-0-9

Analysis of mass voting behavior in the US, past and present. Evaluation of leading theories of American electoral politics in light of inferences from data analysis. Primary emphasis on longitudinal system dynamics and other properties, both quantitative and nonquantitative. Some comparative analysis of electoral dynamics and theories of electoral politics in other Western political systems. Attention to American voting behavior since 1960.
W. D. Burnham

17.266 Government and the American Economy (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Deals with what the US government does about regulation, international trade, collective bargaining, restrictive licensing, fiscal and monetary policy and theories about why it does it. Does not presuppose any special knowledge of American history, law, or economics. Methodological points concerning the use of business and economic data in political science research receives some attention.
T. Ferguson

17.268 Executive Leadership: Presidents, Governors and Mayors in the US (A)

Prereq.: 17.241
Year: G (1)
3-0-9

An examination of the role of chief executives — presidents, governors and mayors — in the American political process. Focuses on the nature of executive leadership and on the environment in which chief executives make decisions. Students expected to do research on one or more political executives who interest them. (Meets with 17.253.)
M. W. Weinberg

17.270 Seminar on the Evolution of American Politics (A)

Prereq.: 17.241 or 17.249 or 17.245 or 17.251
Year: G (2)
3-0-9

Focus on the historical development of American political structures and processes. Approach, however, oriented at least as much to social science perspectives as to those of more conventional history. Topics: the evolution of Congress, the Presidency, and electoral politics, with attention to changes in behavior, structure, and performance. Some consideration given to changes in the role of the Supreme Court. (Meets concurrently with 17.247.)
W. D. Burnham

Urban Politics and Public Policy

17.281 Urban Politics

Prereq.: —
Year: U (1)
3-0-6

Analysis of current American urban political issues in terms of their historical and sociological bases, theoretical significance, and relationship to broader American politics. Deals with concepts involving power structures, ethnicity, law, justice, public participation, and public administration. Specific concerns include education, housing, police, transportation, welfare, and other dimensions of public policy.
E. L. Jackson

17.283J Urban Politics, Planning and Public Policy (Revised Content)

(Same subject as 11.164J)
Prereq.: —
Year: U (2) HUM-D
3-0-6

Examination of the politics of urban planning, policy development, and policy implementation. Urban policy viewed as a product of the entire American Federal system. Selected policy topics examined in detail. These include land use planning, urban renewal, fiscal policy, transportation, and air pollution control. Special attention paid to the bases for alternative theoretical interpretations, such as Marxist and neo-conservative, of the record in each policy arena. (Meets with 17.288J).
A. A. Altshuler

17.285 Racial and Ethnic Politics

Prereq.: —
Year: U (2)
3-0-6

Analysis of the extent to and the ways in which societal issues such as fiscal scarcity, slow growth and government contraction alter the growth-politics of America's most visible racial and ethnic groups. Provides an historical overview of racial and ethnic politics in developmental stages and growth eras. Reconsiders the future of racial and ethnic politics. Considers, too, the potential impact of limits on subgroup politics on the larger social order. Suggests possibilities and opportunities for alternative policies toward a viable political future in a multiracial society of limits.
E. L. Jackson

17.286 Seminar in Urban Politics (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Examination of current issues in urban politics, and alternative perspectives for analyzing them. Topics: machine politics, the legacy of the reform movement, community action and citizen participation, decentralization, metropolitanization, public service policy and delivery, and the fiscal crisis of the city. Consideration of the utility of pluralist and neo-Marxist frameworks in understanding American urban political development and public policy.
M. Lipsky

17.288J Urban Politics, Planning and Public Policy (A)

(Same subject as 11.505J)
Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Examination of the politics of urban planning, policy development, and policy implementation. Urban policy viewed as a product of the entire American Federal system. Selected policy topics examined in detail. These include land use planning, urban renewal, fiscal policy, transportation, and air pollution control. Special attention paid to the bases for alternative theoretical interpretations, such as Marxist and neo-conservative, of the record in each policy arena. (Meets with 17.283J.)
A. A. Altshuler

17.290 Urban Political Economy

Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Analysis of the changing roles and functions of cities in the evolving framework of American Political Economy. Special attention to: city fiscal crises and cutback political processes; industrial relocation and corporate outmigration; decline of Industrial Northeastern cities and growth of Sun Belt cities. (Open to advanced undergraduates. Meets concurrently with 17.293.)
E. L. Jackson

17.292 Field Seminar in Urban Politics (Issues in Theory and Research) (A)

Prereq.: Permission of Instructor
Year: G (2)
Arr.

Comprehensive review of the urban politics field in preparation for the general qualifying examinations.
Staff

17.293 Urban Political Economy (New)

Prereq.: —
Year: U (1)
3-0-6

Analysis of the changing roles and functions of cities in the evolving framework of American Political Economy. Special attention to city fiscal crises and cutback political processes; industrial relocation and corporate outmigration; decline of Industrial Northeastern cities and growth of Sun Belt cities. (Meets with 17.290.)
E. L. Jackson

17.294 Urban Scarcity Politics and City Fiscal Crises (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Focuses on contemporary city fiscal crises and "cutback" political processes as graphic particulars of US urban scarcity politics. Organizationally, the central questions concern causes, processes and consequences of scarcity politics. Special attention given to internal city politics, external political actors, agencies and markets and to exogenous structural forces (regional economic shifts, social demographics and national urban "policies"). (Meets concurrently with 17.297.)
E. L. Jackson

17.296 Seminar on Bureaucracy and Implementation in Public Services (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Analysis of dimensions of public service delivery that bear on the quality, availability, and mode of organizing public services. Particular emphasis on social services in which workers interact directly with citizens (i.e., police, teachers, welfare, court, and health personnel.) Topics: interactions between citizens and clients, control of public service bureaucracies, and the balance between bureaucratic and professional accountability. (Open to qualified undergraduates.)
M. Lipsky

17.297 Urban Scarcity Politics and City Fiscal Crises (New)

Prereq.: —
Year: U (2)
3-0-6

Focuses on contemporary city fiscal crises and "cutback" political processes as graphic particulars of US urban scarcity politics. Organizationally, the central questions concern causes, processes and consequences of scarcity politics. Special attention given to internal city politics, external political actors, agencies and markets and to exogenous structural forces (regional economic shifts, social demographics and national urban "policies"). (Meets with 17.294.)
E. L. Jackson

Science, Technology and Policy

17.301 Science, Technology and Politics

Prereq.: —
Year: U (1)
3-0-6

Upperclass seminar that examines the impacts of science and technology on governmental institutions and processes. Major themes include extent to which science and technology have transformed fundamental political institutions and relationships, role of scientists and engineers in political decision making, Federal government structure and processes for managing R&D and dealing with technological innovation, budgeting for R&D, societal mechanisms for reaching decisions on controversial technological issues, government/private sector relationships, and impact of science and technology on foreign policy and international political relationships. Case material drawn from such public policy areas as energy, defense, biomedical research, and the environment. (Meets with 17.320.)
T. R. I. Greenwood

17.303 Theories of Technological Society and Politics

Prereq.: —
Year: U (2)
3-0-6

Political theory examining the relationship between technology and politics. Attention to ways in which social science, Marxism, Liberalism, phenomenology, and critical theories of technological societies have dealt with this question. Themes include domination of nature, instrumental rationality, technocracy, complexity and responsibility, the control of technology. Consideration of the writings of Marx, Ellul, Habermas, Horkheimer, Heidegger, Mumford, and others. (Meets with 17.324. ***Not offered 1981-82.***)
Staff

17.305J Rationality, Risk, and Choice in Industrial Society

(Same subject as STS 401J)
Prereq.: —
Year: U (2) HUM-D
3-0-9

Survey of the environmental and health consequences of 20th-century technology, as viewed from historical, ethical, legal, and scientific perspectives. Historical development of the concepts of risk and uncertainty; 19th- and early 20th-century precursors of current environmental controversies. Health effects of nuclear and fossil electricity generation. Toxicity of chemicals and food additives in general use. Value choices underlying social decisions to create modern technological systems; ethical limitations of cost-benefit analysis in valuing human life for public policy purposes. Justification for and limitations of formal adversary methods for dealing with rights in conflict.
J. Yellin

17.307J Legal, Ethical, and Scientific Issues in the Regulation of Dangerous Industries

(Same subject as STS 411J)
Prereq.: Permission of Instructor
Year: U (1)
3-0-9

Upperclass seminar dealing with regulation of industrial activities in which the health and safety of the public are important considerations. Judicial review of environmental decisions made by Federal agencies. Litigation over air and water quality and nuclear power. Constitutional basis of American administrative law: Congressional delegation of powers. Use of scientific and statistical methods by Federal agencies and courts. Consideration of whether

procedural and scientific issues are separable in environmental controversies. Philosophical, economic, and ethical issues related to the valuation of human life.
J. Yellin

17.309 Politics of Environmental Policy

Prereq.: —
Year: U (1)
3-0-6

Examines four cases which facilitiate study of the interactions of politics and technical policy analysis. Cases are: environmental aspects of nuclear power controversy; threats to global ozone layer; control of auto emissions; and recombinant DNA controversy. Students come to grips with at least a fair sample of political *and* technical complexities in each. Focus is on common threads in these diverse issues, and attempts to develop a sense of how analysis can proceed in the face of uncertainties and complexities characteristic of such issues. Attention paid to conditions under which, and extent to which, it is realistic to expect analysis to influence highly politicized controversies. ***(Not offered 1981-82.)***
Staff

17.320 Science, Technology and the State (A)

Prereq.: 17.241
Year: G (1)
3-0-9

Seminar examines the impacts of science and technology on governmental institutions and processes. Major themes include extent to which science and technology have transformed fundamental political institutions and relationships, role of scientists and engineers in political decision making, Federal government structure and processes for managing R & D and dealing with technological innovation, budgeting for R & D, societal mechanisms for reaching decisions and controversial technological issues, government/private sector relationships, and impact of science and technology on foreign policy and international political relationships. Case material drawn from such public policy areas as energy, defense, biomedical research, and the environment. (Meets with 17.301.)
T. R. I. Greenwood

17.322 Seminar in Systematic Policy Analysis and Technology Assessment (A)

Prereq.: 14.001, 14.002
Year: G (2)
3-0-6

Analysis of policy problems illustrative of those facing the Federal and local governments. Cost-benefit calculations and topics in welfare economics. Cases selected from such areas as energy policy, the environment, space programs, and communications. (Open to undergraduates by permission of instructor only.)
Staff

17.324 Theories of Technological Society and Politics (A)

Prereq.: 17.701
Year: G (2)
3-0-9

Seminar examining ways in which technology is problematic for modern social theory. Focus on relevant themes in social science, Marxism, phenomenology, and critical theories of technological society. Explores questions of the control of technology, philosophical inquiries into the domination of nature in the West, critiques of instrumental rationality, the question of technological imperatives, the relationship of technical forms and modern culture. Selections from the writings of Bacon, Ellul, Heidegger, Habermas, and others. (Meets with 17.303. ***Not offered 1981-82.***)
Staff

17.326 International Organization, Legal and Political Response to Science and Technology (A)

Prereq.: 17.320
Year: G (1)
3-0-6

Seminar examining some of the international political, legal, and institutional implications of selected areas of science and technology. Past and possible future responses of the international political system to new technologies or technology-related problems. Examination primarily from the perspective of the development of international law and international institutions. Concentration of case materials in the field of international regulation of atomic energy applications, the deep ocean and international problems in pollution and environmental control. Conducted jointly with Harvard Law School. (Limited enrollment. Permission of instructor required. ***Not offered 1981-82.***)
E. B. Skolnikoff

17.328 Science and Technology in International Affairs (A)

Prereq.: 17.320
Year: G (1)
3-0-9

Explores the roles of science and technology in international system, and process by which foreign policy involving science and technology is made in the US. Provides an overview of major international political effects of scientific and technological enterprise and develops the role of science and technology in a few issue-areas in some detail: East/West transfer of technology, North/South relations, national security, international organizations, bilateral relations, and a selection of others. Policy structure and process in the US government and the international system to reflect these issues analyzed, with key problems discussed. Roles of scientists and engineers in the US and internationally also explored. (Permission of instructor required.)
E. B. Skolnikoff

17.330J Seminar in Technology and Development (Revised Content)

(Same subject as 21.506J)
Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Explores issues that interface development process and the technological transformation of less-industrial societies. Lectures and case studies are geared to graduate students interested in the experience and social contexts of engineering for development. Taught by an interdisciplinary faculty drawn from political science, anthropology, engineering and economics.
N. Choucri, Staff

17.332 Field Seminar in Science and Public Policy (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Comprehensive review of the Science and Public Policy field in preparation for the general qualifying examinations.
Staff

International Relations/Arms Control and Defense Studies

17.334J International Air Transportation

(Same subject as 16.752J)
Prereq.: —
Year: G (1)
3-0-6

Introduction to problems of international air transportation with emphasis on political and legal aspects. Topics: international civil aircraft industry; types of airline ownership, characteristics of air transport in North and South America, Europe, the Middle East, Asia, Africa, China, and the Soviet Union, world route patterns, bilateral negotiations, international air transport organizations, problems of air transport in developing nations, unlawful interference with aircraft, restrictive governmental practices on airlines, and international charter and cargo operations. Classwork supplemented by guest lecturers. Term paper required.
B. R. Gidwitz, R. W. Simpson

17.336J Scientific Knowledge, Social Values, and Politics (A)

(Same subject as STS 207J)
Prereq.: Permission of Instructor
Year: G (2)
2-0-10

Historical and contemporary studies of the changing role of scientific ideas and arguments in social and political discourse from antiquity to the present. Emphasis on social and political implications that have been drawn from the natural sciences: how scientific concepts and theories have been employed to give meaning to social and political experience; ways in which conceptions of the natural world and people's place in it have served as models for the good society; uses of scientific modes of analysis to explain the values that shape human behavior. ***(Not offered 1981-82.)***
L. R. Graham, P. Buck

17.338J Regulation of Hazardous Materials (A) (New)

(Same subject as STS 414J)
Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Examination of statutory, organizational, procedural, and political bases for the regulation of hazardous materials in the US and how these various input variables influence regulatory outputs, such as standards and permits issued by regulatory agencies. Primary focus on how organizational structure, procedures, and politics interact with the acquisition and use of scientific and technical information and with the use of various methodologies for risk assessment and cost-benefit analysis. Examples include the regulation of carcinogens, air pollutants, hazardous chemicals in the workplace, toxic wastes, and nuclear waste. Students examine the statutes underlying regulatory regimes, actual standards that agencies promulgate and the analyses on which these are based. The issues and politics of the current debate on regulatory reform examined. (Open to advanced undergraduates.)
T. R. I. Greenwood, J. Yellin

Internships

17.351J State and Local Government Internships

(Same subject as 11.197J)
Prereq.: —
Year: U (1, 2)
3-0-9

Internship for each student with a state or local public agency or legislator, supplemented by a seminar of the participants. Instructor assists in arranging internships which normally run from October to April. Seminar meets every other week during both terms. Students required to write several short papers analyzing their work experience. Students receive grade of J at end of first term; they must enroll again for same subject second term. No new students accepted in second term. (Upon successful completion of two semesters, student petitions for one Humanities Elective credit will be honored.)
M. H. King

17.353 Media and Public Policy Internships

Prereq.: 17.255
Year: U (2)
3-0-9

Deals with the relationships among politics, policy, and the mass media and combines weekly seminars with an eight-hour per week internship in a media-related position. Specific case studies of the political uses of television, magazines, and newspapers drawing upon materials from current Executive-Congressional-Press relations. Attention given to the media's role in "tipping" the balance of power toward or away from the Presidency. (Limited enrollment. Permission of instructor required.)
E. Diamond

International Relations and Foreign Policy

17.401 Aggression, War and Civilization

Prereq.: —
Year: U (1) HUM-D
4-0-8

How are aggression and warfare related to the evolution of civilization? Topics include aggression in human evolution, the development of aggression in children and adults, the social invention of warfare, world wars and garrison states. Issues include the glorification of war, the inevitability of aggression, war criminality, and the search for peace. Data drawn from anthropological, sociological and psychological investigations, utopian communities, and cross-societal correlations of warproneness with social, technological, and political development.
H. R. Alker, Jr., L. S. Etheredge

17.403 American Foreign Policy in a Changing World

Prereq.: 17.401 or 17.407
Year: U (2) HUM-D
3-0-6

The US as a major actor in a fast-changing world. Lectures and discussions focusing on: the roots of US foreign policy; origins of the Cold War; the age of intervention; security redefined; interdependence; future options.
L. P. Bloomfield

17.405 Seminar in Middle Eastern Politics

Prereq.: —
Year: U (1)
3-0-6

Focusing on the politics of the Middle East. Divided into three parts: 1) domestic and regional politics of the Arab East, Iran and the Gulf, the Maghreb, and Israel; 2) energy: the world oil and energy picture; 3) Middle East and world politics; the East-West conflict, the Arab-Israeli conflict, and their interaction with the energy crisis. Lectures, discussions, and a paper or a take-home examination. Coordinated with 17.426.
W. E. Griffith, L. P. Bloomfield, N. Choucri

17.407 International Relations: War and Peace

Prereq.: —
Year: U (2)
3-0-6

Introduction to the study of real and potential international systems. Topics: international warfare, the impact of technology on war and the arms race, the balance of power, classical and modern imperialisms, regional and universal international organizations. Alternative and preferred futures also considered.
N. Choucri

17.420 Theories of International Relations (A)

Prereq.: 17.407 or 17.403
Year: G (1)
3-0-9

Selective review and critical discussion of the literature of international relations. Comparison of disciplinary foci and conceptual frameworks proposed by authors in major alternative theoretical traditions: political realism, systems theory, peace research, and Marxism. Material reviewed for its substantive hypotheses, normative orientations, data resources, and research possibilities. Special concern in 1981 on the subject of world order. (Open to undergraduates by permission of instructor only.)
H. R. Alker, Jr.

17.422 World Politics and International Economics (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Interdisciplinary analysis of the ways in which nations undertake dual international objectives: pursuit of power and pursuit of wealth. Survey of major competing paradigms of international political economy, including neoclassical economics, Marxist and neo-Marxist theories, dependency theses, and structural European views of power relations, among others. Analysis of political and economic dimensions of international trade, capital flows, foreign investment, and military and strategic policies. Review of the evolution of international economic organizations and of their political implications for national policy and international politics. (***Not offered 1981-82.)***
N. Choucri

17.424 United States-Latin American Relations

Prereq.: —
Year: G (2)
3-0-9

Survey of political and economic relations between the US and Latin American countries, with emphasis on the post-1940 period. Consequences of US political-economic hegemony for Latin American development. US responses to Latin American revolutionary movements and to Latin American initiatives to establish a new international economic order. (Open to undergraduates with permission of instructor. ***Not offered 1981-82.***)
Staff

17.426 The Politics of the Middle East (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Three parts: 1) domestic and regional politics of the Arab East, Iran and the Gulf, the Maghreb and Israel; 2) energy, the world oil and energy picture, Middle Eastern oil, and its political implications; and 3) the Middle East and world politics: the East-West conflict, the Arab-Israeli conflict, and their interaction with the energy crisis. Lectures, discussions, and a paper or a take-home examination. Coordinated with 17.405. (Open to qualified undergraduates.)
W. E. Griffith, L. P. Bloomfield, N. Choucri

17.428 US Foreign Policy — Past, Present, Future (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Critical analysis of US foreign policy in the context of past tendencies and future possibilities. Roots of US policy; origins of the Cold War; the "Age of Intervention;" security redefined; interdependence; future options. (Open to advanced undergraduates only.)
L. P. Bloomfield

17.430 The Foreign Policy Process (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

The planning and execution of foreign policy in the US (and, where data available, other countries). Relevant organizational and decision-making models and theories critically analyzed. The President and Congress. System weaknesses for interdependence policies. Policy planning, crisis behavior, and issues of irrationality. Simulation and other techniques. Student-run planning game. (Open to advanced undergraduates by permission of instructor only. ***Not offered 1981-82.***)
L. P. Bloomfield

17.432 Field Seminar in International Relations and Foreign Policy

Prereq.: Permission of Instructor
Year: G (1)
2-0-2

Selective review of the International Relations and Foreign Policy field in preparation for the general qualifying examination. Subject meets 4-5 times during one month. (Not for credit.)
H. R. Alker, Jr., L. P. Bloomfield, N. Choucri

17.434 Research: International Relations and Foreign Policy (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Problem approach to areas and issues based on student interest. Review of major themes that cut across the field, such as national security, international organizations, and interdependence. Preparation for generals and professional work.
L. P. Bloomfield

17.436 Comparative Foreign Policy (A)

Prereq.: 17.407 or 17.405
Year: G (2)
3-0-6

Comparative analysis of national and international dynamics insofar as these pertain to domestic sources of foreign policy and external constraints. Special focus on major global problems and the effects on foreign policies of nations, specifically the US, USSR, Western Europe, and developing countries of Asia, Africa, and Latin America. Specific focus on energy issues and technological transfers. (Open to undergraduates. ***Not offered 1981-82.***)
N. Choucri

17.438 Comparative African Politics: Research Seminar (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Comparative analysis of politics and foreign relations of Southern Africa emphasizing South Africa but including other states in the region. Focuses on the interests in and policies toward the states of the region on the part of the US and other Western powers. Domestic economic, social, and political factors

that affect the foreign relations of the states are considered. (Open to undergraduates with permission of instructor. ***Not offered 1981-82.***)
W. R. Johnson

17.440J The Finite Earth: Agendas for a More Just, Sustainable and Participatory Society

(Same subject as 4.761J, 11.486J, 21.919J, 22.83J)
Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Problems such as food supply, energy, material resources, global environment, and rapid changes in third world countries often tend to be looked on as separate; but each affects the other, and the connective tissue between them is too often lost. Subject explores several of these issues (especially food, energy, technology transfer, world security, and the views from alternative social systems) in context. Each topic cannot be developed in depth; purpose of subject is to introduce interested students to these issues; to ways in which they interactively influence the quality of social life for many in today's world; and to assess choices and directions for the future, both generally and as they may affect the student's own personal and professional interests. Content developed via a combination of lectures and discussion groups.
W. R. Johnson, J. Beinart, M. Diskin, N. B. Herman, D. J. Rose

Defense and Arms Control Studies

17.461 Determinants of Strategic Nuclear Forces

Prereq.: —
Year: U (1)
3-0-6

Introduction to the history of the development of strategic nuclear forces and strategy. Consideration of major alternative postures and their implications for deterrence and arms control. Projections of the future role and limitations of strategic nuclear forces.
W. W. Kaufmann

17.463 Determinants of General Purpose Forces

Prereq.: 17.461
Year: U (2)
3-0-6

Introduction to the history of concepts about limited war developed since World War II. Comparison of nuclear and non-nuclear forces for the deterrence and conduct of limited war. Analysis of the problem of escalation and its control. Consideration of current US requirements for limited war forces.
W. W. Kaufmann

17.465J In Pursuit of Arms Control: Analysis of the Past and Choices for the Future

(Same subject as 22.003J)
Prereq.: —
Year: U (2)
3-0-6

Review and analysis of nuclear and non-nuclear arms and efforts at arms control since World War II. Focus on interaction of technological factors, changing strategic concepts, intelligence estimates, and political judgments in the decision making process. Topics: nuclear proliferation, Strategic Arms Limitation Talks, Mutual and Balanced Force Reductions, new military technology, and current trends in US and Soviet weapons programs. Students learn to evaluate and to design alternatives to current government arms control and national security policy.
T. R. I. Greenwood, N. C. Rasmussen

17.467 Arms Trade and Foreign Policy

Prereq.: —
Year: U (2)
3-0-6

Considers international trade in arms from the perspective of producing states and the non-producers. Among the topics considered: foreign policy rationales given for the trade, the nature and pattern of recent arms trade, factors that will affect the future, and proposals for control.
A. C. Leiss

17.469 Military Forces in the Management of Foreign Policy

Prereq.: —
Year: U (2)
3-0-6

National military forces, ostensibly designed and maintained to support nations during times of war, have seen more frequent use in pursuit of non-war foreign policy objectives. This subject examines the application, utility, and effect of national military forces in the management of foreign policy. Five specific applications emphasized: deterring central war between the US and the USSR, coercive diplomacy, crisis management, (limited) intervention, and influencing "global" perceptions. Follows an explicit comparative historical framework, contrasting US and Soviet approaches and behaviors in each area of application from 1945 to 1981. (Meets with 17.492.)
S. M. Meyer

17.480 Development of Strategic Nuclear Forces (A)

Prereq.: 17.461
Year: G (1)
3-0-6

Analysis of major US policy decisions concerning general war systems and strategies in the postwar period. Emphasis on the technological, strategic, political, budgetary, and environmental factors that have affected these decisions. Examination of the role of innovation and analysis in the evolution of general war systems and strategies. (Open to undergraduates by permission of instructor only.)
W. W. Kaufmann

17.482 Development of General Purpose Forces (A)

Prereq.: 17.480
Year: G (2)
3-0-6

Analysis of major US policy decisions concerning limited war systems and strategies in the postwar period. Emphasis on the determination of force structures and on changing views about the utility of nuclear weapons, the problem of escalation, and the relationship between limited war and general war forces and strategies. (Open to undergraduates by permission of instructor only.)
W. W. Kaufmann

Comparative Politics/Political Development/Communist Studies

17.486J The Technology and Politics of Nuclear Weapons and Arms Control (A)

(Same subject as 6.932J)
Prereq.: Permission of Instructor
Year: G (2)
4-0-8

Review of nuclear weapons systems developments and efforts at arms control. Focus on the interaction of technological factors with strategic concepts, intelligence assessments, and political judgments. Topics: nuclear weapons technology and effects, nuclear weapons proliferation, and analysis of current strategic arms programs. To the extent possible, experts who have played key roles in the topics covered are invited to give guest lectures.
G. W. Rathjens, J. P. Ruina

17.488 Principles of Systematic Policy Analysis (A)

Prereq.: 17.461
Year: G (1)
3-0-6

Systems analysis of policy choices in the defense area. Analytical approaches and critique of applications. Political and bureaucratic constraints on analytic procedures. The role of judgment in problem formulation and in the selection of cost and benefit criteria. (Open to undergraduates by permission of instructor only.)
G. W. Rathjens

17.490 Issues in Soviet Defense Planning (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Examines a selection of the historical, recurrent, and contemporary issues that have arisen in the planning and implementation of Soviety defense policy. While specific topics considered vary from year to year, general areas covered include issues in weapons design, procurement and deployment, force structuring, strategy and doctrine, and arms control. In attempting to gain an appreciation of the Soviet perspective, translated Soviet source materials used, and supplemented with analyses by western specialists. ***(Not offered 1981-82.)***
S. M. Meyer

17.492 Military Forces in the Management of Foreign Policy (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Examines the application, utility, and effect of national military forces in the management of foreign policy. Five specific applications emphasized: deterring central war between the US and the USSR, coercive diplomacy, crisis management, (limited) intervention, and influencing "global" perceptions. Follows an explicit comparative historical framework, contrasting US and Soviet approaches and behaviors in each area of application from 1945 to 1981. (Meets with 17.469.)
S. M. Meyer

17.494 Modeling Laboratory for Defense/Arms Control Analysis (A) (New)

Prereq.: 17.480 or 17.482 or 17.488
Year: G (2)
3-0-9

Much of the work done in the defense/arms control field relies on the use of quantitative techniques and analytic models. Students devise elementary models used in force posture planning, develop corresponding computer programs, and run the models. By varying the assumptions of the computer models, students investigate the sensitivity of defense/arms control policy to changes in model structures and assumptions.
S. M. Meyer

See also 17.543, 17.545, 17.547, 17.549, 17.551J, 17.226, 17.232J, 17.326, 17.328, 17.330J, 17.332, 17.583, 17.586, 17.604.

Theories and Research Methods

17.501 The Quest for Equality and Development in Third World Countries

Prereq.: —
Year: U (1) HUM-D
3-0-9

Examines value aspects of, and policy choices in, attempts to balance economic growth with social and economic equity in underdeveloped countries. Tensions between growth and equity explored in such policy areas as education, population control, investment, land reform, food and nutrition: primary attention given to the way in which value issues are defined by those who live in underdeveloped countries, and to place the problems of development in an historical as well as an international context. Two-hour recitation sections devoted to looking at specific countries in Subsahara Africa, Latin America, and Asia. Sections meet together for a weekly lecture. Class discussion, comparative and historical readings, interpretive writing assignments, and a final examination.
M. Weiner

17.503 Political Economy of Urbanization

Prereq.: Permission of Instructor
Year: U (2)
3-0-9

Seeks to provide an overview of the urbanization process in contemporary Third World countries, with principal emphasis on ways in which government policies and programs affect the rate, form, and consequences of the urbanization process. Special attention devoted to differences among various kinds of regimes (e.g., state capitalist, revolutionary socialist) in terms of the content and outcomes of public policies affecting the spatial distribution of population and wealth. (Meets concurrently with 17.524.)
Staff

17.505 Comparative Afro-American and African Politics (Revised Unit)

Prereq.: —
Year U (1)
3-0-9

Analysis of the "colonial analogy" between the political and economic experience and plight of black people and other ethnic minorities in urban American ghettoes, and African peoples. Examination of the similarity and differences in the political economy of the two experiences of dependency, and of efforts to overcome this dependency.
W. R. Johnson

17.506 Theories and Approaches to the Study of Comparative Politics (A)

(17.510)
Prereq.: 17.150
Year: G (2)
3-0-6

An examination of various approaches which underlie our study of comparative politics; literature drawn primarily from Western Europe. The utility of alternate conceptualizations and theoretical formulations found in the general literature on comparative politics. (Open to undergraduates by permission of instructor only.)
L. W. Pye

17.508 Comparative Political Economy (A) (New)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

A review of contemporary political economic studies of advanced and industrializing countries. Topics include inflation-unemployment tradeoffs, the political-business cycle, public and private sector contributions to growth and dependency reversal.
J. Freeman

17.510 Comparative Urban Politics

(17.511)
Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Comparative (cross-national and cross-cultural) study of urban politics and local and national government outputs affecting urban populations. Topics include: relationships between national and local political systems, social bases of urban political leadership, the political implications of regional vs primate cities, and the relationship between partisanship and policy choice. Special attention paid to the development by students of their own comparative framework for the study of selected urban policy issues.
R. J. Samuels

17.512 Theories of Political Development (A)

Prereq.: —
Year: G (1)
3-0-9

Study of analytical models of the political process in transitional societies. Systematic examination of factors influencing political behavior in changing societies; functions of politics in such societies. (Open to qualified undergraduates.)
L. W. Pye

17.514 Migration and Political Development (A)

Prereq.: 17.501
Year: G (1)
3-0-9

Exploration of the political causes and consequences of population movements across international boundaries and within states. Detailed examination of the following: political effects of urban migration; political behavior of political refugees; consequences of internal population movements in multi-ethnic societies; economic and political impact of migrants on the receiving country; effects of migration on the country of origin. Case materials drawn from contemporary Asia, Africa, and Latin America.
M. Weiner

17.516 Democratic Elections in Developing Countries (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Reexamines democratic theories in light of the experiences of those low-income countries that have maintained political parties and competitive democratic elections. Particular attention given to socioeconomic and class theories purporting to explain the development and institutionalization of democratic institutions. Impact of the electoral process on popular participation, demand-making, patron-client relations, inter-ethnic conflicts, political organization and legitimacy considered. Among the countries likely to be studied are Colombia, Greece, India, Malaysia, Nigeria, Portugal, Sri Lanka, Turkey and Venezuela and a number of small countries in Africa and in or near the Caribbean. ***(Not offered 1981-82.)***
M. Weiner

17.518 Field Research in Political Development (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Seminar in field research methods for political research in developing areas. Subject intended to assist students in preparation of their doctoral thesis proposal — defining the problem, designing the research and exploring the utility of a variety of research methods, including interviewing, the use of informants, participation observation, survey research, case methods, experimentation, and documentary research. Attention also given to various aspects of field research, such as the nature of research environment, ethical responsibilities of social scientists, and role of language in social research. Subject conducted with participation of other faculty members. ***(Not offered 1981-82.)***
M. Weiner

17.520 Field Seminar: Politics of Development and Underdevelopment (A)

Prereq.: 17.501
Year: G (2)
3-0-9

Comprehensive survey of the field of Political and Economic Development. Major topics: the evolution of political development theory; normative aspects of political development; social class, ethnicity, territoriality, and patron-client linkages as determinants of political behavior in Third World countries; relationships between socioeconomic change and political system change: role of conflict, violence, and revolution in development; role of political leadership in the development process; authoritarian paths of political development; militarism and performance of military regimes; theories of economic development and underdevelopment; international context of development; policy issues in development; comparative analysis of selected public policies in Third World countries; pedagogical issues and approaches in the development field.
Staff

17.522 Research Seminar on African Development (A)

Prereq.: 17.576
Year: G (1)
3-0-9

Research seminar on particular development problems of selected African countries. Intensive examination of a sector, institutional factor, or process. Examples include agricultural development, the parastatal sector, regional integration. (Permission of instructor required.)
W. R. Johnson

17.524 Political Economy of Urbanization (A)

Prereq.: 17.241
Year: G (2)
3-0-9

Explores the ways in which government policies and programs influence the spatial distribution of population and wealth in Third World countries. Particular attention devoted to contradictions between government efforts to reduce spatial inequalities and other policies having different objectives. Comparison of "modernization/developmentalist" and "neo-Marxist/dependency" conceptions of urbanization and the role of large cities in the development process. Survey of policy alternatives for reducing or rechanneling internal migration flows, and the relative effectiveness of such policies, as demonstrated by the experience of selected Latin American, African and Asian countries. (Meets concurrently with 17.503.)
Staff

See also 17.154J, 17.156J.

Advanced Industrial Societies

17.531 The Welfare State

Prereq.: Permission of Instructor
Year: U (2)
3-0-6

Surveys the development of the modern welfare state, with a focus on five countries (US, Great Britain, West Germany, Sweden, and the Soviet Union). The first part examines ideological, political, and economic factors in the formation of social insurance systems to deal with problems of old age, disability, illness, and unemployment. In the second part, selected topics in social policy considered, including health care delivery and worker participation in industrial management.
D. A. Stone

17.532 Problems of Advanced Industrial Societies (A) (New)

Prereq.: 17.156J
Year: G (2)
3-0-9

Analysis of selected current political economy issues. Topics include Inflation, industrial relations systems, the "crisis of ungovernability," public assistance and family policy, and "reindustrialization." (Permission of instructor required.)
S. Berger, M. J. Piore

17.533 Politics and Policy in Contemporary Japan

Prereq.: Permission of Instructor
Year: U (1)
3-0-6

Divided into two major sections. After an introduction to Japan and to the dominant approaches to the study of Japanese History, Politics, and Society, the first section concerns Japanese politics; Party, Electoral Politics, Bureaucratic Politics, and Interest Group Politics. The second section concerns Japanese Public Policy; Foreign Policy, Energy Policy, Science and Technology Policy, and Industrial Policy. Attention devoted to generalizations about public policy in Japan which challenges the conventional stereotypes of Japan as a monolithic state.
R. J. Samuels

17.534 Domestic Politics of Western Europe (A)

Prereq.: 17.701
Year: G (1)
3-0-6

Comparative study of politics and society in France, Great Britain, Germany, and Italy. Analysis of the "cases" of the integration of feudal remnants and the problem of controlling the economy. (Open to undergraduates.)
S. Berger

17.536 Research Seminar in Comparative Politics: Western Europe (A)

Prereq.: 17.534
Year: G (2)
3-0-6

For students planning research in Western European countries. Discussion of current work in the field. Training in the use of European primary source materials and in research methods applicable to European problems. Presentation of students' own research projects. ***(Not offered 1981-82.)***
S. Berger

17.538 Comparative Social Policy (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Surveys the development of the modern welfare state, with a focus on five countries (US, Great Britain, West Germany, Sweden, and the Soviet Union). The first part examines ideological, political, and economic factors in the formation of social insurance systems to deal with problems of old age, disability, illness, and unemployment. In the second part, selected topics in social policy considered, including health care delivery and worker participation in industrial management. ***(Not offered 1981-82.)***
D. A. Stone

17.540 Politics and Policy in Contemporary Japan (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Analysis of contemporary Japanese politics, focusing primarily upon the post-World War II period. Topics include: examination of the dominant approaches to Japanese politics and society, the structure of the party system, the role of political opposition, the policy process, foreign affairs, and interest groups. Special attention devoted to the development of less idiosyncratic approaches to the study of Japan. (Meets concurrently with 17.533.)
R. J. Samuels

See also 17.156J, 17.338J, 17.436.

Developing Countries

17.543 Mass Politics in Latin America

Prereq.: —
Year: U (1)
3-0-6

Introduction to main currents in Latin American politics. Includes an historical overview of political economy since colonial era, and an analysis of three contemporary explanatory models of development: modernization theory, dependancy perspectives, and bureaucratic-authoritarian explanations. Four contrasting case studies since 1960 are used as tests of competing theories—Chile, Peru, Brazil, and Cuba. A concluding overview of contemporary issues in US foreign policy towards Latin America. (Meets concurrently with 17.580.)
B. H. Smith

17.545 Political Crises in South Asia: India, Pakistan, and Bangladesh

Prereq.: —
Year: U (2)
3-0-6

Examination of the major systemic transformations that have occurred in the politics of South Asia: emergence of Bangladesh, and regime changes in both India and Pakistan, as these relate to problems of modernization and development. Particular attention given to the major social and economic transformations taking place, including rapid population growth, urbanization, agrarian change, and changing caste, regional, religious, and class identifications; and to the political determinants and constraints on development policy. (Meets concurrently with 17.570.)
M. Weiner

17.547 Communist China

Prereq.: —
Year: U (2)
3-0-6

An analysis of the Chinese Revolution. Brief introduction to traditional Chinese civilization and then detailed analysis of the rise of the Communists, Mao's ideology, domestic policies, foreign relations, and the prospects of the post-Mao era. (Meets concurrently with 17.568.)
L. W. Pye

17.549 Political and Economic Development of Tropical Africa

Prereq.: —
Year: U (2) HUM-D
3-0-6

Study of the major facets and problems of economic and political development in tropical Africa. Introduction to the history and cultures of African peoples and to the politics and government of new African states. Consideration of the impact of African culture and philosophy on modern politics.
W. R. Johnson

17.551J Nationalism and Nation Building in 20th Century Africa

(Same subject as 21.451J)
Prereq.: —
Year: U (2) HUM-D
3-0-9

The political development of modern black Africa concentrating on an examination of colonial rule. African resistance and rebellion, the ultimate struggle for independence, and post-independence politics and readjustments. (Meets concurrently with 17.572.)
R. I. Rotberg

17.553J Third World: History, Politics, and Literature

(Same subject as 21.455J)
Prereq.: —
Year: U (1)
3-0-6

Study of the history, society, and politics of the black third world through a selected examination of a dozen critical novels. Some of the authors read include Abrahams, Achebe, Armah, Cary, Lemming, Hutchinson, Mulaisho, Naipaul, Ngugi, Oyonyo, Beti, Sembene, Gordimer, Paton, and Jacobson.
R. I. Rotberg

17.560J Nutrition Policy and Planning in Selected Countries (A)

(Same subject as 20.412J)
Prereq.: 20.410J or Permission of Instructor
Year: G (2)
2-0-7

Examines malnutrition and selected governmental response to it in countries. Special emphasis given to the workings of the political system, the planning process, and several experimental interventions linking nutrition with family planning and other policy concerns.
Staff

17.562J Nutrition and National Development (Revised Unit)

(Same subject as 20.410J)
Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Deals with the nature of world food and nutrition problems and their relationship to the social and economic progress of developing countries. Considers the specific elements of nutrition planning methodology and the variety of concerns in effective nutrition programming at the micro policy level. (Open to advanced undergraduates with permission of instructor.)
M. B. Wallerstein

17.564J Research Seminar in Imperialism and Colonialism (A)

(Same subject as 21.457J)
Prereq.: One graduate subject in Comparative Politics or International Politics
Year: G (2)
3-0-6

Topics in the economic, social, and cultural bases of imperialism and colonialism, its theory and practice. Substantial written work. Instruction in the form of intensive tutorials. ***(Not offered 1981-82.)***
R. I. Rotberg

17.566 Comparative Asian Politics (A)

Prereq.: 17.840
Year: G (2)
3-0-6

Comparative analysis of political systems of Asia. Special attention to the processes of social change and the problem of political stability. Covers the transition from traditional and colonial systems to the contemporary ones (Open to qualified undergraduates. ***Not offered 1981-82.***)
L. W. Pye

17.568 Chinese Politics (A)

Prereq.: 17.150
Year: G (2)
3-0-6

Analysis of contemporary Chinese politics, both pre-Communist and Communist. Special focus on the process of modernization and political development of the Chinese civilization. (Meets concurrently with 17.547.)
L. W. Pye

17.570 Political Development in South Asia (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

A comparative examination of the political determinants and consequences of major demographic and socioeconomic changings in South Asia—rapid population growth, urbanization, the green revolution, education, and changing caste, regional, religious, and class identifications, with special attention given to the political determinants and constraints on development policy. A central concern is the impact that the emergence of Bangladesh and the political regime changes in India and Pakistan have had upon the processes of modernization and development. (Meets concurrently with 17.545.)
M. Weiner

17.572 Nationalism and Nation Building in 20th Century Africa

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

The political development of modern black Africa concentrating on an examination of colonial rule. African resistance and rebellion, the ultimate struggle for independence, and post-independence politics and readjustments. (Open to Undergraduates. Meets concurrently with 17.551J.)
R. I. Rotberg

17.574 Comparative African Politics: Crises in Southern Africa (A)

Prereq.: 21.50 or 21.51 or 17.551J or 17.572
Year: G (2)
3-0-6

Comparative analysis of political systems and problems of southern Africa. Particular attention to the liberation of Namibia and Zimbabwe and evolution of South Africa. Also discusses the development of Botswana, Angola, Mozambique, Zambia, and Zaire. Although seminar's primary focus is on the emergence of stable systems of governance in the southern tier of Africa, it examines the formulation of US foreign policy regarding the region. (Undergraduates permitted with permission of instructor.)
R. I. Rotberg

17.576 Politics of Development and Underdevelopment in Africa (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Analysis of development issues and policies in selected African countries (*inter alia*, Cameroon, Kenya, Nigeria, Tanzania) including a consideration of the nature and functioning of the political systems in these states, their interaction with the environment of other states, international organizations and multinational corporations. Emphasis placed on the policies being pursued by the government to promote economic and social development.
W. R. Johnson

17.578J Race Relations, Politics and Development in the Caribbean (A)

(Same subject as 21.475J)
Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Comparative study of the role of color and race in the politics of the Caribbean. Attention to problems of modernization, leadership, and economic development in French, Dutch, and English speaking areas. ***(Not offered 1981-82.)***
R. I. Rotberg

17.580 Comparative Politics of Latin America (A)

Prereq.: —
Year: G (1)
3-0-9

Introductory survey of Latin American politics in a comparative perspective. Theoretical focus on three contrasting models of development: modernization, dependancy, and bureaucratic-authoritarianism. Four case studies with different political systems and economic models since 1960; Chile, Peru, Brazil, Cuba. Concluding overview of critical problems in contemporary US-Latin American relations. (Meets concurrently with 17.543.)
B. H. Smith

17.581 Religion, Politics and Social Change

Prereq.: —
Year: U (2) HUM-D
3-0-6

Major issues of religion and politics in different cultures—Western democracies, Marxist societies, and developing countries. Special focus on: 1) theories of religion's impact on social change; 2) differing church-state concepts in major religious traditions; 3) religion, electoral politics, and public-policy formation; 4) religion as a progressive and reactionary force in developing countries; and 5) prophetic function of religion under authoritarian governments. Case studies from the US, Western Europe, the Soviet bloc, Latin America, and the Middle East. (Meets concurrently with 17.584.)
B. H. Smith

17.582J Politics of Mexican Development

Prereq.: —
Year: G (2)
3-0-9

Development of Mexican political system and relationships between the State and commercial-industrial elites, organized labor, peasants, and the military. Special attention to effects of international environment on Mexican politics and economic development. Evaluation of Mexican "model" of development and its implications for other Third World Nations. (Open to undergraduates with permission of instructor.)
P. H. Smith

17.583 The Political Role of the Military in a Cross-National Perspective

Prereq.: —
Year: U (2)
3-0-6

A comparative study of the political activities and impact of the armed forces in Western industrial nations, Communist societies and developing countries. Historical themes; 1) the emergence of modern armies; 2) contrast in theories of civil-military relations; 3) expanding functions of armies in contexts of total war or threats to internal security; and 4) strengths and weaknesses of military leaders in managing the tasks of government. Particular attention to contemporary problems such as military-industrial complexes in Western societies, party-military tensions in Communist nations, and effects of military rule on personal, political, and socio-economic rights in developing countries. (Meets concurrently with 17.586.)
B. H. Smith

See also 17.232J, 17.426, 17.438.

17.584 Religion and Politics in Comparative Perspective (A)

Prereq.: —
Year: G (2)
3-0-9

Comparative analysis of the impact of religion on political developments in the US, Western and Eastern Europe, the Soviet Union, Latin America, and the Middle East. Conceptual focus on classical theories of religion and social change and differing church-state models in

major religious traditions. Empirical attention given to survey and case studies of religion and electoral politics in Western industrial countries, church-state conflicts in socialist societies, and the conservative and/or revolutionary potential of religious movements in the third world. (Meets concurrently with 17.581.)
B. H. Smith

17.586 The Military and Politics in Comparative Perspective

Prereq.: —
Year: G (2)
3-0-9

The political interests, resources and impact of the military in Western industrial nations, Communist societies and developing countries. Historical and theoretical treatment of: 1) contrasting models of civil-military relations; 2) conditions enhancing and eroding civilian control of the military; 3) impact of modern technology and social instability on the political role of the military and 4) capabilities and consequences of the armed forces in managing government tasks. Contemporary case studies from the US, Western Europe, the Soviet bloc, Latin America, and the Middle East. (Meets concurrently with 17.583.)
B. H. Smith

See also 17.330J

Communist Studies

17.601J Seminar in the Historical and Political Evolution of the Soviet Union

(Same subject as 21.378J)
Prereq.: Permission of Instructor
Year: U (2)
3-0-6

A reading subject on the history and politics of the Soviet Union, starting with the Russian Revolution and proceeding to the Brezhnev regime and recent political events. Emphasis on internal developments rather than foreign policy. Students expected to discuss the readings weekly. All required readings are in the English language, but supplementary readings in the Russian language are available for those students wishing them. (Open to advanced undergraduates with some previous work in the Soviet area. Meets concurrently with 17.610. ***Not offered 1981-82.***)
L. R. Graham

17.602 Soviet Communism (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

An historically oriented introduction to Soviet politics and society organized around four major topics: 1) Lenin and the creation of the Bolshevik party in the context of pre-revolutionary Russia; 2) the seizure of power and the economic and political crises of 1917-28 which shaped the new regime; 3) the Stalin era: forced industrialization and totalitarianism; 4) the evolution of Soviet politics since Stalin. (Open to qualified undergraduates. ***Not offered 1981-82.***)
D. L. M. Blackmer

17.604 Soviet and Chinese Foreign Policy and the Communist World (A)

Prereq.: 17.602
Year: G (1)
3-0-9

Review of Soviet state and party relations with China and East Europe during the Stalin period, followed by analysis of Sino-Soviet relations since 1953. Includes Soviet and Chinese dealings with East Europe, North Korea, North Vietnam, Cuba, and the Eurocommunist parties. (Open to qualified undergraduates.)
W. E. Griffith

17.606 The Politics of Communist States and Parties in Eastern and Western Europe (A)

Prereq.: 17.501
Year: G (2)
3-0-9

Primarily an analysis of the domestic problems and foreign relations of the Communist states of East Europe since World War II, followed by a survey of the domestic and foreign policies of the major West European Communist parties. (Open to qualified undergraduates.)
W. E. Griffith

17.608 Radical and Revolutionary Ideologies (A)

Prereq.: 17.602
Year: G (2)
3-0-9

Consecutive treatment of the following: background of Marxism in German idealist philosophy; thought of Marx, Engels, Bakunin, and Anarchism; the revisionists, orthodox Marxists, leftist Marxists, origins of Russian radicalism and Russian Marxism; Lenin, Trotsky, Bukharin, Stalin; Fascism; the Western-Marxists; Titoism; East European revisionism; Maoism; ideology in Sino-Soviet split; radicalism in Cuba; Chinese Cultural Revolution; Asian and African Socialism; North Vietnam; Radicalism and the New Left in North American and Western Europe; ideology of Eurocommunism. (Open to qualified undergraduates.)
W. E. Griffith

17.610 Seminar in the Historical and Political Evolution of the Soviet Union

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Readings on the history and politics of the Soviet Union, starting with the Russian Revolution and proceeding to the Brezhnev regime and recent political events. Emphasis on internal developments rather than foreign policy. Students expected to discuss the readings weekly. All required readings in the English language, but supplementary readings in the Russian language available for those students wishing them. (Meets concurrently with 17.601. ***Not offered 1981-82.***)
L. R. Graham

See also 17.490

Political Communication/ Political Behavior

17.701 Human Nature and Public Policy

Prereq.: —
Year: U (2)
3-0-6

A survey of basic sociological and psychological theories that can inform the understanding, design, and evaluation of public policy. Issues include crime, poverty, problems of authority and freedom; personal growth and alternative sources of subjective satisfaction in life. Emphasis on scientific bases for systematically evaluating the adequacy of American social institutions and public policies.
L. S. Etheredge

17.703 Society and Man

Prereq.: —
Year: U (1)
3-0-6

Introduction to the social sciences. Focus on the relation of the individual to his society, considering both the individual's capacity to affect his society and his society's effect on him. Life in the contemporary world examined by such methods as sociological surveys, psychological experiments, mathematical models, and political and anthropological studies.
I. D. Pool

17.705 The Social Effects of Communications Technologies

(17.702)
Prereq.: —
Year: U (2)
3-0-6

Extraordinary changes in the technology of communications are having important effects on social relations and behavior in modern society. Five cases examined: 1) rural communications in underdeveloped countries; 2) CATV; 3) electronics in publishing; 4) computer networks, national and international; and 5) communications satellites.
I. D. Pool

17.707 Mass Communication and American Culture (New)

Prereq.: —
Year: U (2) HUM-D
3-0-6

Study of the emergence of the modern media of mass communication and their influence in shaping the individual's values and knowledge of world events. Topics: political control through mass communication, violence, racial and sex role stereotypes, popular culture, and future communication technologies.
W. R. Neuman

17.720 Public Opinion and Propaganda (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-9

History and development of public opinion as a factor in public policy: relationship of public opinion and private attitudes; organization of political parties and pressure groups; techniques used by them; conditions of effective and ineffective communication. (Open to qualified undergraduates.)
I. D. Pool

17.722 Mass Media and Communication Systems (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Examination of the pattern of communication in societies at different stages of development. Comparison of networks of oral communication with systems based on mass media and telecommunications. The role of networks, literacy, the press, radio, film, CATV satellites, and international communication. (Open to qualified undergraduates.)
I. D. Pool

17.726 Political Culture (A)

Prereq.: 17.02
Year: G (2)
3-0-9

Analysis of the psychological and attitudinal bases of politics. Special emphasis on socialization patterns, styles of politics, and elite operational codes. (Open to qualified undergraduates. ***Not offered 1981-82.***)
L. W. Pye

17.728 Identity and Ideology (A)

Prereq.: 17.701
Year: G (2)
3-0-6

Study of personality theory and political behavior with special emphasis on the relationships between characterological elements and themes and appeals in political ideologies. Case studies of the personal development of historic leaders and the impact of their personalities on historical processes. (Open to qualified undergraduates.)
L. W. Pye

17.730 Executive Branch Learning

Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Theoretical approaches to the analysis of executive branch learning and roles and decision making. Emphasis on diagnosis of shortfalls and alternatives that increase learning risks. Includes both domestic and foreign policy case material.
L. S. Etheredge

17.732 Graduate Seminar in Normative Political Psychology (A)

Prereq.: Permission of Instructor
Year: G (1)
2-1-9

A review of major areas of research in the psychology of political behavior: meaning and belief systems, power, socialization, leadership, decision making, personality and politics, quality of life. The overall framework is the comprehensive evaluation of political systems.
L. S. Etheredge

17.734 Topics in Political Sociology (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Examination of the changing role of political authority and conflict in mass society. Topics include: political behavior, mass ideology, stratification, social movements, and interest groups with an emphasis on American politics. (Meets concurrently with 17.711.)
W. R. Neuman

17.736 Proseminar in Communications Research (A) (New)

Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Analysis of new research strategies in the study of mass communications processes. Topics include audience research, content analysis, and comparative policy research focusing on the social effects of new communications technologies.
W. R. Neuman

See also 17.255

Polimetrics/Models and Methods

17.803 Formal Logics and Political Arguments

Prereq.: —
Year: U (2)
2-1-9

Examines the fallacies and logics of a variety of recent liberal, radical, and conservative political arguments. Special emphasis on the varieties of formal representations usable for making and testing such arguments, and the conditions of their applicability. Specific attention given to psychologics characteristic of "ideological" political arguments, causal belief algebras useful for decision analysis, formal democratic theory, Marxian dialectical reasoning, and the structure of legal debate. (Assumes only high school mathematics as a prerequisite, plus a modest degree of familarity with social science literature. A laboratory introduces the computer modeling of some of the various logics discussed. ***Not offered 1981-82.***)
H. R. Alker, Jr.

17.838 Introduction to Mathematical Models in the Social Sciences (A) (New)

Prereq.: Permission of Instructor
Year: G (1)
2-2-8

First part focuses on rational models of collective choice including two-person game theory. Second part covers elementary difference and differential equations with applications primarily drawn from the literature on electoral mobilization, class conflict, revolution, and political economy. (Open to qualified undergraduates.)
J. Freeman

17.840 Theory Formation and Research Technique in the Social Sciences

Prereq.: Previous social science subjects
Year: G (1)
2-2-8

Professional introduction to empirical social and political research. Logical foundations of evidence and inference, quantity and quality, parts and wholes, cause and effect. Research technique in sample surveys, comparative research, controlled experiment, clinical diagnosis and historical case studies. ***(Not offered 1981-82.)***
H. R. Alker, Jr.

17.844 The Uses of Multi-Purpose Programming Languages in the Social Sciences (A)

Prereq.: Permission of Instructor
Year: G (1)
Arr.

Provides students with competence and proficiency in the utilization of multipurpose programming languages and derivative computer-based systems of special relevance to the social sciences. Instruction modules given in PI/I, SAS, The General Inquirer, TROLL, etc., on a cooperative basis with the Psychology and Social Relations Department at Harvard University.
H. R. Alker, Jr.

17.846 Multivariate Political Analysis (A)

Prereq.: Permission of Instructor
Year: G (2)
2-2-8

Focus on multivariate data analysis procedures. Topics: multiple regression analysis, analysis of variance and covariance, time series analysis, multiequation causal modeling, and dimensional analysis. Social and political research applications undertaken on the TROLL computer analysis system. Students must have taken at least one previous subject in statistics. (Open to qualified undergraduates.)
J. Freeman

17.848J Seminar on Complex Models of Social Systems (A) (Revised Content)

(Same subject as 11.802J)
Prereq.: Permission of Instructor
Year: G (2)
Arr.

The research seminar focuses on the communicative content of social-political interactions. Grammatical approaches to the modeling of social and political competence and performance reviewed as well as data analysis procedures for uncovering linguistic codes and messages. Models from biological, linguistic, logical, semiotical, and artificial intelligence traditions discusses. Examples drawn from small group, urban, national, and international contexts.
H. R. Alker, Jr., A. Fleisher

17.850 Advanced Topics in Statistical Modeling (A)

Prereq.: 17.846
Year: G (2)
3-0-6

Focus on selected topics in statistical modeling and data-based simulation, including: lag theory, mixed model estimation, Box-Jenkins models for policy impact research, analytical vs. numerical techniques of dynamic analysis, nonlinear estimation methods. Emphasis on political science applications. (Open to undergraduates by permission of instructor.)
Staff

17.852 Survey Research (A)

Prereq.: Permission of Instructor
Year: G (2)
2-2-8

Basic principles of survey research methodology including sampling, interviewing techniques, questionnaire design, and the analysis and interpretation of survey data. A review of the uses and misuses of survey research in policy analysis and the testing and refinement of social science theory.
W. R. Neuman

See also 17.150, 17.488, 17.494, 17.901.

General

17.UR Undergraduate Research

Prereq.: —
Year: U (1, 2)
Arr.

Undergraduate research opportunities in Political Science in theoretical and applied research. For further information contact the Departmental Coordinator.
Staff

17.901 Independent Undergraduate Research

Prereq.: —
Year: U (1, 2)
Arr.

Independent research enabling students to do work in an agency, state or local government, or other public organization. The academic component involves close contact between the student and a faculty advisor and written work. Work may be done during the summer. (Admission by arrangement with individual faculty member.)
A. A. Altshuler

17.905-17.911 Reading Seminar in Social Science

Prereq.: —
Year: U (1, 2)
Arr.

Reading and discussion of special topics in the fields of social science. Open to advanced undergraduates by arrangement with individual staff members.
Staff

17.913 Pre-thesis Reading Seminar

Prereq.: —
Year: U (1, 2)
3-0-6

Intensive reading on topics of interest to students in preparation for senior thesis under guidance of thesis supervisor. A written paper required, forming a substantial part of the senior thesis.
Staff

17.ThU Undergraduate Political Science Thesis

Prereq.: —
Year: U (1, 2)
0-9-0

Program of undergraduate research leading to the writing of an S.B. Thesis. To be arranged by the student under approved supervision.
A. A. Altshuler

17.950-17.960 Reading Seminar in Social Science (A)

Prereq.: 17.02
Year: G (1, 2)
Arr.

Reading and discussion of special topics in the fields of social science. (Open to advanced graduate students by arrangement with individual staff members.)
A. A. Altshuler

18 Mathematics

General Mathematics

18.UR Undergraduate Research

Prereq.: —
Year: U (1, 2)
Arr.

Undergraduate research opportunities in Mathematics. Permission required in advance to register for this subject. For further information consult the Departmental Coordinator.
Staff

18.001 Calculus

Prereq.: —
Year: U (1)
5-0-7

Emphasis on the concepts and techniques of calculus relevant to science and technology. Mathematical formulation of problems and approximate methods of solution. Limits, differentiation, rates, maxima and minima problems, applications, Taylor series, L'Hôpital's rule, finite differences, definite and indefinite integrals, techniques for integration, improper integrals, the Monte-Carlo method, perturbation and iteration procedures, stability, series, summation techniques, asymptotic series, symbolic methods, numerical analysis, differential equations.
G. R. Baker

18.002 Calculus

Prereq.: 18.001 or 18.01 or 18.011 or 18.012
Year: U (1, 2)
5-0-7

Continuation of 18.001. Presentation of the concepts and techniques of calculus relevant to science. Vector algebra, analytic geometry, planetary motion, orbit stability, partial differentiation, functions of several variables, Taylor series, extremal problems, linear programming examples, numerical methods, multiple integrals, approximate and asymptotic methods of evaluation, applications; vector calculus, gradient, curl, theorems of Stokes, Green & Gauss, conservation laws, fluid motion.
Term 1: *D. J. Benney*
Term 2: *D. Z. Freedman*

18.01 Calculus

Prereq.: —
Year: U (1, 2)
5-0-7

Differentiation and integration of functions of one variable, with applications. Concept of function, limits, and continuity. Differentiation rules, application to graphing, rates, approximations, and extremum problems. Mean-value theorem. Definite and indefinite integration. Fundamental theorem of calculus. Applications of integration to geometry and science. Elementary functions. Techniques of integration. Approximation of definite integrals, improper integrals, and l'Hôpital's rule.
F. P. Peterson, D. Alvis, Staff

18.011 Calculus (New)

Prereq.: —
Year: U (1)
5-0-7

Review of 18.01 material in five weeks. Infinite series, Taylor's formula. Vectors, vector-valued functions of one variable, space motion. Applications and special topics such as probability, planetary motion, or mathematics in industry.
F. Morgan

18.012 Calculus with Theory

Prereq.: —
Year: U (1)
5-0-7

Covers much the same material as 18.01, but at a deeper and more rigorous level. Emphasis on careful reasoning and understanding of proofs. Knowledge of elementary calculus assumed. Topics: axioms for the real numbers; the Riemann integral; limits, theorems on continuous functions; derivatives of functions of one variable; the fundamental theorems of calculus; Taylor's theorem; infinite series, power series, rigorous treatment of the elementary functions.
S. Szczepanski

18.02 Calculus

Prereq.: 18.001 or 18.01 or 18.011 or 18.012
Year: U (1, 2, S)
5-0-7

Functions of several variables. Vector algebra in 3-space and n-space determinants, matrices. Vector-valued functions of one variable; space motion. Scalar functions of several variables; partial differentiation, gradient, approximation techniques. Double and triple integration, with applications. Vector fields, line integrals, exact differentials, Green's Theorem. Additional topics: linear algebra and vector integral calculus (Term 1); infinite series and Taylor's formula (Term 2).
Term 1: *Staff*
Term 2: *A. P. Mattuck*

18.021 Calculus (New)

Prereq.: 18.011
Year: U (2)
5-0-7

Continuation of 18.011: functions of several variables, with elementary linear algebra and applications. Scalar functions of several variables; partial differentiation, gradient, approximation techniques. Double and triple integration, with applications. Vector fields, line integrals, exact differentials. Elementary linear algebra, matrices, inverses, interpolation, Jacobians. Green's Theorem, Divergence Theorem, Stokes' Theorem. Applications and special topics such as extrema theory in economics. (Permission of instructor required for those not having 18.011.)
Staff

18.022 Calculus with Theory

Prereq.: 18.012
Year: U (2)
5-0-7

Continuation of 18.012. Parallel to 18.02, but at a deeper level, with emphasis on careful reasoning and understanding of proofs.
S. Szczepanski

18.03 Differential Equations

Prereq.: 18.002 or 18.02 or 18.021 or 18.022
Year: U (1, 2, S) SD
4-0-8

Examples of initial value problems in science and engineering associated with single equations and with systems of first order equations. Methods of solution include graphical constructions, series, Laplace transforms, matrices, numerical integration and the phase plane. Emphasis on formulation of natural phenomena in terms of differential equations and on interpretation of the solutions.
Term 1: *G.-C. Rota*
Term 2: *R. B. Melrose, A. Toomre*

18.04 Complex Variables with Applications

Prereq.: 18.03
Year: U (1, 2)
4-0-8

Complex algebra and functions; analyticity; contour integration, Cauchy's theorem; singularities, Taylor and Laurent series; residues, evaluation of integrals; multivalued functions, potential theory in two dimensions; asymptotic analysis; Fourier analysis and Laplace transforms. (18.04 and 18.075 may not both be taken for credit.)
Term 1: *A. Toomre*
Term 2: *R. P. Stanley*

18.041 Principles of Applied Mathematics

Prereq.: 18.002 or 18.02 or 18.021 or 18.022
Year: U (1)
3-0-9

Introductory survey of fundamental concepts in applied mathematics: optimization, random process, coding, computer algorithms. In this independent half of the complete sequence, emphasis is on the ideas and topics that relate to a "discrete" mathematical approach: computation, combinatorics, probability, linear programming.
I. M. Gessel

18.042 Principles of Applied Mathematics

Prereq.: 18.03 or 18.031
Year: U (2)
3-0-9

Introductory survey of fundamental concepts in applied mathematics: propagation, stability, equilibrium, optimization. In this independent half of the complete sequence, emphasis is on the ideas and topics that relate to a "continuous" mathematical approach, but connection with discrete mathematical approach also stressed: random walk, diffusion, waves, instabilities, characteristics and first order partial differential equations, with applications to traffic problems, fluid flow, and other problems in classical mathematical physics.
R. R. Rosales

18.05 Introduction to Probability and Statistics

Prereq.: 18.001 or 18.01 or 18.011 or 18.012
Year: U (2) SD
3-0-9

A one-semester introduction, covering both basic probability and statistics, with applications to the social, physical, and life sciences. Treatment of statistics is less formal than that in 18.441 and 18.443, making only limited use of calculus, but is more oriented toward theory and concepts than that in 18.055J and 18.057. Relative frequency. Probability models. Combinatorics. Binomial and Poisson experiments. Normal approximation. Descriptive level of significance. Composite models. Chi-square approximation. Contingency tables. Hypothesis testing. Confidence regions. Random variables. Non-parametric methods. Normal distribution methods. Regression. Elements of decision theory.
H. Rogers, Jr.

18.055J Biostatistics I (A except XVIII)

(Same subject as 20.113J)
Prereq.: —
Year: U (1) G (1) SD
3-0-9

Introduction to statistical reasoning with applications to research in the life sciences. Topics: probability models, descriptive statistics, estimation and significance testing, frequency tables, regression and correlation, analysis of variance, nonparametric statistics, retrospective and prospective studies, clinical trials. Other topics in Biostatistics included according to the interests of the students.
W. M. Rand, S. L. Rasmussen

18.057 Introduction to Applied Statistics (A except XVIII)

Prereq.: —
Year: U (1) G (1) SD
3-2-7

Basic statistical methods of data analysis from the user's point of view. Topics: organizing and describing a data set; samples, populations and sampling distributions; the normal distribution; estimation of proportions and means; one-way analysis of variance; correlation and multiple regression; estimation of the odds ratio in a 2 x 2 table; the analysis of 2- and 3-way frequency tables. 18.057 emphasizes understanding the intuitive bases of common statistical procedures and using interactive computer packages to analyse a wide variety of data sets, whereas 18.441 emphasizes the mathematical theory; each supplements the other and may be taken for credit.
W. H. DuMouchel

18.063 Introduction to Algebraic Systems

Prereq.: 18.02 or 18.002 or 18.021 or 18.022
Year: U (1) SD
4-0-8

Introduction to algebraic systems primarily for students interested in computer and information sciences, with emphasis on finite systems. Review of elementary set theory, natural numbers, modular arithmetic, induction, counting arguments, elementary probability. Elementary number theory and group theory. Applications to fast arithmetic, cryptography, combinatorics. Elementary graph theory. Introduction to rings and fields. Finite fields; coding theory, Hamming and BCH codes.
A. P. Mattuck

18.07 Introduction to Numerical Analysis

Prereq.: 18.03 or 18.031
Year: U (2)
3-0-9

Introduces basic techniques for efficient solution of numerical problems in science and engineering. Topics and exercises largely within the scope of programmable calculators. Root finding, integration, function approximations, differential equations, direct and iterative methods in matrix theory, optimization with constraints, analysis of numerical stability.
A. Toomre

18.075 Advanced Calculus for Engineers (A except II, VI, VIII, XII, XIII, XVI, XVIII, XXII)

Prereq.: 18.03 or 18.031
Year: G (1, 2, S)
3-0-9

Functions of a complex variable; calculus of residues. Ordinary differential equations; integration by power series; Bessel and Legendre functions. Expansion in series of orthogonal functions, including Fourier series. (18.075 and 18.04 may not both be taken for credit.)
Term 1: *Staff*
Term 2: *F. B. Hildebrand*

18.076 Advanced Calculus for Engineers (A except II, VI, XVI, XVIII, XXII)

Prereq.: 18.075
Year: G (1, 2, S)
3-0-9

Vector analysis: orthogonal curvilinear coordinates. Calculus of variations. Solution of classical partial differential equations of mathematical physics, including applications of conformal mapping and the Laplace transformation.
Term 1: *F. B. Hildebrand*
Term 2: *Staff*

18.085 Methods of Applied Mathematics for Engineers (A except VI and XVIII)

Prereq.: 18.075
Year: G (1, 2)
3-0-9

Operations with matrices and determinants; linear vector spaces; characteristic-value problems. Techniques of calculus of variations: constraints, direct methods. Formulation and treatment of integral equations; Green's function; analytical and numerical methods of solution.
M. Prasad

Analysis

18.089 Review of Mathematics

Prereq.: —
Year: G (S)
Arr.

Review of calculus and differential equations. (Primarily for students in Course XIII-A. Degree credit allowed only in special circumstances.)
Staff

18.093 Tutoring in Mathematics

Prereq.: 18.002 or 18.02 or 18.021 or 18.022
Year: U (1, 2)
Arr.

For undergraduates who are teaching or tutoring in mathematics subjects. Limited enrollment, based on positions available. Permission must be secured in advance to register for this subject.
F. Morgan

18.094 Seminar in Mathematical Education

Prereq.: —
Year: U (1, 2)
Arr.

Study of school mathematics from an advanced standpoint together with practical experience in teaching. The seminar will investigate school mathematics curricula and teaching methods in light of modern ideas on teaching intuition and thinking skills. Students required to engage in four hours of practical work per week with children. (Enrollment by permission of instructor. ***Not offered 1981-82.***)
S. A. Papert

18.099 Independent Activities

Prereq.: —
Year: U (1, J, 2)
Arr.

For undergraduates desiring credit for studies during IAP or for special individual reading on an undergraduate level during the regular terms. Specific programs and credit arranged in consultation with individual faculty members and subject to departmental approval.
J. R. Munkres

18.100 Analysis I (A except XVIII)

Prereq.: 18.03 or 18.031
Year: U (1, 2) G (1, 2)
3-0-9

Two options offered, both covering the fundamentals of mathematical analysis: real numbers and euclidean n-space; open, closed, and connected subsets of n-space; continuous and differentiable functions; convergence of series and sequences of functions. Both options show the utility of abstract concepts and teach the understanding and constructing of proofs. *Option A* also emphasizes applications. *Option B* places greater emphasis on rigorous proofs and includes more abstract concepts; it is the "standard" analysis subject.
Option A: Term 1: *Staff*
Term 2: *A. P. Mattuck*
Option B: Term 1: *J. Sacks, Staff*
Term 2: *V. W. Guillemin, Staff*

18.101 Analysis II-M (A except XVIII)

Prereq.: 18.100
Year: U (1) G (1)
3-0-9

Continuation of 18.100, stressing the topics most useful in the study of manifolds and global analysis: differentiable maps, Jacobians, differentials, inverse and implicit function theorems, change of variables in multiple integration, general Stokes theorem.
J. R. Munkres

18.102 Analysis II (A except XVIII)

Prereq.: 18.100
Year: G (2)
3-0-9

Continuation of 18.100, in the direction of modern integration theory and its applications. Lebesgue integration in Euclidean space. Its applications to Fourier analysis, including the Riesz-Fischer theorem. Brief introduction to functional analysis. Much more concrete treatment than in 18.125, 18.126, which deal with abstract measure spaces rather than euclidean space. ***(Not offered 1981-82.)***
G. Uhlmann

18.103 Fourier Analysis—Theory and Applications (A except XVIII)

Prereq.: 18.100
Year: G (2)
3-0-9

Continuation of 18.100. Roughly half the subject devoted to the theory of the Lebesgue integral and half to Fourier series and Fourier integrals. 18.103 is an alternative to 18.102; the material is somewhat similar, but it differs from 18.102 in that a heavy stress is paid to applications, particularly applications in probability theory.
V. W. Guillemin

18.104 Seminar in Analysis

Prereq.: 18.100
Year: U (1, 2)
3-0-9

Seminars for mathematics majors in several topics, each under the direction of a faculty member whose special interest is in the field of the seminar. Reports and discussion by students on topics taken from current journals or from texts not regularly used in other mathematics subjects. Certain topics may require an additional prerequisite.
G. Uhlmann, Staff

18.109 The Architecture of Modern Analysis (A)

Prereq.: 18.125, *18.126*
Year: G (2)
3-0-9

An orientation and survey complementary to the grammatical development initiated in the analysis core program. Guest lecturers. ***(Not offered 1981-82.)***
I. E. Segal

18.115 Functions of a Complex Variable (A)

Prereq.: 18.100
Year: G (1)
3-0-9

Cauchy integral formula and applications. Runge approximation theorem, meromorphic functions, the Mittag-Leffler and Weierstrass theorems, subharmonic functions. Riemann surfaces and conformal mapping.
G. Uhlmann

18.116 Topics in Complex Variables (A)

Prereq.: 18.115
Year: G (2)
3-0-9

Topics vary from year to year: may be repeated for credit. Topic for 1980-81: classical theory of automorphic functions including the spectral decomposition and distribution of eigenvalues of the Laplacian on a compact Riemann surface, Selberg trace formula, and proof of Riemann-Roch theorem. Emphasis is directed to as elementary an exposition as possible. ***(Not offered 1981-82.)***
D. M. Goldfeld

18.117 Topics in Several Complex Variables (A)

Prereq.: 18.115, 18.125
Year: G (2)
3-0-9

Cauchy integral formula in polydiscs. Domains of holomorphy, pseudoconvexity and plurisubharmonic functions. Existence and approximation theorems for holomorphic functions via L^2- estimates for the $\bar{\partial}$-operator. Domains of holomorphy. Stein manifolds. Sheaves. ***(Not offered 1981-82.)***
W. Ambrose

18.125 Measure and Integration (A)

Prereq.: —
Year: G (1)
3-0-9

The general theory of Lebesgue integration, in R^n and in abstract spaces. The basic theorems of Fubini, Radon-Nikodym, Riesz-Fischer, et al., with illustrative applications. Invariant measures, L^p-spaces; duality and weak topologies; introduction to linear topological spaces. (Prerequisites: Introductory general set theory and topology.)
I. E. Segal

18.126 Functional Analysis (A)

Prereq.: 18.125
Year: G (2)
3-0-9

Normed vector spaces, Hilbert spaces, Banach spaces, L^p-spaces, topological vector spaces. Banach algebras. Fredholm operators. The spectral theorems.
W. Ambrose

18.128 Geometric Measure Theory (A)

Prereq.: 18.125
Year: G (2)
3-0-9

Hausdorff measure, rectifiable sets, structure theory, integral currents, compactness theorem. Applications to minimal surfaces, existence and regularity. Reports and discussions by students. ***(Not offered 1981-82.)***
F. Morgan

18.135 Fourier Analysis (A)

Prereq.: 18.126
Year: G (2)
3-0-9

General principles of harmonic analysis. Fourier analysis on n-dimensional Euclidean space. Spherical functions, Paley-Wiener theorem, group theoretic potential theory. Eigenfunctions, entire functionals and hyperfunctions. Eigenspace representations.
S. Helgason

18.155 Distributions and Differential Equations (A) (Revised Content)

Prereq.: 18.102
Year: G (1)
3-0-9

A treatment of the basic theory of distributions with many applications to linear ordinary, and partial, differential equations: Distributions and elementary operations, Green's formula, wave operator in two dimensions. Fourier transform, temperate distributions, Sobolev spaces and constant coefficient elliptic operators. Convolution, fundamental solutions and the Malgrange-Ehrenpreis theorem. Schwartz kernel theorem. Homogeneous distributions, Hadamard-Reisz theory of second order equations.
R. B. Melrose

18.156 Introduction to Microlocal Analysis (New)

Prereq.: 18.155, 18.965
Year: G (2)
3-0-9

The examination of singularities of distributions. Distributions singular across a submanifold, singular points of ordinary differential equations, non-characteristic boundary value problems. Pseudodifferential operators, regularity of elliptic differential operators, wavefront set and microdistributions. Darboux's theorem. Hamilton-Jacobi theory, the Maslov bundle. Lagrangian distributions, Fourier integral operators and the Cauchy problem for hyperbolic equations.
R. B. Melrose

18.157 Partial Differential Equations (A) (Revised Content)

Prereq.: 18.155, 18.156
Year: G (1)
3-0-9

Examination of general classes of operators and problems in the theory of linear partial differential operators. Boundary value problems for elliptic operators, hypoelliptic operators with double characteristics. Operators of real principal type. Uniqueness for the Cauchy problem. Spectral theory. ***(Not offered 1981-82.)***
R. B. Melrose

18.158 Topics in Partial Differential Equations (A) (Revised Content)

Prereq.: 18.155
Year: G (2)
3-0-9

Content varies from year to year; may be repeated for credit. A selection of advanced topics in the theory of partial differential operators. Typical themes are: scattering theory, pseudoconvex domains and holomorphic functions, nonlinear equations, hyperfunctions, boundary value problems. Topic for 1981-82: Nonlinear hyperbolic equations.
G. Uhlmann

18.168 Analysis on Lie Groups and Homogeneous Spaces (A)

Prereq.: 18.755
Year: G (2)
3-0-9

Invariant measures and abstract integral geometry illustrated by examples. Invariant differential operators and geometric transformations of these, like projections, radial parts and transversal parts. Global and local solvability, integral formulas for eigenfunctions and irreducibility questions for eigenspace representations. ***(Not offered 1981-82.)***
S. Helgason

18.175 Theory of Probability (A)

Prereq.: 18.125
Year: G (2)
3-0-9

Ergodic theorems, laws of large numbers, convergence of probability measures, central limit theorems, stochastic processes, Brownian motion, martingales, strong Markov properties. ***(Not offered 1981-82.)***
R. M. Dudley

18.177 Stochastic Processes (A)

Prereq.: 18.175
Year: G (1)
3-0-9

Topics in stochastic processes, such as Gaussian, Markov, diffusion and empirical processes. Content varies from year to year; may be repeated for credit.
R. M. Dudley

18.199 Topics in Analysis (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Topics vary from year to year; may be repeated for credit. ***(Not offered 1981-82.)***
W. G. Strang, R. B. Holmes

18.247 Operator Theory (A)

Prereq.: —
Year: G (1)
3-0-9

The general theory of bounded and unbounded linear operators in Banach and Hilbert spaces. One-parameter groups and semigroups, perturbation and scattering theory. Introduction to operator algebra; C*- and W*-algebras, non-commutative integration. Illustrative applications to harmonic analysis and partial differential equations. (Prerequisites: General topology and Lebesgue integration theory. ***Not offered 1981-82.***)
I. E. Segal

18.255 Quantum Mechanics and Field Theory (A)

Prereq.: —
Year: G (1)
3-0-9

A survey of fundamental concepts from finite non-relativistic systems to nonlinear relativistic quantum fields, from a modern mathematical standpoint. Quantum phenomenology, classical and C*-algebraic. Bose and Fermi quantization; functional integration; equivalence of particle and wave representations of general free fields. Quantized relativistic fields, the problem of local interactions, aspects of constructive quantum field theory. (Prerequisite: Introductory functional analysis. ***(Not offered 1981-82.)***
I. E. Segal

18.257 Group Theory and Fundamental Physics (A)

Prereq.: —
Year: G (2)
3-0-9

An explication of physical symmetry groups and their relations to invariant wave equations, elementary particle models, and physically admissible space-time structures, from a modern mathematical standpoint. (Prerequisite: Introductory graduate group theory, or consent of instructor. ***Not offered 1981-82.***)
I. E. Segal

18.259 Theoretical and Observational Cosmology (A)

Prereq.: —
Year: G (2)
3-0-9

Following a survey of extragalactic phenomenology and its analysis in accordance with modern statistical methods, the major comprehensive theories are developed and their predictions systematically compared with observations. The implications of various forms of causality, homogeneity, isotropy, and stability for possible space-time models are also analyzed. Selection effects; data sources; local hypotheses; computer simulations and programs. (Prerequisite: Advanced calculus and linear algebra.)
I. E. Segal

18.275 Numerical Analysis (A except XVIII)

Prereq.: 18.075 or 18.301
Year: G (1)
3-0-9

18.276 Numerical Analysis (A except XVIII)

Prereq.: 18.275
Year: G (2)
3-0-9

Introduction to the theory and practice of the solution of equations, interpolation, numerical differentiation and integration, numerical solution of ordinary differential equations and related topics. ***(18.276 not offered 1981-82.)***
F. B. Hildebrand

18.284 Introduction to Functions of a Complex Variable (A except XVIII)

Prereq.: 18.03 or 18.031
Year: G (1)
3-0-9

18.285 Introduction to Functions of a Complex Variable (A)

Prereq.: 18.115 or 18.284
Year: G (2)
3-0-9

Complex numbers, analytic functions, Riemann surfaces for certain functions, Cauchy's theorem, singularities, residues, contour integrals, conformal mapping. Schwarz-Christoffel transformation, series and sequences, analytic continuation, harmonic functions, conjugate functions, the gamma function, second-order linear differential equations and special functions. Laplace transforms, asymptotic series, saddle-point method, Hilbert transforms. More advanced than 18.04. ***(18.285 not offered 1981-82.)***
18.284: *M. Prasad*

18.295 Tensor Calculus (A) (Revised Content)

Prereq.: 18.700
Year: G (2)
3-0-9

Tensors, differential forms and Riemmanian geometry with applications in general relativity. Some modern differential geometry.
D. Z. Freedman

Applied Mathematics

18.301 Introduction to Physical Mathematics I

Prereq.: 18.03
Year: U (1)
3-0-9

Interdependence of mathematics and scientific problems, examples; deterministic and random processes; particle mechanics and differential equations, Brownian motion and random walk; Fourier analysis; tensors; partial differential equations of mathematical physics and continuum mechanics.
C. C. Lin, K. K. Tung

18.302 Introduction to Physical Mathematics II

(18.304)
Prereq.: 18.04 or 18.284 or 18.301
Year: U (2)
3-0-9

Partial differential equations of mathematical physics, classification and solution of boundary-value problems, method of separation of variables. Sturm-Liouville problems, Fourier integrals, integral transforms. Bessel functions and other special functions. Applications of calculus of variations. (A knowledge of complex variables desirable but not essential.)
C. C. Lin, K. K. Tung

18.305 Methods of Applied Mathematics I (A)

Prereq.: 18.04 or 18.075 or 18.284 or 18.304
Year: G (1)
3-0-9

18.306 Methods of Applied Mathematics II (A)

Prereq.: 18.305
Year: G (2)
3-0-9

A comprehensive treatment of the advanced methods of applied mathematics. Term 1: asymptotic behavior of differential and difference equations; asymptotic evaluation of integrals; regular and singular perturbation methods; boundary-layer techniques. Term 2: WKB method; multiple scales; partial differential equations; transform methods; characteristics, initial and boundary-value problems; Green's functions; singular perturbation problems; nonlinear wave propagation.
18.305: *S. A. Orszag*
18.306: *G. R. Baker*

18.307 Methods of Applied Mathematics III (A)

Prereq.: 18.04 or 18.075 or 18.284
Year: G (1)
3-0-9

Calculus of variations (the first variation and the second variation are both discussed), Integral equations (Volterra equations; Fredholm equations, the Hilbert-Schmidt theorem); the Hilbert Problem and singular integral equations of Cauchy type; Wiener-Hopf Method and partial differential equations; Wiener-Hopf Method and integral equations; group theory.
H. Cheng

18.308 Wave Motion (A)

Prereq.: 18.306
Year: G (2)
3-0-9

Review of linear concepts, dispersion and group velocity. Weakly nonlinear wave systems, resonances and instabilities. Free and forced responses. Long wave theories, breaking permanent wave forms. The inverse scattering method, solitons. Nonlinear dispersive waves, multiphase modes. Interactions between short and long waves. Statistical properties of nonlinear waves, asymptotic closure methods. Nonlinear stability theory, transition phenomena. Emphasis on topics of current research interest.
R. R. Rosales

18.313 Probability

Prereq.: 18.002 or 18.02 or 18.021 or 18.022
Year: U (2) SD
3-0-9

Development of theory and applications of probabilistic concepts for scientists and engineers. Emphasis on formulation and solution of probabilistic problems by the algebra of random variables. Topics: sample space, Bernoulli and Poisson processes, uniform process, generating functions and Laplace transforms, discrete and continuous-parameter Markov chains. Introduction to the Central Limit Theorem and to the foundations of probability.
G.-C. Rota

18.314 Applied Combinatorial Analysis

Prereq.: 18.001 or 18.01 or 18.011 or 18.012
Year: U (2)
3-0-9

Applications of combinatorial methods to practical problem solving. Emphasis on problems involving discrete optimization. Techniques from graph theory, matching theory, network flows. Other topics include enumeration, sorting and coding.
G.-C. Rota

18.315 Combinatorial Theory (A)

Prereq.: 18.700
Year: G (1)
3-0-9

Content varies from year to year; may be repeated for credit. Topics previously offered have included enumerative combinatorics, symmetric functions, asymptotic enumeration, and extremal problems.
Staff

18.316 Seminar in Combinatorics (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Content varies from year to year; may be repeated for credit. Readings from current research papers in combinatorics. Topics to be chosen and presented by the class.
D. J. Kleitman

18.318 Topics in Combinatorics (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Content varies from year to year; may be repeated for credit. Topic for 1981-82: combinatorial commutative algebra. Includes Hilbert functions, Cohen-Macaulay rings, Gorenstein rings, etc., and their connections with simplicial complexes, convex polytopes, matroid theory, partitions, invariant theory, and related topics.
R. P. Stanley

18.325 Topics in Applied Mathematics (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Asymptotic theory of differential equations: turning points, singular points, and applications to galactic dynamics, hydrodynamic stability, plasma dynamics, etc. Waves, action principle, strained coordinates, and other asymptotic solutions of partial differential equations. ***(Not offered 1981-82.)***
C. C. Lin

18.335 Numerical Methods of Applied Mathematics I (A)

Prereq.: 18.304, 18.700
Year: G (1)
3-0-9

18.336 Numerical Methods of Applied Mathematics II (A)

Prereq.: 18.335
Year: G (2)
3-0-9

Introduction to the theory and application of numerical methods. Term 1: Numerical linear algebra, root finding, approximation theory, integration, ordinary differential equations, optimization techniques. Term 2: Partial differential equations, initial and boundary value problems, spectral and finite element methods, computational fluid, solid, and plasma dynamics.
18.335: *S. A. Orszag*
18.336: *P. Marcus*

18.354 Fluid Mechanics

Prereq.: 18.04 or 18.075 or 18.302
Year: U (1)
3-0-9

A theoretical study of basic concepts of fluid dynamics: real and ideal fluids; conservation equations of mass, momentum, and energy; equations of state; vorticity and circulation theorems; boundary layer theory; instability; waves, modes; compressible flows and shocks. 18.354 and 18.355 form a one-year sequence in fluid mechanics.
D. J. Benney

18.355 Fluid Mechanics (A)

Prereq.: 18.354
Year: G (2)
3-0-9

Continuation of 18.354; selection of topics from other fluids courses not offered this year.
H. P. Greenspan

18.356 Rotating Fluids (A)

Prereq.: 18.305, 18.354, or Permission of Instructor
Year: G (1)
3-0-9

Introduction to the theory of rotating fluid motions; both uniform and variable Coriolis forces treated, with applications to planetary atmospheres and oceans; transient flows: the problems of spin-up and adjustment; normal mode solutions on a sphere: Laplace tidal equation, Hough modes and their approximations; propagations of Rossby and equatorial waves; effects of shear; wave-mean flow interactions; conservation laws; Ekman boundary layers; western currents; stability of rotating flows; nonlinear wave motions and interactions.
K. K. Tung

18.357 Seminar in Fluid Dynamics (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Discussion of the present frontiers in the theoretical study of solar, planetary, and geodynamos. The first weeks are devoted to review of applicable hydromagnetic processes, linear and nonlinear flows in rotating systems, and formal techniques needed to address the full dynamo problem. Students report on current papers and/or their own projects.
W. V. R. Malkus

18.358 Hydrodynamic Stability and Turbulence (A)

Prereq.: 18.354
Year: G (2)
3-0-9

Laminar flows, linear instability, finite-amplitude theory and turbulence. Examples in shearing flow, convection, rotating flow, and hydromagnetics. Compact reviews and demonstrations. Modified and singular perturbation theory developed for detailed flow studies. Statistical and optimal theories developed for turbulence studies. Applications to biophysics, engineering, geophysics, and astrophysics.
W. V. R. Malkus

18.359 Biological Fluid Dynamics (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-9

A seminar on various fluid models and simulations of biological processes. Cell cleavage, adhesion, motility; the relationship between shape and function of a cell; colony growth and tissue organization; analogies with the hydrodynamics of droplets and foams; variable surface tension phenomena. Blood flow, pattern formation, and other topics of special interest to the class.
H. P. Greenspan

18.375 Stellar Dynamics, Galaxies, and Plasmas (A)

Prereq.: 8.06, 18.076, or 18.304
Year: G (2)
3-0-9

Types and composition of galaxies, spiral arm and star formation. Dynamics of stellar systems and self-gravitating gaseous systems. Gravitational instability, density waves, dispersion relationship, resonances, self-excited spiral modes. Shock waves and star formation. Dynamics of plasmas, the mirror machine, equilibrium, loss cone distributions; microinstabilities, drift cone mode, negative energy modes, convective modes; stability criteria for the above modes; quasi-linear theory, comparison with experiments. ***(Not offered 1981-32.)***
C. C. Lin

18.395 Applications of Group Theory to Quantum Mechanics (A)

Prereq.: 18.304 or 18.305 or 8.321
Year: G (1)
3-0-9

Emphasizes modern applications of group theory to particle physics. Representations of the Rotation, Lorentz, Poincare, Symmetric, and Unitary Groups. Internal Symmetry Groups. Characters. Young Tableaux. Gauge Groups. Applications to the spectra and interactions of elementary particles, nuclei and atoms. ***(Not offered 1981-82.)***
D. Z. Freedman

18.396 Topics in Theoretical Physics (A)

Prereq.: 8.321
Year: G (2)
3-0-9

Topics vary from year to year; may be repeated for credit. An introduction to quantum field theories. Path integrals, Feynman rules, gauge principles, scattering amplitudes, etc.
H. Cheng

18.411 Applied Algebra

Prereq.: 18.700
Year: U (2)
3-0-9

Topics in algebra which have had wide application in computer science and other areas. Emphasis is to introduce practical algorithms and relevant algebra. Possible topics in algebra: modular arithmetic, finite abelian groups, finite fields, polynomial rings, and linear algebra. With applications to: multiplication of integers, polynomials, and matrices; factoring of polynomials and integers; GCD: primality testing; finite Fourier transforms, linear programming, coding theory; symbolic integration. Some knowledge of linear or abstract algebra useful. Complements 18.424 but may be taken independently. No computer programming.
G. L. Miller

18.419J Cryptography and Cryptanalysis (A)

(Same subject as 6.875J)
Prereq.: 18.061 or 18.063, 6.045, 18.05
Year: G (2)
3-0-9

Mathematical history of cryptographic systems. Principles of design and usage that enhance security. Standard cryptanalytic attacks and statistical weaknesses. Modern cryptographic systems: DES, public-key systems. Protocols for secure communication in networks. Key distribution, physical security of devices. Relationship of cryptography and cryptanalysis to complexity theory, information theory, and theory of random numbers. ***(Not offered 1981-82.)***
Staff, R. L. Rivest

18.420J Computability, Automata, and Formal Languages

(Same subject as 6.045J)
Prereq.: 18.041 or 18.061 or 18.063
Year: U (2)
3-0-9

Introduction to the basic mathematical models of computation and the finite representation of infinite objects. Finite automata and regular languages. Pushdown automata and context-free languages. Deterministic and pushdown automata and their application to parsing of programs. Turing machines and their variants. Partial recursive functions and grammars as models equivalent in power to turing machines — Church's Thesis. Undecidable problems concerning machines, languages, grammars, and combinatorial systems. The time complexity of algorithms and NP-complete problems.
M. Sipser, A. R. Meyer

18.424 Combinatorial Algorithms

Prereq.: —
Year: U (1)
3-0-9

Methods for transforming combinatorial ideas into efficient algorithms. Emphasis on practical problems, but without programming. Typical problems: sorting and searching, generating permutations, network optimization algorithms, computationally hard problems, algorithms on graphs, NP-completeness. Complements 18.411, but may be taken independently.
R. Kannan

18.425 Symbolic and Algebraic Computation (A) (Revised Content)

Prereq.: 18.700, 18.411 or 18.703
Year: G (1)
3-0-9

Studies the computational complexity of algebraic questions. Topics include: GCD (integer, polynomial, resultants), tests for primality, factoring integers and polynomials, finite fields, Hensel's lemma, binary quadratic diophantine equations, NP-completeness. Topics in algebraic number theory (primality, irreducibility, quadratic forms). Graphic isomorphism — group theory.
G. L. Miller

18.427J Theory of Computation (A)

(Same subject as 6.840J)
Prereq.: 6.045J or 18.420J
Year: G (2)
3-0-9

A graduate introduction to computability, undecidability, computational complexity, automatic theorem-proving, and the expressiveness of programs (program schemes). Includes: Elementary recursion theory: Godel numberings, reducibility, degrees of undecidability. Elementary complexity theory: time and space measures on computation, inherently complex decidable predicates, the nonexistence of optimal algorithms (the speed-up theorem), efficient reducibility. Undecidable theorem-proving problems: predicate calculus and arithmetic. Inherently complex decidable problems: examples from logic and automata theory. Proving theorems about programs: uninterpreted program schemes; proving formal correctness, equivalence and termination assertions. (Permission of instructor required.)
M. Sipser, A. R. Meyer

18.428J Computation by Automata (A) (New)

(Same subject as 6.853J)
Prereq.: 6.045J or 6.840J
Year: G (2)
3-0-9

Time and space-bound Turing machines. Simulation, diagonalization, information-theoretic and overlap arguments. Contrast between nondeterminism and determinism in logarithmic space, linear space, and polynomial time; polynomial hierarchy, alternation of quantifiers, and games. Equivalence of push-down tape-bounded automata and time-bounded computers, time-space tradeoffs, and a pebbling game. Time and space bounds for parsing context-free languages. Circuit and formula complexity of finite functions. (Alternate years. ***Not offered 1981-82.***)
M. Sipser, A. R. Meyer

18.436 Topics in Algorithms and Complexity

Prereq.: Permission of Instructor
Year: G (1)
3-0-9

A seminar on advanced topics in algorithms and complexity. Current literature presented by students and instructors with a view to preparing students for research in theory of algorithms and complexity.
M. Sipser

18.437J Algorithms (A)

(Same subject as 6.851J)
Prereq.: 18.061 or 18.063, 6.045J
Year: G (1)
3-0-9

The design and analysis of fast and optimal algorithms for sorting and manipulating families of sets, searching graphs, finding patterns in strings, manipulating polynomials, matrices and integers, performing geometric constructions, and solving linear inequalities. Random and probabilistic algorithms. The class of NP-complete problems.
G. L. Miller, V. R. Pratt

18.438J Advanced Algorithms (A)

(Same subject as 6.854J)
Prereq.: 6.851J or 18.437J; 6.043 or 18.700
Year: G (2)
3-0-9

Exploration in greater depth of some topics from 6.851J/18.437J. New topics include network and matroid algorithms, advanced graph algorithms, and problems from logic. Greater emphasis on the underlying models of computation and on precise mathematical analysis. (Alternate years. ***Offered 1981-82.***)
R. Kannan, R. L. Rivest

Probability and Statistics

18.440 Probability and Random Variables

Prereq.: 18.002 or 18.02 or 18.021 or 18.022
Year: U (1, 2) SD
4-0-8

A standardized introduction to probability covering the basic topics useful in applications. Probability spaces, random variables, distribution functions, expected value. Binomial, geometric, hypergeometric, Poisson distributions. Uniform, exponential, normal, gamma and beta distributions. Mean, variance, moments and generating functions. Conditional probability, Bayes theorem, joint distributions, and distributions of transformed random variables. Tchebychev inequality, law of large numbers and central limit theorem. Multivariate normal distribution, covariances and correlation. Random walk and Markov processes. Some applications to statistics and decision theory.
Staff

18.441 Statistical Inference (A except XVIII)

Prereq.: 6.041 or 18.440 or 18.313
Year: U (2), G (2)
4-0-8

Introduction to statistical inference. Decision theory, hypothesis testing, point and interval estimation. Bayesian methods, maximum-likelihood and likelihood-ratio tests. Chi-square goodness of fit tests. Comparison of populations by parametric and nonparametric methods. Analysis of variance, regression and correlation. Sequential analysis if time permits. Treatment more mathematical than that of 18.05 and more detailed in its treatment of statistics.
Staff

18.443 Statistics for Applications (A except XVIII)

Prereq.: 18.440 or 18.313 or 6.041
Year: G (1, 2)
4-0-8

A broad treatment of statistics concentrating on specific statistical techniques used in science and industry. Topics: hypothesis testing and estimation. Chi-square goodness of fit, regression, correlation, analysis of variance and experimental design. Treatment more oriented toward application and less toward theory than 18.441.
Term 1: *J. F. Buoncristiani*
Term 2: *Staff*

18.444 Probability and Statistics for Scientists and Engineers (A)

Prereq.: 18.002 or 18.02 or 18.021 or 18.022, 18.700
Year: G (1)
Arr.

An advanced and accelerated introduction to probability and statistics. Designed to cover most of the material in 18.440 and 18.441 plus part of 18.445J; for engineers and scientists who are talented mathematically and perceive a need to apply statistical ideas but lack the time to take two or three semesters of course work. Material presented from a case study point of view, and relatively little class time devoted to explaining or exploring mathematical details. Topics: probability, distribution expectation, central limit theorem, law of large numbers, estimation, hypothesis testing, confidence intervals, maximum likelihood, information, Neyman-Pearson theory, regression, design of experiments, decision theory, and Markov processes.
H. Chernoff

18.445J Introduction to Stochastic Processes (A)

(Same subject as 15.073J)
Prereq.: 18.313 or 18.440 or 6.041
Year: G (1, 2)
4-0-8

Introduction to the theory and application of stochastic processes. Examples of empirical phenomena for which stochastic processes provide mathematical models. Random walk, gambler's ruin, recurrent events, discrete-time Markov chains, Branching processes, Poisson processes, non-homogeneous Poisson processes, compound Poisson processes, renewal theory. Continuous-time Markov chains, birth and death processes, queueing theory, and Brownian motion. Time permitting, additional topics chosen from: semi-Markov processes, Markov renewal processes, Markov decision process, inventory theory, and Gaussian processes.
Term 1: *Staff*
Term 2: *A. I. Barnett*

18.446 Applied Time Series Analysis (A)

Prereq.: 18.441 or 18.443
Year: G (1)
4-0-8

Applications and aims of time series analysis. Stationary time series—autocorrelation, autoregressive, moving average and mixed models. Prediction and estimation of autoregressive moving average models. Non stationary time series—integrated models, seasonal models, regression with time series errors. Transfer function models—cross correlation, identification and estimation. Introduction to spectral analysis of stationary time series. Emphasis on applying time series techniques to various data sets. A set of computer programs is available and knowledge of computer programming not required.
J. F. Buoncristiani

18.448 The Analysis of Categorical Data (A)

Prereq.: 18.441 or 18.443 or 15.075
Year: G (1)
4-0-8

Theory and application of log-linear models to multi-way contingency tables and other data sets where the dependent variable is categorical, including the possibility that the categories are ordered. Topics: the Poisson distribution, one-way, two-way, and multi-way frequency tables, logit regression, and maximum likelihood estimation and computations. Class uses and compares various computer programs for the estimation of log-linear models. Most of the technical theoretical material is reserved until the final few weeks of the semester, and students outside of Course XVIII may arrange to substitute a data analysis project for it.
W. H. DuMouchel

18.455 Analysis of Variance and Design of Experiments (A)

Prereq.: 18.700, 18.441 or 18.443 or 15.075
Year: G (1)
4-0-8

Detailed presentation and use of the classical models of analyses of variance (ANOVA): one-way classification, two-way classifications, block designs, nested designs, latin squares, etc. Model II type of designs. Tests of hypothesis, simultaneous confidence intervals. Presentation of regression, and analyses covariance (ANOCOVA). Then a more abstract point of view: properties of the multivariate normal and related distributions, linear models of full rank, linear models not of full rank, general linear hypothesis. Geometric interpretation. Finally: effect of departure from assumptions.
Staff

18.456 Multivariate Methods in Statistics (A)

Prereq.: 18.700, 18.441
Year: G (2)
4-0-8

Theory and application of commonly used techniques involving multivariate data. Attention devoted to specific applications, and to computational facilities for applying the methods. Topics selected from the following: multivariate regression, discriminant analysis, and pattern classification. Cluster analysis, factor analysis, and principal components. Multidimensional scale analysis. Contingency tables.
J. F. Buoncristiani

18.457J Statistics for Model Building (A)

(Same subject as 15.076J)
Prereq.: 18.443 or 15.075, 18.700
Year: G (2)
3-0-9

Designed to be an advanced subject in statistical data analysis for those interested in model building, calibration, and validation. Topics: linear and nonlinear regression analysis with emphasis on detection and correction of model violations, robustness, selection of variables, models with categorical data. Introduction to multivariate methods, and statistical computing.
H. Chernoff, R. E. Welsch

18.458 Non-parametric Statistics and Statistical Robustness (A)

Prereq.: 18.440, 18.441
Year: G (1)
3-0-9

Introduction to the theory and application of statistical methods commonly used when the functional form of the underlying distribution is unknown. Such nonparametric methods are designed to deal with data that are difficult to analyze with the standard parametric models, and are particularly useful in biology, psychology, etc. Lectures include nonparametric analogues of the one- and two-sample tests and the analysis of variance: the sign test, median test, Wilcoxon's test, Kruskal-Wallis test, and permutation tests in general. Goodness of fit tests, including chi-square, contingency tables, and Kolmogorov-Smirnov methods also discussed. Emphasis on proper application of the techniques discussed in lecture, rather than on theory. ***(Not offered 1981-82.)***
Staff

18.459 Statistical Laboratory (A)

Prereq.: Permission of Instructor
Year: G (2)
2-0-4

Lectures consist of presentations of applied problems with or without solutions. Students expected to give a presentation based on the literature or the solution of a minor problem. The solution of a major problem serves as the basis for a master's thesis.
H. Chernoff

18.465 Topics in Statistics (A)

Prereq.: Permission of Instructor
Year: G (1, 2)
3-0-9

Introduction to some special theoretical topics in mathematical statistics at an intermediate level. Students assumed to be familiar with the elements of probability theory and the fundamental concepts and basic techniques of statistical inference. Topics chosen in accordance with the interests of the instructor and the students.
Term 1: *Staff*
Term 2: *W. Stuetzle*

18.466 Mathematical Statistics (A)

Prereq.: 18.441 or 18.443
Year: G (1)
3-0-9

Decision theory, estimation, confidence intervals, hypothesis testing. Introduction to large sample theory. Asymptotic efficiency of alternative statistical procedures. Linear statistical inference. (Permission of instructor required.)
H. Chernoff

18.467 Mathematical Statistics (A)

Prereq.: 18.466, 18.102 or 18.125
Year: G (2)
3-0-9

Continuation of 18.466, using elementary measure theory. Sequential analyses.
H. Chernoff

18.468 Advanced Time Series Analysis (A)

Prereq.: 18.441 or 18.443
Year: G (2)
4-0-8

Stationary vector processes. Correlation. Spectra. Vector autoregressive-moving average models — parameterisation and estimation. Non-stationary vector processes. Asymptotic spectra. Vector difference equations for input/output, their parameterisation, estimation, and relation to state space models. The Kalman filter. Depending on participants' interests, topics chosen from: Models for long term dependence; robust filtering and parameter estimation; incomplete data problems; model order determination; nonlinear models; time series principal components analysis; classification problems.
E. J. Hannan

18.485 Risk Theory (A)

Prereq.: 18.441 or 18.443
Year: G (1)
3-0-9

A survey of the literature relating to the mathematical foundations of risk taking as a business. Topics: distribution of claims, calculation of premiums, probability of ruin, premium loading, and reinsurance and utility theory. (Permission of instructor required. ***Not offered 1981-82.***)
W. H. DuMouchel

Logic

18.511 Introduction to Mathematical Logic

Prereq.: —
Year: U (2)
3-0-9

Propositional and predicate logic. Elementary model theory, completeness, compactness, and Lowenheim-Skolem theorems; elementary recursion theory, enumeration and recursion theorems. Gödel incompleteness theorems. Special additional topics as time permits. (While this subject has no formal prerequisite, any Course XVIII subject with first decimal digit one or higher is adequate preparation.)
Staff

18.515 Mathematical Logic (A)

Prereq.: 18.511
Year: G (1)
3-0-9

18.516 Mathematical Logic (A) (New)

Prereq.: 18.515
Year: G (2)
3-0-9

First-order logic. Completeness, compactness, Lowenheim-Skolem theorems. Type-omitting, categoricity. Incompleteness of arithmetic. Recursively enumerable sets and Turing degrees. Friedberg-Muchnik theorem. Zermelo-Fraenkel set theory. Ordinals and cardinals. Reflection principles, absoluteness. Consistency of axiom of choice and Generalized Continuum Hypothesis. (Permission of instructor required for those not having 18.511.)
S. D. Friedman

18.565 Recursion Theory (A)

Prereq.: 18.516
Year: G (1)
3-0-9

Topics in recursion theory chosen from: priority arguments, hyperarithmetic theory, ordinal recursion, E-recursion, theory of projective sets. (Permission of instructor required for those not having 18.516. ***Not offered 1981-82.***)
S. D. Friedman

18.575 Theory of Models (A)

Prereq.: 18.516
Year: G (1)
3-0-9

Topics in model theory chosen from: model-theoretic algebra, Morley rank, infinitary model theory, generalized quantifiers, ultraproducts. Permission of instructor required for those not having 18.516
S. D. Friedman

18.585 Set Theory (A)

Prereq.: 18.516
Year: G (2)
3-0-9

Forcing. Other topics in set theory chosen from: large cardinals, combinatorial set theory, iterated forcing, descriptive set theory, fine structure of L. (Permission of instructor required for those not having 18.516.)
Staff

18.595 Seminar on Current Topics in Logic (A) (Revised Unit)

Prereq.: 18.565, 18.575, 18.585
Year: G (1, 2)
3-0-9

Analysis of results of current interest in logic. Students present recent developments in the field for general discussion. Formal and informal sources used. Topics vary from year to year; may be repeated for credit.
S. D. Friedman

18.599 Philosophy of Mathematics and of Natural Science

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Analogy in mathematics. Exposition of topics at the borderline of algebra and the foundations of mathematics. Universal algebra, category theory, algebraic aspects of logic, Gentzenian logic, analogies between logic and probability, mathematical and logical aspects of circuit theory. The logic of quantum mechanics, noncommutative probability. Topics vary from year to year; may be repeated for credit.
G.-C. Rota

Algebra and Number Theory

18.700 Linear Algebra

Prereq.: 18.002 or 18.02 or 18.021 or 18.022
Year: U (1, 2, S) SD
3-0-9

Basic subject on matrix theory and linear algebra, emphasizing the topics most useful in other disciplines. Covers the fundamental theory: systems of equations, vector spaces, determinants, eigenvalues, similarity, positive definite matrices and quadratic forms. Applications given to such topics as Gauss elimination with pivoting, least squares approximations, stability of systems of differential equations, linear programming, and game theory. Compared with 18.710 this subject is oriented more towards linear algebra as used in applications, and less towards theorems and proofs. 18.720 is a sequel to both subjects 18.700 and 18.710.
W. G. Strang, Staff

18.701 Algebra I

Prereq.: 18.002 or 18.02 or 18.021 or 18.022
Year: U (1)
3-0-9

18.702 Algebra II

Prereq.: 18.701
Year: U (2)
3-0-9

More extensive and theoretical than the 18.700 (or 18.710)-18.703 sequence. Experience with linear equations and matrices (as in 18.03) helpful. First term: determinants, matrix groups, eigenvectors, symmetry, Sylow theorems, bilinear forms. Second term: ideals, polynomial rings, unique factorization, modules, Jordan form for matrices, extension fields, Galois theory.
18.701: *M. Artin*
18.702: *Staff*

18.703 Modern Algebra

Prereq.: 18.002 or 18.02 or 18.021 or 18.022
Year: U (1, 2) SD
3-0-9

A one-term treatment, covering the traditional algebra topics which have found greatest application in science and engineering as well as in other mathematical disciplines: group theory, with emphasis on finite groups; ring theory, including ideals, unique factorization, in polynomial and Euclidean rings; field theory, including properties and applications of finite fields. 18.700 and 18.703 together cover most of basic algebra. 18.700 or 18.710 should precede 18.703 if both subjects are to be

taken. Open to students with some experience in abstract thinking (college level mathematics).
Term 1: *G. W. Whitehead*
Term 2: *Staff*

18.704 Seminar in Algebra and Number Theory

Prereq.: 18.702 or 18.703
Year: U (1)
3-0-9

Seminars for mathematics majors in several topics, each under the direction of a faculty member whose special interest is in the field of the seminar. Reports and discussion by students on topics taken from current journals or from texts not regularly used in other mathematics subjects. Topic 1981-82: Group theory.
R. D. Schafer

18.705 Commutative Algebra (A)

Prereq.: 18.701-02 or 18.700, 18.703
Year: G (1)
3-0-9

18.706 Noncommutative Algebra (A)

Prereq.: 18.705
Year: G (2)
3-0-9

First term: basic topics in commutative algebra, with a brief introduction to categorical ideas and homological algebra. Modules, derived functors, localization, noetherian rings, finiteness properties, theory of depth and dimension. Second term: topics in noncommutative algebra, selected from such areas as Wedderburn theorems, group representations, Lie algebras, algebraic groups. ***(18.706 not offered 1981-82.)***
W. E. Lang

18.710 Abstract Linear Algebra

Prereq.: 18.002, 18.02 or 18.021 or 18.022
Year: U (1, 2) SD
3-0-9

An algebraic treatment of linear algebra including vector spaces, systems of linear equations, bases, linear independence, matrices, determinants, eigenvalues, inner products, quadratic forms, and canonical forms of matrices. More theoretical than 18.700, with less emphasis on matrix theory and applications.
Staff

18.715 Homological Algebra (A)

Prereq.: 18.705
Year: G (1)
3-0-9

18.716 Homological Algebra (A)

Prereq.: 18.715
Year: G (2)
3-0-9

Classifying spaces of categories, higher K-groups, exact sequences in K-theory, calculations. Familiarity with homotopy and cohomology groups required. ***(Not offered 1981-82.)***
D. G. Quillen

18.720 Applications of Linear Algebra (New)

Prereq.: 18.700 or 18.710
Year: U (1)
3-0-9

Applications to engineering (e.g., systems theory, structures, optimization), to economics (nonnegative matrices, mathematical programming), to computations (eigenvalues, sparse matrices), and to science and mathematics. The subject develops from the foundation provided by 18.700.
W. G. Strang

18.725 Algebraic Geometry (A)

Prereq.: 18.705
Year: G (1)
3-0-9

Introduction to contemporary algebraic geometry. The course is centered around the basic techniques of the subject, including sheaf cohomology and the Riemann-Roch theorem for curves.
S. Kleiman

18.727 Topics in Algebraic Geometry (A)

Prereq.: 18.725
Year: G (2)
3-0-9

Topics vary from year to year; may be repeated for credit. Topics in the past few years have included generalized Riemann-Roch theorem, etale cohomology, algebraic spaces, Riemann hypothesis for curves over finite fields, deformation theory, topics in the theory of algebraic surfaces, the Picard scheme.
M. Artin

18.735 Topics in Algebra (A)

Prereq.: 18.702 or 18.703
Year: G (1)
3-0-9

Content varies from year to year; may be repeated for credit. Topics in the past few years have included algebraic groups, noncommutative rings and algebras, Lie algebras, nonassociative algebras, local rings, algebraic K-theory, and quadratic forms. ***(Not offered 1981-82.)***
N. C. Ankeny

18.737 Linear Algebraic Groups (A)

Prereq.: 18.705
Year: G (1)
3-0-9

An introduction to the classification of affine groups over an algebraically closed field via their representations as groups of invertible matrices.
G. Lusztig

18.739 Theory of Invariants (A)

Prereq.: 18.705
Year: G (1)
3-0-9

Hilbert's finiteness theorem for reductive groups. Properties of the orbits and the orbit space. Classical invariants theory. Hilbert-Mumford-Richardson theorem. Rosenlicht's theorem on the existence of invariants. Matsushima criterion. Richardson's theorem on the principal stabilizer. Chevalley-Luna-Richardson theorem. Linear actions with a non-trivial stabilizer. Nice representations. Methods of the orbit classification. Applications to classical problems of linear algebra. Other topics. ***(Not offered 1981-82.)***
V. Kač

18.745 Introduction to Lie Algebras (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Primary emphasis on theory of Lie algebras, and algebraic aspects of Lie theory. Structure of finite-dimensional Lie algebras; Engel and Lie theorems, Cartan subalgebras, Cartan criteria. Structure and classification of semi-simple Lie algebras. Weyl and Levi theorems. Campbell-Hausdorff formula and connection between Lie groups and Lie algebras. Finite-dimensional representations of semi-simple Lie algebras, Weyl character formula. Verma models.
V. Kač

18.749 Infinite-dimensional Lie Algebras (A)

Prereq.: 18.745
Year: G (2)
3-0-9

Infinite-dimensional Lie algebras, associated with an arbitrary Cartan matrix. Structure of the highest weight representations. Character formula. Applications to the classification of symmetric spaces. Applications to combinatorics and classical problems of linear algebra. Connection with classical theta functions and modular forms. Basic representations and their relation to the quantum field theory. Other topics.
V. Kač

18.755 Introduction to Lie Groups (A)

Prereq.: 18.100, 18.710
Year: G (1)
3-0-9

A broad general introduction to Lie groups, suitable for physicists as well as mathematicians. Study of basic elementary examples: the classical matrix groups, the Galilei, Lorentz, and Poincare groups. Spinors, special functions, invariants, classical dynamics. Introduction to manifolds, general Lie groups, homogeneous spaces, and Lie algebras. Automorphism and adjoint groups.
D. A. Vogan

18.756 Analysis of Lie Groups (A)

Prereq.: 18.755
Year: G (2)
3-0-9

Semi-simple Lie groups and symmetric spaces. Topics in function theory on symmetric spaces, such as Fourier analysis and Radon transform, invariant differential operators and potential theory. Emphasis on connections with classical analysis and representation theory. ***(Not offered 1981-82.)***
S. Helgason

18.757 Representations of Lie Groups (A)

Prereq.: 18.755
Year: G (2)
3-0-9

Representations of compact groups, Peter-Weyl theorem and the Borel-Weil-Bott theorem. Introduction to representations of simple Lie groups.
M. F. Vergne

18.758 Representations of Lie Groups (A)

Prereq.: 18.757
Year: G (2)
3-0-9

Continuation of 18.757. ***(Not offered 1981-82.)***
B. Kostant

18.759 Automorphic Forms and Group Representations (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Seminar covering the following topics: automorphic forms and group representations; classical case; representations of the group SL(2;IR); the Weil representation and Theta series. ***(Not offered 1981-82.)***
M. F. Vergne

18.769 Topics in Lie Theory (A)

Prereq.: Permission of Instructor
Year: G (1, 2)
3-0-9

Topics in Lie theory, varying from year to year. May be repeated for credit. Topics for 1979-80: Representations of finite groups. Emphasis on complex representations of Chevalley groups over finite fields. Cuspidal representations; decomposition of the principal representations; representations of Hecke algebras; representations of $GL_n(F_q)$. Some familiarity with Lie groups, Lie algebras, or algebraic groups helpful. ***(Not offered 1981-82.)***
G. Lusztig

18.775 Algebraic Number Theory (A)

Prereq.: 18.705
Year: G (1)
3-0-9

18.776 Algebraic Number Theory (A)

Prereq.: 18.775
Year: G (2)
3-0-9

Study of algebraic number fields. Ideals, class-numbers, units, zeta functions, prime ideal theorem, abelian L-series and reciprocity laws. Non-abelian L-series, Chebotarev density theorem, Brauer-Siegel theorem and class-number problems. ***(Not offered 1981-82.)***
N. C. Ankeny

18.781 Theory of Numbers

Prereq.: 18.701 or 18.703
Year: U (1)
3-0-9

Study of primes, congruences, and arithmetic functions and proofs of their asymptotic formulae. Approximations of the real numbers by rationals, Kronecker's theorem, and the introduction of geometry of numbers. Quadratic forms and quadratic number fields. Elementary proof of the prime number theorem.
N. C. Ankeny

18.785 Analytic Number Theory (A)

Prereq.: 18.115
Year: G (2)
3-0-9

Analytic algebraic number theory. Functional equations of zeta and L-functions. Zero-free regions and prime number theorems. Zeroes on the critical line (Levinson's method). Class numbers of quadratic fields. Sieve methods leading to Bombieri's mean value theorem for primes in arithmetic progressions. We prove several deep theorems as above illustrating the use of hard analytic estimates.
D. M. Goldfeld

18.786 Topics in Number Theory (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Topics vary from year to year; may be repeated for credit. Topics in the past few years include: Diophantine analysis and transcendence; quadratic number fields and complex multiplication; automophoric forms.
H. M. Stark

Topology and Geometry

18.901 Introduction to Topology I (A except XVIII)

Prereq.: 18.100
Year: G (1, 2)
3-0-9

18.902 Introduction to Topology II (A except XVIII)

Prereq.: 18.901, 18.701 or 18.703
Year: G (2)
3-0-9

An introduction to topology, covering topics fundamental to modern analysis and geometry. Intended for those going on to graduate work. 18.901: Topological spaces, connectedness, compactness, continuous functions, separation axioms, function spaces. Metrization theorems, the Tychonoff theorem. Topological groups. 18.902: introduction to algebraic topology. Fundamental group, covering spaces, Van Kampen theorem, classification of covering spaces. Applications to knot theory, classification of compact surfaces, separation theorems in the plane. ***(18.902 not offered 1981-82.)***
Term 1: *S. Szcepanski*
Term 2: *D. Pengelley*

18.903 Introduction to Algebraic Topology

Prereq.: 18.100; *18.701* or *18.703*
Year: U (1)
3-0-9

Introduction to some of the ideas of algebraic topology, but less advanced than 18.901 and 18.902. The notions of homotopy, zero and first cohomology groups, and their properties studied. Proof of the Jordan curve theorem. Classification of two-dimensional manifolds. ***(Not offered 1981-82.)***
F. P. Peterson

18.904 Seminar in Topology

Prereq.: 18.901
Year: U (2)
3-0-9

Seminars for mathematics majors in several topics, each under the direction of a faculty member whose special interest is in the field of the seminar. Reports and discussion by students on topics taken from current journals or from texts not regularly used in other mathematics subjects. Certain topics may require an additional prerequisite.
G. W. Whitehead

18.905 Algebraic Topology (A)

Prereq.: 18.702 or 18.705; 18.901
Year: G (1)
3-0-9

18.906 Algebraic Topology (A)

Prereq.: 18.905
Year: G (2)
3-0-9

Fundamental group, covering spaces, simplicial homology, simplicial approximation manifolds. Homology and cohomology of topological spaces, universal coefficient theorem, plus additional topics to be chosen by the instructor.
J. R. Munkres

18.915 Graduate Topology Seminar (A)

Prereq.: 18.906
Year: G (1)
3-0-21

Study and discussion of important original papers in the various parts of algebraic and differential topology.
D. M. Kan

18.917 Advanced Topology (A)

Prereq.: 18.906
Year: G (2)
3-0-9

Content varying from term to term so that graduate students taking the subject in successive terms may have an introduction to several important phases of topology such as homotopy theory, cohomology theory, fibre spaces, K-theory, combinatorial topology, and/or differential topology. Homotopy theory, cobordism theory. ***(Not offered 1981-82.)***
Staff

18.950 Elementary Differential Geometry

Prereq.: 18.100
Year: U (2)
3-0-9

Detailed study of curves and surfaces in R^3 with emphasis on specific examples. Frenet formulas, fundamental forms, curvature, Gauss's theorem, parallelism, Gauss-Bonnet theorem, minimal surfaces.
R. W. Urwin

18.961 Elementary Differential Topology

Prereq.: 18.101, 18.901
Year: U (1)
3-0-9

Differentiable manifolds in R^n; differentiable mappings; transversality; Sard's theorem; intersection theory; the Euler characteristic of a manifold and the Lefschetz fixed point theorem; integration on manifolds, Stokes' theorem, DeRham cohomology. ***(Not offered 1981-82.)***
V. W. Guillemin

18.965 Geometry of Manifolds (A)

Prereq.: 18.101
Year: G (1)
3-0-9

Surfaces and Differentiable Manifolds. Grassmann Algebra. Affine Connections. Exponential Mapping. Geodesics. Riemannian Manifolds. Curvature. Lie Groups. Symmetric Spaces. Complex Manifolds.
S. Helgason

18.966 Geometry of Manifolds (A)

Prereq.: 18.965
Year: G (2)
3-0-9

Continuation of 18.965. Selected topics in Differential Geometry.
J. Sacks

18.969 Topics in Geometry (A)

Prereq.: 18.965
Year: G (1)
3-0-9

Content varies from year to year; may be repeated for credit. Topics for 1981-82: Geometric quantization. Hamilton-Jacobi theory, symplectic manifolds, line bundles with connection. Prequantization, polarizations, BKS transform, the metaplectic group and symplectic spinors, coadjoint orbits. Applications to completely integrable systems (Toda lattice, KdV equation, Whittaker functions, Maslov theory and the Bohr-Sommerfeld condition), the hydrogen atom, Schroedinger equation, Maxwell's equation, special relativity, representations and characters.
B. Kostant

18.975 Elliptic Operators (A)

Prereq.: 18.965
Year: G (1)
3-0-9

Elliptic pseudodifferential operators and Fourier integral operators associated with them. Spectral theorems relating asymptotic properties of the spectrum to geometric properties of the bicharacteristics. The Selberg trace formula and various generalizations of it.
V. W. Guillemin

18.976 Elliptic Operators (A)

Prereq.: 18.975
Year: G (2)
3-0-9

Continuation of 18.975. Spectral properties of differential and pseudodifferential operators on open manifolds, scattering theory, non-self-adjoint operators. ***(Not offered 1981-82.)***
V. W. Guillemin

18.994 Seminar in Geometry

Prereq.: —
Year: U (1, 2)
3-0-9

Seminars in several topics, for math majors. Each under direction of a faculty member whose interest is in the field of the seminar. Reports and discussions by students on topics from current journals or texts not regularly used in other math subjects.
Term 1: *S. Helgason*
Term 2: *Staff*

18.999 Mathematical Reading

Prereq.: —
Year: G (1, 2, S)
Arr.

Reading of advanced mathematical treatises under supervision of a member of the Department. For graduate students desiring advanced work not provided in regular subjects.
Staff

19 Meteorology and Physical Oceanography

19.UR Undergraduate Research

Prereq.: —
Year: U (1, 2)
Arr.

Undergraduate research opportunities in Meteorology. For further information consult the Departmental Coordinator.
F. Sanders, Staff

19.02 Descriptive Meteorology

Prereq.: 18.01
Year: U (2) SD
2-2-5

The general circulation of the earth's atmosphere; the secondary circulations, both tropical and extratropical, including the role of air masses and fronts; the tertiary (local) circulations, including drainage winds, local convection, whirlwinds, showers, thunderstorms, land and sea breeze, large-scale turbulence eddies, föhn winds, etc. (Limited enrollment)
Staff

19.05J Environmental Chemistry of the Ocean-Atmosphere System

(Same subject as 12.20J)
Prereq.: —
Year: U (1)
3-0-9

The earth's air and water. Factors controlling the steady-state composition of the ocean and atmosphere. Response times of the system to natural and anthropogenic perturbations. Exchange of material between the ocean and atmosphere. Global and regional balances of water, carbon, oxygen, hydrogen, sulfur, and nitrogen. Residence times of these species in the various subsystems. Cycle of aerosols and role of rain and snow as removal processes. Continental weathering cycle and its effect on the composition of the dissolved and suspended load of rivers. Special problems involving use of radiocarbon, tritium, radon, and other natural and artificial radioactive and stable isotopes as tracers. Effect of human activities on the various interrelated cycles that control the chemistry of the global environment. (Prerequisite: General Institute Science Requirement or the equivalent.)
R. E. Newell, J. M. Edmond

19.10 Climate of the Past

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Suitable for undergraduate and graduate students with little or no previous background in meteorology. Climatic change on time scales from past 100,000 years to past 20 years. For Quaternary era, data on glaciers, isotope ratios in ice cores, ocean bed cores, pollen records, lake levels, etc. used to reconstruct past climates, including rainfall patterns and global air and sea temperatures. For recent period, use meteorological sounding balloon data, pressure, surface air and sea surface temperature observations to construct patterns of change. Phenomena such as biennial oscillation, Southern Oscillation, and other nonseasonal changes in atmosphere and ocean. Possible explanations of changes in terms of current concepts of atmospheric and oceanic general circulation. Role of volcanoes, carbon dioxide changes, and other anthropogenic influences in controlling climate. Consideration of hypotheses for climatic change and prospects for climatic forecasting. (Prerequisite: General Institute Science Requirement or the equivalent.)
R. E. Newell

19.34 Statistical Methods in Meteorology

Prereq.: 18.02
Year: G (1)
2-0-4

Designed to examine recent development in statistical weather forecasting and to provide a background for performing and evaluating statistical studies with meteorological data. Statistical forecasting by linear regression, nonlinear statistical forecasting, significance of empirical relations, and hypothesis testing. ***(Not offered 1981-82.)***
E. N. Lorenz

19.35 Statistical Problems in Meteorology (A)

Prereq.: 19.34
Year: G (2)
2-0-4

Various statistical problems in meteorology, including such topics as power spectrum analysis, properties of stationary time series, and predictability of atmospheric motion. ***(Not offered 1981-82.)***
E. N. Lorenz

19.43 Synoptic Meteorology I (A)

Prereq.: 19.69 or 18.350
Year: G (1)
3-3-6

Development of concepts for studying atmospheric circulations, particularly extratropical cyclones and anticyclones, and tropical storms. Coriolis force and relationships between wind and pressure fields. Dry-adiabatic and moist-adiabatic processes, and elementary analysis of cumulus convection. The vorticity equation and its application to analysis of circulations. Mean state of the atmosphere and its typical disturbances. Daily discussions of current weather situations over North America.
F. Sanders

19.44 Synoptic Meteorology II (A)

Prereq.: 19.43
Year: G (2)
3-3-6

Explanations of extratropical cyclones and anticyclones from polar-front theory to quasi-geostrophic theory. Fronts and frontogenesis. Cumulus convection and its interaction with larger scales of motion. Development and behavior of tropical storms. Analysis of meteorological data, both routinely available and from special field experiments.
F. Sanders

19.46 Numerical Modeling in Meteorology and Oceanography (A)

Prereq.: 19.71J
Year: G (2)
3-0-9

Derivation of simplified sets of model equations, primarily by scale analysis. Discussion of characteristics of atmospheric and oceanographic motions relevant to numerical analysis. Study of principal numerical methods used in geophysical fluid models. Consistency, convergence, linear and nonlinear stability. Data assimilation and the problem of meteorological noise. Examples drawn from meteorology and oceanography, with emphasis on numerical weather prediction.
M. A. Cane

19.61 Dynamic Meteorology I (A)

Prereq.: 18.075
Year: G (1)
3-0-9

Thermodynamics of dry and moist air. Hydrodynamic equations for a rotating spherical atmosphere. Quasi-hydrostatic motions. Boundary-layer phenomena. ***(Not offered 1981-82.)***
E. N. Lorenz

19.62 Dynamic Meteorology II (A)

Prereq.: 19.61
Year: G (2)
3-0-9

A continuation of 19.61. Quasi-geostrophic motions. Small-scale convective motions. Theory of small perturbations. Energetics of the atmosphere. ***(Not offered 1981-82.)***
E. N. Lorenz

19.63 Diagnostic Studies of the General Circulation (A)

Prereq.: 19.70
Year: G (1)
3-0-9

Description of diagnostic studies of atmospheric transports and energetics and discussion of their implications for the theory of the structure and general circulation of the atmosphere. Discussion of the validation and use of numerical general circulation models as atmospheric analogs.
P. H. Stone, R. D. Rosen

19.64 Atmospheric Modeling (A)

Prereq.: 19.70, 19.72
Year: G (2)
3-0-9

Development of simple models for radiative heating, small-scale convection, and large-scale advection, and their use in deductive analyses of the structure and general circulation of planetary atmospheres. Application of these models to comparative studies of Venus, the Earth, Mars, and Jupiter, and to climate problems.
P. H. Stone

19.65J Turbulence and Random Processes in Fluid Mechanics (A)

(Same subject as 16.044J)
Prereq.: 1.612 or 2.20 or *16.035* or 18.350
Year: G (1)
3-0-9

Development of descriptions of random fields. Response of systems and fields to random inputs, with examples from waves. Sources of turbulence, hydrodynamic stability, equations, spectra, equilibrium, and decay. Shear flow turbulence, turbulent boundary layers. Methods of observation, measurement, and analysis. Discussion of problems of current interest.
E. L. Mollo-Christensen, M. T. Landahl

19.681 Synoptic Scale Dynamics in the Atmosphere and Oceans (A) (Revised Content)

Prereq.: 19.69, 19.70, 19.71J
Year: G (1)
3-0-9

Quasi-geostrophic equations for a stratified fluid on a sphere. The potential vorticity equation and low Rossby number. Available potential energy. Internal Rossby waves; the vertical structure equation and spin-down. Planetary mountain waves and radiation of energy. The instability of currents in the atmosphere and oceans. Necessary conditions for instability. Baroclinic and barotropic instability. Energy cycles in the general circulations. Enstrophy and geostrophic turbulence.
R. T. Pierrehumbert

19.682 Instability and Turbulence in Geophysical Systems (A) (Revised Content)

Prereq.: 19.681
Year: G (2)
3-0-9

Comprehensive introduction to the methodology of stability theory as applied to problems of interest in geophysical fluid dynamics. Most of the mathematical techniques required are presented in conjunction with the physical problems to which they are applied. Problems governed by quasi-geostrophic dynamics emphasized, but selected topics related to mesoscale motions are discussed. Topics in linear theory include: baroclinic-barotropic instability, numerical methods for eigenvalue problems, Rossby wave instability, symmetric instability, and solution of initial value problems. Nonlinear processes discussed include: instability, strange attractors, and equilibrium chaos in geostrophic turbulence.
J. Pedlosky

19.69 Fluid Dynamics of The Atmosphere and Ocean (A)

Prereq.: 8.03, 18.04
Year: G (1)
3-0-9

Introductory subject for first-year graduate students in meteorology and oceanography. Variables and conservation principles, equations of motion in Eulerian and Lagrangian forms, pressure integrals, vorticity, vorticity theorems, potential motion. Rotating fluids, illustrated by problems and examples, quasigeostrophic approximation, Rossby waves, barotropic flows and instabilities, baroclinic instability, transport processes and convection.
E. L. Mollo-Christensen

19.70 Oceanic and Atmospheric Models (A) (Revised Content)

Prereq.: 19.69
Year: G (2)
3-0-9

Basic theories used to explain the large-scale steady circulations of the atmosphere and oceans, with related observational data. Fundamental simplifications of the equations of motion for a compressible, stratified fluid on a spherical, rotating earth which can be applied for the large-scale steady circulations. The forces which drive the motions. The Hadley cell model of atmospheric circulations and the role of moist convection. Eddy fluxes and the role of topography and variations in surface temperature upon the circulation. Sverdrup theory for the mid-ocean circulation. Models of western boundary currents and the formation of the thermocline. Ideas on the role of eddies in the ocean circulation.
D. B. Haidvogel (Woods Hole Staff), G. R. Flierl

19.71J Wave Motions in The Atmosphere and Oceans (A)

(Same subject as 12.810J)
Prereq.: 18.350 or 19.69
Year: G (2)
3-0-9

Introduction to general concepts in wave theory, dispersive and nondispersive waves, energy flux, wave action, ray theory. Derivation of wave equations in geophysical systems: Laplace tidal equation, shallow water theory, planetary waves, topographic waves, internal gravity waves. Wave-mean flow and wave-wave interactions.
N. G. Hogg (Woods Hole Staff)

19.72 Atmospheric Radiation (A)

Prereq.: 5.61 or 8.05, 18.075
Year: G (2)
3-0-9

Quantum theory of radiation and its absorption by molecules. Equation of radiative transfer and spectral line formation in a non-scattering atmosphere. Application to computation of atmospheric heating rates and radiative decay times. Remote sensing of atmospheric temperature, pressure, and composition from earth orbiting satellites and planetary probes. Theory of light scattering (including polarization) by molecules and particles. Analytical and numerical solutions to the equation of radiative transfer for various phase functions and spectral line formation in a scattering atmosphere. Effects of scattering on the computation of radiative heating rates and on the interpretation of satellite data.
R. G. Prinn

19.73 Chemistry and Dynamics of Upper Atmospheres (A)

Prereq.: 19.61
Year: G (2)
3-0-9

Description of composition, structure, circulation, and energetics of the upper atmosphere. Zonally averaged, and longitudinally and temporally varying phenomena. Transport of trace substances including molecular diffusion above the turbopause, parameterized eddy transport below the turbopause, and atmospheric escape. Chemical kinetics in the atmosphere. Scale analysis of the continuity equation and photochemical-dynamical steady states. Dynamics of the upper atmosphere studied using zonal-mean and perturbation forms of equations of motion. Excitation and propagation of internal gravity and quasi-geostrophic waves using linear theory. A 3-D photochemical-dynamical description of the stratospheric ozone layer, emphasizing interactions between chemistry, dynamics, and radiation. Projected ozone destruction by anthropogenic odd nitrogen and chlorine species. Recent studies of the chemistry and dynamics of the upper atmospheres of Venus, Mars, and Jupiter. ***(Not offered 1981-82.)***
R. G. Prinn

19.74 Cloud and Precipitation Physics (A)

Prereq.: 19.02, 18.03, 5.60
Year: G (1)
3-0-9

Introduction to the physics and chemistry of hydrometeor nucleation and growth in convective and stratiform cloud systems, with discussions of the physics and state-of-the-art of cloud seeding.
R. E. Passarelli

19.75 Radar Meteorology

Prereq.: 19.74
Year: G (2)
3-0-9

Introduction to radar sensing of the atmosphere with emphasis on the meteorological information content of coherent (Doppler) and non-coherent (non-Doppler) radar signals.
R. E. Passarelli

19.77 Introduction to Physical Oceanography (A) (New)

Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Designed to introduce the nonphysical oceanography major to the basic elements of descriptive and dynamic physical oceanography. Topics include properties of sea water, equations of motion with application to oceanic flows, descriptive general circulation, and the water masses of the world's oceans. Emphasis on the physical understanding of the major features of general circulation. Mathematics through calculus required.
Woods Hole Staff

19.78 Dynamics of Shelf Circulation (A) (New)

Prereq.: 19.851
Year: G (2)
3-0-6

Advanced discussion of tides over the shelf, coastally-trapped waves, and wind driven upwelling and circulation over the shelf. Emphasis on the relationship between theory and observation, and on the design and analysis of fluid experiments. (Topics covered depend somewhat on the background and research interests of students enrolled. Alternate years. ***Offered 1981-82.***)
K. Brink, R. C. Beardsley (Woods Hole Staff)

19.79 Numerical Modeling in the Oceanographic Sciences (A) (New)

Prereq.: Permission of Instructor
Year: G (1)
3-6-0

Primarily a problem-solving course in which a variety of numerical techniques are derived and discussed in the context of specific oceanographic problems and applications. Examples drawn from biological chemical, physical oceanography. General problem areas include: curve fitting and the approximation of functions; ordinary differential equations; and eigenvalue/eigenvector problems. Also considers partial differential equations. Some of the associated approximation methods discussed are: fitting by least-squares and cubic splines; Tunga-Kutta predictor-corrector and phase plane solution techniques; "shooting" methods; and finite-difference techniques.
D. B. Haidvogel (Woods Hole Staff)

19.83 Physical Oceanography

Prereq.: 8.02
Year: U (1) SD
3-0-9

An introduction to the physics of the oceans — observations and dynamical models. Elementary fluid mechanics, composition of seawater, and driving forces acting on the ocean. Classical water mass analysis and geostrophic computations, and modern methods and instruments for studying the circulation. Descriptive picture of the flow. Simple models and conceptual pictures of general circulation. Data and models of the time dependent motions with a wide range of time and space scales. (Some previous exposure to elementary fluid mechanics helpful but not required. Similar to 12.21. ***Not offered 1981-82.)***
Staff

19.842 Dynamics of Eddies and Circulation (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Theory of ocean eddies and waves of scales ≥ 50 kilometers, and periods longer than a day. Planetary and topographic waves; baroclinic and barotropic instability; geostrophic turbulence; energy cycles; general circulation of an ocean containing eddies. Reference to data and numerical models, with term projects involving theory or computer modeling. (Alternate years. ***Not offered 1981-82.***)
P. B. Rhines (Woods Hole Staff)

19.851 Circulation in the Coastal Ocean (A) (Revised Content)

Prereq.: Permission of Instructor
Year: G (1)
3-0-6

Fundamental equations and their simplification. Inertial response to wind, generation of setup, effect of rotation on setup. Coastal currents generated by impulsive longshore and cross-shore wind, adjustment drift. Behavior of a stratified sea, impulsive response of continuously stratified and two-layer models. The subtle effects of topography, impulsive response of variable depth models, vortex stretching effects. Topographic waves and their generation by sudden wind. Observational evidence on wind-driven currents, quantitative comparison with inertial response theory. Flow controlled by bottom friction, adjustment to frictional equilibrium, parallel transport model of shelf circulation. Circulation cells in the coastal ocean, trapped pressure fields associated with long-shore and cross-shore winds. Thermohaline circulation, inertial adjustment problems. Interaction of density and velocity fields, diffusion dominated regime of thermohaline circulation, shear diffusion. Trapped pressure field associated with freshwater inflow, far-field effects of rivers. Observational evidence on hurricane driven currents and mean circulation in shallow seas, detailed comparison with theory. (Alternate years. ***Offered 1981-82***).
G. Csanady (Woods Hole Staff)

19.86 The General Circulation of the Oceans (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-6

Subject consists of reading and discussion on the large-scale, permanent ocean circulation. There is no single text which covers more than a fraction of the subject matter. Parts of "The Oceans" will serve as a starting point but most of the reading consists of more recent papers. A complete reading list supplied at the first session. Reading list consists of most of the important work on the world water masses, their distribution, and what is known or surmised about their rate of formation. Also included are works on the major current systems of the oceans. While the Pacific, Indian, and South Atlantic oceans are not neglected, the North Atlantic receives the most detailed treatment. (Given at Woods Hole Oceanographic Institution.)
M. McCartney, V. Worthington (Woods Hole Staff)

19.87 Physical Properties of Seawater (A)

Prereq.: 18.60
Year: G (1)
3-0-6

Physical properties of seawater necessary to formulate a hydrodynamical and thermodynamical description of an open, non-equilibrium seawater system. Topics: the equation of state, thermodynamic potentials, colligative properties, diffusion potentials and energy transformations. (Permission of instructor required. Alternate years. ***Not offered 1981-82.***)
N. Fofonoff (Woods Hole Staff)

19.89 Special Problems in Oceanography (A)

Prereq.: Permission of Instructor
Year: G (1, 2)
Arr.

Reading, consultation, and original investigation on oceanographic problems.
Staff

19.891-19.899 Special Problems in Oceanography (A)

Prereq.: —
Year: G (1, 2)
Arr.

Reading, consultation, and original investigation on oceanographic problems.
Woods Hole Staff

19.901 Undergraduate Research Problem

Prereq.: —
Year: U (1, 2)
Arr.

19.902 Undergraduate Research Program

Prereq.: —
Year: U (1, 2)
Arr.

Extended participation in the work of a research group, including independent study of the literature, direct involvement in the group's research (commensurate with the student's skills and preparation), or project work under an individual faculty member extending over more than one term. (Admission by arrangement with the individual instructor.)
Staff

19.93 Special Problems in Oceanography

Prereq.: *19.83*
Year: G (1, 2)
Arr.

Reading, consultation, and original investigation on oceanographic problems.
Staff

19.94 Special Problems in Meteorology

Prereq.: 19.02
Year: G (1, 2)
Arr.

Reading, consultation, and original investigation on meteorological problems.
Staff

19.95 Special Problems in Meteorology (A)

Prereq.: 19.43, 19.62
Year: G (1, 2)
Arr.

Reading, consultation, and original investigation on meteorological problems of more advanced nature than those in 19.94.
Staff

19.961-19.969 Special Subject in Meteorology (A)

Prereq.: —
Year: G (1, 2)
Arr.

Organized lecture or laboratory subject on some aspect of meteorology not normally covered in the regularly scheduled subjects.
Staff

19.97 Laboratory Course in Geophysical Fluid Dynamics (A) (New)

Prereq.: Permission of Instructor
Year: G (2)
0-3-3

A substantial portion devoted to simple experiments which simulate large scale geophysical flows and hence involving rotating or stratified fluids. Topics include properties of surface and internal waves, flow over topography, convection, and boundary layers. Aspects of smaller scale flows (low Reynolds number, surface tension, Langmuir cells) covered. The last third devoted to a student project.
J. A. Whitehead (Woods Hole Staff)

19.971-19.979 Special Subject in Oceanography (A)

Prereq.: —
Year: G (1, 2)
Arr.

Organized lecture or laboratory subject on some aspect of oceanography not normally covered in the regularly scheduled subjects.
Staff

19.98 Air Sea Interactions (A) (New)

Prereq.: Permission of Instructor
Year: G (1)
3-0-6

Concentrates on methods, instruments, and recent results in the interaction of the atmosphere and the ocean on spatial scales less than 1000 km and time scales less than seasonal. Topics emphasized are vertical fluxes of momentum, heat and moisture over the ocean, mixed layer development, and parameterization of ocean forcing by synoptic scale meteorology. Examples taken from recent experiments. (Alternate years. ***Offered 1981-82.***)
M. G. Briscoe, R. Weller (Woods Hole Staff)

19.99 Experimental Physical Oceanography (New)

Prereq.: Permission of Instructor
Year: G (1, 2)
3-0-6

Philosophy and design of physical experiments in the ocean. Review of dynamic and kinematic equations, scaling and sampling theory. Description of previous experiments with regard to formulation of a hypothesis from a conceptual or theoretical model: translation of the hypothesis into an experimental design; and analysis of measurements. (Alternate years. ***Not offered 1981-82***).
H. L. Bryden (Woods Hole Staff)

20 Nutrition and Food Science

Undergraduate Subjects

Undergraduate Laboratory Subjects

20.002 Laboratory in Applied Biology

Prereq.: 5.41; 7.01 or 20.021
Year: U (1) LAB
2-8-4

A series of techniques in basic analytical biochemistry and separation science presented through observations on yeasts, mammalian cells and mammalian tissues. Subcellular fractionation, enzyme assays, disc gel electrophoresis, affinity chromatography, use of radioisotopes, experimental surgery and other techniques applied in experiments illustrative of research in various departmental groups. Recommended for students anticipating careers in applied areas of biology, such as food and biochemical engineering, environmental toxicology, pharmacology, nutrition, cancer research, genetic engineering, or medicine.
R. S. Langer, Jr., A. M. Klibanov, M. A. Marletta, W. G. Thilly

Undergraduate Research

20.ThU Undergraduate Thesis

Prereq.: —
Year: U (1, 2, S)
Arr.

Program of undergraduate research leading to the writing of S. B. thesis; to be arranged by the student and an appropriate faculty member.
A. J. Sinskey

20.UR Undergraduate Research Opportunities

Prereq.: —
Year: U (1, 2)
Arr.

Opportunities available in a wide variety of research programs in mammalian biochemistry and metabolism, clinical and public health nutrition, international nutrition, neuroendocrine regulation and endocrinology, toxicology, food science and technology, and biochemical engineering. Problems emphasize direct and active involvement of undergraduates in laboratory research which may be extended over multiple terms.
C. L. Cooney

20.011 Special Projects in Undergraduate Research

Prereq.: —
Year: U (1)
Arr.

20.012 Special Projects in Undergraduate Research

Prereq.: —
Year: U (2)
Arr.

Directed research in the fields of mammalian biochemistry and metabolism, clinical and public health nutrition, international nutrition, neuroendocrine regulation and endocrinology, toxicology, food science and technology, and biochemical engineering.
C. L. Cooney

General Undergraduate Subjects

20.021 Physiological and Nutritional Biochemistry

Prereq.: 5.41
Year: U (2) SD
4-0-8

A study of the dynamic interaction between the animal and its environment, particularly the diet. Chemical and metabolic phenomena involved in the development and maintenance of the mammalian organism. Regulation as a means of adaption. Some current issues in nutrition related to health are discussed.
B. A. Underwood

20.022 Mammalian Physiology (Revised Unit)

Prereq.: 7.01 or 20.021
Year: U (1)
5-0-7

Structure and function of organs and systems that participate in the regulation of the internal milieu. Emphasis on integration of individual control mechanisms in regulating body functions. Topics include cardiovascular regulation, gastrointestinal function, kidney functions, immune defense, respiration, and nervous system function, with the roles of central and peripheral nervous systems in the regulation of body functions considered in detail. (Permission of instructor required for students having no subjects in Life Sciences.)
J. D. Fernstrom

20.023 Human Nutrition

Prereq.: 20.021
Year: U (1)
3-0-6

Basic principles of human nutrition and worldwide nature and distribution of nutritional disease. Emphasis on understanding requirements for and interrelationships among essential nutrients in individuals and populations, nutritional needs during pregnancy and lactation, growth and maturation, and disease, causality, clinical and biochemical assessment of nutritional deficiencies, evaluation of food intakes and dietary habits, interaction of nutrition and infection, and the relationship between malnutrition and mental development. Analysis of both malnutrition in developing countries and underprivileged populations and the problems of overnutrition in industrialized societies.
N. W. Solomons

20.028 The Vitamins

Prereq.: Permission of Instructor
Year: U (2)
3-0-6

The nutritional, physiological, and biochemical properties and functions of the vitamins, and how they fit into mammalian metabolism; a discussion of the topics on which the vitamins impinge; e.g., connective tissue, collagen and vitamin C; blood clotting and vitamin K; the synthesis of fatty acids and biotin; calcium homeostasis, bone metabolism and vitamin D; the structure of membranes and vitamin A.
G. Wolf

20.029J Food, People and Cultures

(Same subject as 21.592J)
Prereq.: —
Year: U (1)
3-0-6

Food and nutrition within the cultural context. First part considers how different societies define food, meals, and adequate nutrition. Cultural solutions to the food quest in different environments. Ways in which kinship, politics, and ritual structure the food quest and influence how food is distributed among the members of a community. Role of food as a source of nutrition, a symbol, a political tool, an index of wealth. Illustrated through case studies of foraging peoples, horticulturalists, and pastoralists. Second part examines food symbolism, food technology, and human adaptation to the diet. Last segment surveys how food and diet have changed over the last 10,000 years and concludes with an anthropological view of current food problems. (May be counted toward Humanities Requirement. Alternate years. ***Not offered 1981-82.***)
M. Diskin, W. E. Wetterstrom

General Graduate Subjects

Graduate Subjects by Area

20.111 Analytical Practices in Biochemistry (A)

Prereq.: 5.42
Year: G (1)
3-8-5

A series of techniques basic to analytical biochemistry. Basic spectro-photometric analyses and separations are taught in first portion of subject. Modular laboratories present specialized techniques such as high pressure liquid chromatography, analysis of metabolic dynamics, and gas chromatography-mass spectrometry analysis and others. Emphasis on quantitative and statistical interpretation.
R. S. Langer, Jr., H. Brunengraber, W. G. Thilly, J. S. Wishnok, M. A. Marletta, A. M. Klibanov, J. Fox, G. Wolf

20.113J Biostatistics I (A)

(Same subject as 18.055J)
Prereq.: Permission of Instructor
Year: U (1) G (1) SD
3-0-9

Introduction to statistical reasoning with applications to research in the life sciences. Topics: probability models, descriptive statistics, estimation and significance testing, frequency tables, regression and correlation, analysis of variance, nonparametric statistics, retrospective and prospective studies, clinical trials. Other topics in Biostatistics included according to the interests of students.
W. M. Rand, S. L. Rasmussen

20.114 Biostatistics II (A)

Prereq.: 20.113J
Year: G (2)
2-2-4

Continuation of 20.113J with emphasis on use of packaged computer programs to analyze real data. Lectures cover analysis of variance, multiple regression and correlation, and various other multivariate statistical methods.
W. M. Rand

20.115 Design of Field Studies

Prereq.: Permission of Instructors
Year: G (1, 2)
2-0-4

Consists of planning for, and presentation of, successive stages in the elaboration of a specific field project by each individual, from preliminary reconnaissance to final processing and evaluation of data, with group discussion of each stage. Limited to persons actually planning specific field projects.
J. E. Gordon, Staff

Metabolism and Human Nutrition

20.211 Regulation of Mammalian Intermediary Metabolism (A) (Revised: Content and Unit)

Prereq.: 7.05, 20.022; 20.111
Year: G (2)
4-1-7

Metabolic regulation of intermediary metabolism with an emphasis on quantitative interpretation of data. Carbohydrate, fatty acids, cholesterol, and alcohol metabolism. Regulation of the tricarboxylic acid cycle and of ketogenesis. Modulation of carbon flow through pathways by variations in redox and energy charge parameters. Amplification of biochemical signals. (20.111 strongly recommended.)
H. Brunengraber, H. N. Munro

20.212 Basic and Human Nutrition (A) (Revised Unit)

Prereq.: 20.022, 7.05
Year: G (1)
4-0-8

Function and metabolism of essential nutrients and factors that affect nutrient metabolism in the mammalian organism. Knowledge of their biochemistry and physiology, based on studies in experimental animals, is integrated with a detailed discussion of human nutrition and metabolism including public health considerations. Emphasis on modern developments in nutritional research.
V. R. Young

20.213 Endocrinology in Nutrition and Metabolism (A)

Prereq.: 20.211
Year: G (2)
4-0-8

Basic principles of endocrine function. Survey of endocrine organs and their secretions. Hormone receptor physiology. Factors regulating endocrine function. Impact of hormones on metabolism of cells and organs. Endocrine balance in relation to nutritional state. Effect of hormones on metabolism of individual nutrients. Age-related changes in endocrine function.
M. J. Baum, J. D. Fernstrom, M. F. Holick

20.214 Advanced Nutrition (A)

Prereq.: 20.212
Year: G (1)
4-0-8

A discussion and evaluation of advances in research concerning the function and metabolism of essential nutrients. Emphasis on vitamins, trace elements, essential amino acids, fatty acids, lipids; e.g., connective tissue, collagen and vitamin C; calcium, homeostasis, bone metabolism and vitamin D; glycoproteins, membrane structure and vitamin A; lysine and carnitine; iron, zinc, copper, manganese, chromium, selenium and newer trace elements.
G. Wolf, N. W. Solomons, Staff

20.215 Regulation of Mammalian Protein Metabolism (A) (Revised Content and Unit)

Prereq.: 20.211
Year: G (1)
4-1-7

Metabolic regulation of protein and nucleic acid metabolism with an emphasis on quantitative interpretation of data. Metabolism of amino acids: transport, protein synthesis, individual pathways of amino acid metabolism. Protein and amino acid metabolism in individual tissues. Hormones and other regulators of protein metabolism. Nucleic acids and nucleotide metabolism. Ammonia metabolism: urea and purine nucleotide cycle.
H. N. Munro, H. Brunengraber

20.217 Trace Mineral Nutrition (A)

Prereq.: Permission of Instructor
Year: G (1)
2-0-6

Concentrates on the trace minerals in human and animal nutrition. Emphasis on the biochemical, metabolic, and physiological function of the trace minerals: iron, zinc, copper, manganese, chromium, and selenium with minor discussion of molybdenum, nickel, tin, vanadium, cadmium, arsenic. Technique of clinical assessment of nutritional status; anemia, trace metal content of breast milk, and primary and conditional deficiency states. Discussion and evaluation of current research in trace mineral nutrition. (Open to selected undergraduates.)
N. W. Solomons

Human and Clinical Nutrition

20.311 Advanced Human and Clinical Nutrition (A)

Prereq.: 20.212
Year: G (2)
4-0-8

Discussion of the application of nutrition knowledge in the therapy and support of humans and in various physiological and pathological states. Evaluation of nutritional requirements and status of humans. Includes consideration of the nutrition of normal and low-birth weight infants; nutrition and immunity; the cancer and traumatized patient; patients with specific organ disease (liver, brain, kidney, endocrine system, gastrointestinal tract). Patients with genetic and other metabolic diseases, obesity, degenerative diseases, and the elderly.
N. S. Scrimshaw, V. R. Young, Staff

20.312 Clinical Nutrition in Practice (A)

Prereq.: 20.311
Year: G (1, 2)
0-8-4

Coordinated practical experience on the application of nutrition in the management and care of hospitalized patients. Conducted in collaboration with units at hospitals within the Boston area.
N. S. Scrimshaw, Staff

20.313 Field Observations in Human Nutrition (A) (Revised Unit)

Prereq.: 20.023 or 20.311
Year: G (2)
3-6-3

Practical laboratory and field experience in human nutrition problems. Planning execution and interpretation of nutrition surveys including dietary, clinical, laboratory, and related socioeconomic data. Demonstration of techniques and methods used to determine nutritional status including clinical, anthropometric, hematological, and biochemical. Field survey conducted in January. (Permission of instructor required.)
B. A. Underwood, Staff

20.314 Nutrition and Immunity (A)

Prereq.: Permission of Instructor
Year: G (2)
2-0-6

The nutritional modulation of immune responses and protective immunity; includes the effects of nutritional deficiency and overnutrition on antigen specific and non-specific host defenses and the implication of the interaction in disease response and biological phenomena.
R. K. Chandra

20.315 Food Intolerance (A)

Prereq.: Permission of Instructor
Year: G (1)
2-0-4

Review of the immunologic and biochemical basis of intolerance and allergy to foods. First part examines the developmental aspects of gastrointestinal immunity and physiology. Latter part focuses on causes, pathogenesis, immunopathology, manifestations, diagnosis, management and prevention.
R. K. Chandra

20.317 Malnutrition, Learning and Behavior

Prereq.: Permission of Instructor
Year: G (2)
2-0-7

Review of available information concerning the effects of malnutrition on various physiological and behavioral responses. Topics: the socioeconomic context of malnutrition in developing countries; behavioral and intellectual functioning of children following mild to moderate malnutrition, nutritional marasmus, or kwashiorkor; learning behavior in experimentally malnourished animals; the maturation of various neuronal elements that mediate behavioral and intellectual functioning in the normal and malnourished organism.
J. Brozek

20.318 Atherosclerosis (A)

Prereq.: Permission of Instructor
Year: G (2)
2-0-4

A review of the etiology, pathogenesis, pathology, and treatment of atherosclerosis including dietary, environmental, and hereditary factors. The human disease is the major focus of the subject, but animal models are analyzed in depth for their contribution to the understanding of the disease.
R. S. Lees

International Food and Nutrition

20.410J Nutrition and National Development (Revised Unit)

(Same subject as 17.562J)
Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Deals with the nature of world food and nutrition problems and their relationship to the social and economic progress of developing countries. Considers the specific elements of nutrition planning methodology and the variety of concerns in effective nutrition programming at the micro policy level. (Open to advanced undergraduates with permission of instructor.)
M. B. Wallerstein

20.411J International Food and Nutrition Policy (A)

(Same subject as 17.232J)
Prereq.: 20.410J or Permission of Instructor
Year: G (2)
2-0-7

Considers the manner in which the issues of food and nutrition are handled at the macro political level. It focuses first on the domestic and foreign policy elements of concern to governments in formulating policy on these matters. Attention then directed to the major policy impacts of bilateral and multilateral approaches to food and nutrition issues between developed and developing nations. Concludes with an examination of the political effectiveness of international institutional mechanisms established to deal with problems such as malnutrition and insufficient food availability.
M. B. Wallerstein

20.412J Nutrition Policy and Planning in Selected Countries (A)

(Same subject as 17.560J)
Prereq.: 20.410J or Permission of Instructor
Year: G (2)
2-0-7

Examines malnutrition and selected governmental response to it in countries. Special emphasis given to the workings of the political system, the planning process, and several experimental interventions linking nutrition with family planning and other policy concerns.
Staff

20.413 Social Sector Microeconomics and Planning (A)

Prereq.: Permission of instructor
Year: G (1)
2-0-7

First part reviews microeconomic theory, with particular emphasis on its application to problems in agricultural and health economics (including the use and interpretation of mathematical programming methods in applied economic analysis). In the latter part, this material used as a basis for discussion and criticism of economic planning techniques in developing countries. For the final exam, students are asked to criticize a plan for a hypothetical country and formulate (in detail) a better one, with emphasis on food and nutritional aspects.
L. J. Taylor

20.414 The Political Economy of Food

Prereq.: Permission of Instructor
Year: G (1)
3-0-6

Looks at the world food economy, and the role that the US as the dominant exporting country plays in it. Emphasis on changes in diet patterns; impacts of technical change on agricultural productivity and income distribution in developing countries, and how they are affected by policy decisions in the US and other advanced countries; changes in food technology; food aid; political changes. Students expected to undertake independent research into some aspect of the world food economy. Readings include works of economic and social history, government documents, anthropological and political studies, trade statistics, surveys of food consumption.
L. J. Taylor

20.415 Epidemiology of Malnutrition

Prereq.: —
Year: G (2)
2-0-7

Examination of the highly complex interaction of environmental and host factors responsible for major disease problems holding back the social and economic progress of developing countries with special emphasis on the role of nutrition. (Open to qualified undergraduates.)
N. S. Scrimshaw, Staff

Neuroendocrine Regulation and Endocrinology

20.511J The Neurosciences I (A)

(Same subject as 9.014J)
Prereq.: 7.05
Year: G (2)
6-0-9

First of a two-semester sequence designed to expose graduate students to the broad range of contemporary topics in the Neurosciences. Topics: 1) mammalian neuroanatomy; 2) basic neurochemistry (protein, fat, energy metabolism in the brain, blood-brain-barrier transport); 3) cellular neurophysiology (excitation and conduction properties of nerves, synaptic transmission); 4) neuroendocrinology, (reproductive neuroendocrinology, anterior and posterior pituitary function, pineal gland, adrenal medulla); 5) feeding and hunger, drinking, sleep.
M. J. Baum, J. D. Fernstrom, A. M. Graybiel, M. A. Moskowitz, W. J. Nauta, T. F. Weiss

20.512J The Neurosciences II (A)

(Same subject as 9.015J)
Prereq.: 20.511J
Year: G (1)
6-0-9

Second semester subject of a two-semester sequence designed to expose graduate students to the broad range of contemporary topics in the Neurosciences. Topics: 1) neurotransmitter biochemistry and pharmacology, 2) sensory physiology (somatosensory, chemosensory, auditory, visual systems); 3) motor system (central control of movement, muscle dynamics, reflex spinal and supraspinal mechanisms governing movement); 4) development and plasticity of the nervous system; 5) neuropsychology (cortical functions, language, cognitive function, sensorimotor functions); 6) clinical neuroscience (pharmacology and anatomy of pain, mental diseases, neurological diseases).
E. Bizzi, S. Corkin, R. M. Held, P. H. Schiller, G. E. Schneider, R. J. Wurtman

20.514J The Human Nervous System (A)

(Same subject as 9.016J, HST 130J)
Prereq.: Permission of Instructor
Year: G (1)
6-3-6

This subject encompasses a) *the gross anatomy, internal organization* and *fine structure* (light- and electron-microscopic) of the mammalian nervous system with particular emphasis, wherever possible, on the human nervous system and its functional disorders; b) *neurophysiology* from the level of the single cell to that of complex neural organizations, in particular perceptual, motor, and associative systems; c) *neuropharmacology*, and *neuroendocrinology*. (Enrollment limited.)
R. J. Wurtman, E. Bizzi, A. M. Graybiel, W. J. H. Nauta

20.516 Advanced Topics in Behavioral Biology (A)

Prereq.: 20.511J, 20.512J
Year: G (1)
2-0-4

Seminar on recent advances in psychopharmacology and behavioral endocrinology; primarily student presentations.
M. J. Baum

20.517 Advanced Topics in Neurotransmitter Biochemistry (A)

Prereq.: 20.511
Year: G (2)
2-0-4

Seminar on recent advances in neurotransmitter biochemistry; presentations by staff, guest lecturers, and students. (Alternate years. ***Offered 1981-82.***)
R. J. Wurtman

20.519 Advanced Topics in Neuropharmacology

Prereq.: 20.511J, 20.512J
Year: G (2)
2-0-4

Seminar on recent advances in the neuropharmacology and cellular neurophysiology of the mammalian nervous system; student presentations primarily.
Staff

Toxicology

20.610 Principles of Toxicology

Prereq.: Permission of Instructor
Year: G (S)
12-6-12

Development of basic principles and techniques of biology, analytical chemistry, epidemiology, and risk assessment relevant to the study of toxic chemicals of environmental and occupational importance. Includes pathology, occupational health, the regulatory framework, and environmental decision making. Laboratory demonstrations and exercises present basic principles and current research techniques. (Enrollment is limited; admission is by permission of instructors. Students must be regular graduate students or be admitted as special graduate students.)
G. N. Wogan, Staff

20.611 General Toxicology (A)

Prereq.: 7.05
Year: G (2)
3-0-9

Quantitative considerations of release, distribution, deposition, and biological concentration of environmental pollutants. Principles of pharmacokinetics relating to toxic properties. Occurrence and mechanism of action of toxic chemicals; factors affecting toxicity; evaluation of toxicity and extrapolation to humans. (Alternate years. ***Not offered 1981-82.***)
G. N. Wogan

20.612 Biochemistry of Xenobiotics (A)

Prereq.: 5.42, 7.05
Year: G (1)
3-0-9

Major enzyme systems involved in metabolism of xenobiotic compounds with concentration on the mechanisms of activation and detoxification and interaction of metabolites with cellular macromolecules. A detailed examination into the mechanisms of oxidation, reduction, hydrolysis and conjugation reactions especially where these reactions may result in the potential generation and removal of toxic intermediates. Emphasis on events occurring at the molecular level. (Alternate years. ***Not offered 1981-82.***)
M. A. Marletta

20.613 Genetic Toxicology (A)

Prereq.: 20.612, 7.03, 7.05
Year: G (2)
3-0-9

Genetic disease as a public health problem. Chemically induced error in gene structure, chromosome structure and chromosome number. Role of specific chemical lesions, DNA repair, DNA replication and other aspects of cell physiology in determining the probability of genetic change. (Open to undergraduates. Alternate years. ***Not offered 1981-82.***)
W. G. Thilly

20.617 Pathobiology (A)

Prereq.: Permission of Instructor
Year: G (2)
6-3-6

An introduction to pathology for experimental biologists. Includes autopsy and gross examination of organs and tissues of several species of animals, the histologic and ultrastructural appearance of cells and tissues in health and disease and factors which influence structure and function. Particular emphasis placed on attempts to understand disease processes by an integration of biochemical and morphologic correlates and how they are deranged by toxic and nutritional factors. Position papers on selected disease entities required.
P. M. Newberne, A. E. Rogers

20.618 Laboratory Animals: Usage in Biological Experimentation

Prereq.: 7.01
Year: G (2)
2-1-3

Designed to introduce current concepts of anesthesia, surgery, disease, and experimental manipulation of the research laboratory animal. Emphasis is placed on the selection of proper animal models and techniques used in the experimental protocol. Techniques and skill learned from lectures and audiovisual aids are practiced in laboratory sessions.
J. G. Fox, J. C. Murphy

20.619J Current Economic and Regulatory Problems in Toxicology (A) (New)

(Same subject as 14.285J)
Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Examination of tools available to economists and toxicologists for decision making in a regulatory environment. Case method used with lectures on topics such as multistage carcinogenesis, diet and cancer, carcinogenesis and mutagenesis testing, some aspects of FDA and EPA regulatory law, extrapolation of test results, decision making, and risk assessment.
S. R. Tannenbaum, J. E. Harris

Food Science and Technology

20.702 Food Science

Prereq.: —
Year: G (1)
3-0-6

Examination of the scientific and engineering basis of food processing operations. Discussion of organoleptic and sensory methodology for evaluation of food quality and properties.
A. J. Sinskey

20.712 Separation in Food Processes (A)

Prereq.: 20.701
Year: G (1)
3-0-6

Separation processes and equilibrium operations are important components of food engineering. Consideration given to principles of separation kinetics and equilibria. Emphasis on distillation, liquid-liquid and solid-liquid extractions, and dehydration processes. (Alternate years. ***Not offered 1981-82.***)
C. L. Cooney, M. Karel

20.721 Physical and Engineering Properties of Food Materials (A)

Prereq.: 20.701
Year: G (1)
3-0-6

Emphasis on the theories and principles of rheological properties of simple and complex systems. Concept, determination, analysis, and modeling of the mechanical and textural properties of food materials with supporting discussions on thermal and surface properties when necessary. Consideration of these properties as related to food engineering and effect of these properties on food quality and accept-

ability. Methods of determination of these properties and application of laboratory information in process design with examples. (Alternate years. ***Not offered 1981-82.***)
C. K. Rha

20.723 Food Fabrication and Structure Synthesis (A)

Prereq.: 20.721
Year: G (1)
3-0-6

Fundamentals of food fabrication and structure synthesis including solvation, flocculation, emulsion, foam, gels, granular, plexilaminar and fibrous network formation. Emphasis on thermal treatment, extrusion and spinning technology. Advantages and limitation of the present fabrication technology. Principles of ingredient selection, fabrication methods, and processing conditions to obtain desired structural effects. Study of the controlling factors in fabricated foods and methods for quantitating quality standards for fabricated foods. (Alternate years. ***Offered 1981-82.***)
C. K. Rha

20.731 Food Chemistry (A)

Prereq.: 7.05
Year: G (2)
3-0-6

Consideration of the chemistry and biochemistry of plant and animal tissues used as food from the perspective of the chemical and physical behavior of the food components: water, proteins, carbohydrates, lipids, vitamins, pigments, flavors, etc. Application of reaction kinetics to problems of food stability. Postmortem and postharvest biochemistry and physiology. Reactions leading to deterioration of food and their control. (Alternate years. ***Not offered 1981-82.***)
S. R. Tannenbaum, M. Karel

20.732 Physical Chemistry of Foods (A)

Prereq.: 5.60
Year: G (2)
3-0-6

Physicochemical principles controlling food properties and the behavior of food materials in processing and storage. Colloidal and surface phenomena in foods: emulsions, foams, dispersions, and gels. Transport properties of foods and their significance in selected food operations. Phase transformations of food components and their effects on food quality. Physical and chemical changes occurring during and after food processing. Enzymatic reactions in heterogeneous systems, and in food systems. (Alternate years. ***Offered 1981-82.***)
M. Karel, A. M. Klibanov

20.733 Food Biochemistry (A)

Prereq.: 7.05
Year: G (1)
3-0-6

Effects of storage and processing procedures on factors such as cellular organization, membrane deterioration, post-mortem or post-harvest protein synthesis and degradation, and enzymic control in plant and animal tissues used as food. (Alternate years. ***Not offered 1981-82.***)
H. O. Hultin

20.734 Applied Enzymology (A)

Prereq.: 7.05
Year: G (1)
3-0-6

Production and purification of commercial enzymes. Mechanisms of some practically important enzymes. Protein stability and denaturation. Types and mechanisms of enzyme inactivation. Approaches to enzyme stabilization. Immobilized enzymes: synthesis, physicochemical properties, and enzyme reactors. Immobilized coenzymes and cells. Enzymatic processes in heterogeneous systems. Principles of practical applications of enzymes: in food processing, in preparative chemistry, in analyses, in medicine; the future trends. Economic, health, and legal aspects of the use of enzymes. (Alternate years. ***Not offered 1981-82.***)
A. M. Klibanov

20.741 Food Microbiology (A)

Prereq.: 7.05, 20.001
Year: G (2)
3-0-6

Qualitative and quantitative aspects of microbiology in relation to the behavior and detection of microorganisms and microbial toxins. Microbial toxins discussed include botulinum toxin, perfringens toxin, *Staphylococcus aureus* enterotoxins. Spore physiology presented. Applications of microorganisms for detection of environmental agents, as well as for production of selected food products. (Alternate years. ***Offered 1981-82.***)
A. J. Sinskey

20.742 Food Microbiology Laboratory (A)

Prereq.: *20.741*
Year: G (2)
0-6-0

Laboratory exercises of selected topics presented in 20.741. (Alternate years. ***Offered 1981-82.***)
A. J. Sinskey

20.743 Advanced Food Microbiology (A)

Prereq.: 20.741
Year: G (2)
3-0-6

Discussions centered on sporulating and toxin-producing microorganisms. Emphasis placed on those microorganisms which have served as model systems in the development of current concepts and on those which are of public health significance. Focuses on the physiology, biochemistry and genetics of sporulation and toxicology. Topics in sporulation include: sporulation, dormancy and resistance, activation, germination and outgrowth. Topics in toxicology include: genetics, mechanisms of action and assay systems.
A. J. Sinskey

20.751 Food Marketing (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-6

Examination of the distribution system through which food moves from the farm and range to the ultimate consumer. Emphasis on understanding critical problems faced by various members of the food distribution system: the farmer, the processor, the wholesaler, and the retailer. Use of the case method to develop analyses of key issues and possible solutions to marketing problems. Attention also on maladjustments in food distribution system and role of government in relationship to food marketing. Problems of pricing, nutritional labeling, food additives, and the consumerist movement considered.
G. F. Bloom, S. A. Goldblith

20.752 Food Plant Visits (A)

Prereq.: Permission of Instructor
Year: G (2)
2-0-2

Visits to selected food factories in the Boston area and associated lectures.
M. Karel

Biochemical Engineering

20.811 Biochemical Engineering (A)

Prereq.: Permission of Instructor
Year: G (2)
4-0-8

Interaction of chemical engineering, biochemistry, and microbiology. Mathematical representations of microbial systems. Kinetics of growth, death, and metabolism. Continuous fermentation, agitation, mass transfer and scale-up in fermentation systems, product recovery, enzyme technology.
C. L. Cooney, D. I. C. Wang

20.812 Biochemical Engineering Laboratory (A)

Prereq.: 20.811
Year: G (2)
0-5-1

Laboratory portion of Biochemical Engineering, experiments focus on mass transfer problems, microbial kinetics, product formation and recovery processes, and computer-aided fermentation. Fermentation process plant design. (Permission of instructor required.)
D. I. C. Wang, C. L. Cooney

20.821 Industrial Microbiology (A)

Prereq.: 7.21, 20.001
Year: G (1)
3-0-4

Selected topics concerned with the use of microorganisms for the production of substances of industrial, medical, or nutritional value, such as amino acids, antibiotics, vitamins, and organic acids, with emphasis on metabolic regulation of and biochemical pathways leading to fermentation products.
A. L. Demain

20.822 Industrial Microbiology Laboratory (A)

Prereq.: 20.821
Year: G (1)
0-6-0

Laboratory exercise of selected topics presented in 20.821.
A. L. Demain

Seminars, Selected Topics and Research

20.901 Research Programs in Nutrition and Food Science

Prereq.: Permission of Instructor
Year: G (1)
2-0-2

Seminars, presented by individual departmental faculty members, on active and proposed research areas and specific research programs. Presentations of a general nature, including discussions of rationale and significance of programs in addition to detailed progress reports.
G. Wolf, Staff

20.902 Seminar in Nutrition and Food Science

Prereq.: Permission of Instructor
Year: G (1)
2-0-2

20.903 Seminar in Nutrition and Food Science

Prereq.: Permission of Instructor
Year: G (2)
2-0-2

Opportunity for students to practice oral presentations, before an audience, on scientific topics. Guidance and criticism with respect to speaking ability, use of speaking aids (blackboard, slides, etc.), and content of the presentation. Participation in a weekly research seminar required.
Staff

20.904 Teaching Experience in Nutrition and Food Science

Prereq.: Permission of Instructor
Year: G (1, 2)
2-0-4

For qualified graduate students interested in teaching. Tutorial or classroom teaching under the supervision of a faculty member. Students selected by interview. Total enrollment limited by availability of suitable teaching assignments.
A. J. Sinskey

20.911 Seminar in Nutritional Pathology (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-3

20.912 Seminar in Nutritional Pathology (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-3

Systematic study of disease problems common to various animal species resulting from nutrition and other factors with particular attention to ongoing research projects. Research papers required.
A. E. Rogers, P. M. Newberne

20.921 Selected Topics in Nutrition and Food Science (A)

Prereq.: —
Year: G (1, 2)
Arr.

Detailed discussion of selected topics of current interest. Class work in various fields of nutrition, food science and technology, toxicology, and biochemical engineering not covered by regular subjects of instruction.
Staff

20.941 Research Problems (A)

Prereq.: —
Year: G (1)
Arr.

20.942 Research Problems (A)

Prereq.: —
Year: G (2)
Arr.

Directed research in the field of nutrition and food science.
Staff

21 Humanities

Literature

21.UR Research in Humanities

Prereq.: —
Year: U (1, 2)
Arr.

Individual participation in an ongoing research project. (For students in the Undergraduate Research Opportunities Program.)
Staff

21.ThU Undergraduate Thesis in Humanities

Prereq.: as specified for particular field
Year: U (1, 2)
Arr.

Preparation for and production of senior major thesis in Humanities, under supervision of a faculty member. For most students in programs XXI-A, XXI-B,1 and XXI-B,2, in their last year, except those registering for 21 Ex. Humanities General Examination. Normally taken in each of the last two semesters before graduation. Total number of credit units varies according to field of study. Each particular field specifies necessary prerequisites.
T. R. Merritt

21.Ex Humanities General Examination

Prereq.: as specified for particular field
Year: U (1, 2)
Arr.

Preparation for and taking of senior general examination in one of the Humanities fields, under supervision of a faculty member and examining committee. For those students in programs XXI-A, XXI-B,1, and XXI-B,2 who do not write an undergraduate thesis. Normally registered for in each of the last two semesters before graduation. Total number of credit units varies according to field of study. Each particular field specifies necessary prerequisites.
T. R. Merritt

The subjects listed below are arranged in three graduated categories or tiers: 1) Introductory subjects (21.001-21.010), focused on major literary texts grouped in broad historical and generic sequences, all carrying Humanities Distribution credit. 2) Intermediate subjects (21.021-21.120), some carrying Humanities Distribution credit and some limited to students who have already taken one literature course. Intermediate subjects explore literary forms in greater depth and center on historical periods, literary themes, or genres. Students are encouraged to consult individual instructors about prerequisite requirements. 3) Seminars (21.170-21.178), restricted to students who have taken at least two previous subjects in literature, and demanding considerable independent work, such as oral reports and other special projects. Enrollment in seminars is strictly limited to a maximum of 12 students. Subjects in creative and performing arts (21.180-21.186) are offered outside the tiering system.

A *Supplement* to this catalogue, available from the Humanities Department offices, offers more detailed descriptions of all literature subjects and includes specific information about required texts, writing assignments, and examinations.

Introductory Subjects

21.001 Literature I: World Masterpieces

Prereq.: —
Year: U (1, 2) HUM-D
3-0-6

Masterworks of epic, drama, lyric, novel, and film. Includes works by such writers as Homer, Sophocles, Shakespeare, Donne, Molière, Tolstoy, Chekhov, Yeats, Mann, and at least one film. Emphasis on intrinsic merit of each text and on social or mythological function of literature, its role as a carrier (and critic) of the central moral, political, and psychological beliefs of its society. One joint lecture and two class discussions each week.
D. M. Halperin, S. Mullaney, S. J. Tapscott

21.003 Introduction to Fiction

Prereq.: —
Year: U (1, 2) HUM-D
3-0-6

An introduction to prose narrative, especially the novel. Emphasis on literary structure, social and historical context, the relations between fiction and its audience. Reading lists vary among the sections but include works by such writers as Fielding, Laclos, Austen, Dickens, Stendhal, E. Brontë, Tolstoy, Conrad, Lawrence, Kafka, Lu Hsun, D. Lessing, T. Olsen, G. Garcia-Marquez, C. Achebe.
Term 1: *T. R. Merritt, R. Perry, C. G. Wolff*
Term 2: *L. Kampt, T. R. Merritt, R. Perry*

21.004 Major Poets

Prereq.: —
Year: U (1, 2) HUM-D
3-0-6

Close study of at least six major poets. Emphasis on learning how to enjoy poetry and on the evolution of poetic form. Syllabus varies somewhat from year to year but always includes authors from this list: Chaucer, Spenser, Shakespeare, Milton, Donne, Pope, Wordsworth, Keats, Browning, Yeats, Auden, Eliot, Whitman, Williams, Frost, Stevens.
Term 1: *B. Spacks*
Term 2: *S. J. Tapscott*

21.005 World Drama

Prereq.: —
Year: U (1, 2) HUM-D
3-0-6

Critical reading of representative drama. Emphasis on drama as a collaborative art form which comes from and speaks to a particular community whose values and assumptions can be seen in historical context. Includes works by the Greek playwrights, Shakespeare, Ibsen, Chekhov, Shaw, and such moderns as Pinter, O'Neill, and Beckett. Students have the possibility of participating in the practical side of the theatre through work in productions approved by the instructor.
Term 1: *P. S. Donaldson*
Term 2: *R. N. Scanlan*

21.006 Introduction to American Literature I

Prereq.: —
Year: U (1, 2) HUM-D
3-0-6

Survey of major American texts, stressing literary and ideological traditions and the emergence of a national literature. Offered as a two-semester sequence. Students may take either term independently but are encouraged to consider the full sequence. The Fall sylla-

bus usually begins with a modern text by a writer such as Mailer or Fitzgerald and often includes one American film. Principal readings in Emerson, Whitman, Hawthorne, Melville, Douglass, Dickinson.
L. Marx, S. J. Tapscott, A. Lang

21.007 Introduction to American Literature II

Prereq.: —
Year: U (2) HUM-D
3-0-6

Continuation of 21.006, with emphasis on 20th century writers. Principal readings in Twain, James, Wharton, Faulkner, Fitzgerald, Ellison, Stevens, Frost, others. (May be taken independently of 21.006.)
S. J. Tapscott, A. Lang, Staff

21.009 Shakespeare

Prereq.: —
Year: U (1, 2) HUM-D
3-0-9

Close study of the major comedies, histories, and tragedies in the context of Renaissance thought, Elizabethan theatre, and the political and social setting of Shakespeare's age. Lectures and class discussions each week, supplemented by occasional reading of scenes and attendance at live or filmed performances.
Term 1: *P. S. Donaldson*
Term 2: *S. Dickman*

21.010 Literature and Film (Revised Unit)

Prereq.: —
Year: U (1, 2) HUM-D
3-0-6

Studies in literary and cinematic narrative. Close reading and viewing of literary works and films, chosen for their cultural diversity and artistic excellence. Emphasis falls equally on aesthetic and on cultural matters: on the artistic value of the chosen texts and on their identity as anthropological specimens whose conventions of discourse and assumptions about experience are rooted in particular times, places, and technologies. Included are such authors and directors as Homer, Shakespeare, Austen, Dickens, Chekhov, Chaplin, John Ford, Hitchcock, Kurosawa, and Renoir.
Term 1: *W. J. Paul*
Term 2: *A. C. Kibel*

Intermediate Subjects

Genres and Themes

21.021 Comedy

Prereq.: —
Year: U (1, 2) HUM-D
3-0-6

Reading and discussion of various works designed to make us laugh; investigation of the culture that produced them, and of various theories of comedy. Authors to be studied: Aristophanes, Plautus or Terence, Chaucer, Shakespeare, Molière, Pope, Lewis Carroll, Twain, Faulkner, Woody Allen, and others.
Term 1: *D. Thorburn*
Term 2: *W. J. Paul*

21.022 Tragedy

Prereq.: —
Year: U (2) HUM-D
3-0-9

Reading and discussion of tragic literature, together with an exploration of established, tentative and possibly new theories about the tragic vision. Readings from Sophocles; Shakespeare and his contemporaries; Strindberg, Ibsen, Beckett, and some modern writers, and Aristotle and other theorists.
T. Postlewait

21.023 The Short Story

Prereq.: One subject in literature or equivalent
Year: U (1)
3-0-6

A study of stories concentrating on variety of style and technique in the use of the form. Reading: collections of stories by Poe, Chekhov, Borges, Welty, Lessing, Barthelme, and two authors chosen by the class. Writing: brief critical or theoretical papers, as well as an opportunity to experiment with the creation of an original story.
B. Spacks

21.030 Popular Narrative: Science Fiction

Prereq.: One subject in literature or equivalent
Year: U (2)
3-0-9

Examines the relationship between popular and high culture and the problem of evaluating texts that tell stories. Treats a range of narrative and dramatic works as well as films and television series with emphasis on science fiction in relation to American culture.
Staff

21.031 The Film Experience

Prereq.: —
Year: U (1, 2) HUM-D
3-0-6

An introduction to the art of film, emphasizing the unique properties of the movie-house and of the motion-picture camera. Attention to film genres (the western, the gangster film, the musical, the horror movie), to film adaptations of texts from other media, and to the historical development of film. Films by Welles, Curtiz, Hawks, Ford, Chaplin, Keaton, Hitchcock, others.
Term 1: *W. J. Paul*
Term 2: *D. Thorburn*

21.032J American Television: A Cultural History

(Same subject as STS 625J)
Prereq.: One subject in literature or equivalent
Year: U (2)
3-0-6

Television's evolution as a system of story telling and myth making, studied from anthropological, literary, and cinematic perspectives. The subject centers on prime-time commercial broadcasting but also examines the medium's technological and economic history as well as the theoretical perspectives from which scholars and policy makers have perceived our television system. Much required viewing as well as readings in media theory and cultural interpretation. (Cambridge Humanities Seminar subject given at MIT.)
D. Thorburn

21.041 Women in Literature

Prereq.: One subject in literature or equivalent
Year: U (1)
3-0-6

Images of women in literary work. Primary emphasis on individual texts, but consideration as well of such issues as: cultural contexts, recurring themes and patterns, the tradition of fictional "types," and fiction as social criticism. Texts by Austen, Charlotte Brontë, Gaskell, Hawthorne, Eliot, Dickens, Meredith, Hardy, and others.
I. Tayler

21.042 Modern Black Poetry

Prereq.: one subject in literature or equivalent
Year: U (2)
3-0-6

Examination of 20th century Afro-American poetry, and its relationship to both the poetry of the Euro-American tradition and the poetry of blacks in Africa and the Caribbean. Readings include popular forms like the spirituals and the blues in addition to the poetry of more familiar figures: Langston Hughes, Gwendolyn Brooks, and Robert Hayden from America; Senghor (Senegal) and Okigbo (Nigeria); Cesaire (Martinique) and Walcott (Trinidad). Discussion, short papers.
Staff

Periods of World Literature

21.060 Medieval Literature

Prereq.: One subject in literature or equivalent
Year: U (1)
3-0-6

Introduction to the literature of the Middle Ages, concentrating on such central writers and works as St. Augustine, *The Song of Roland, Beowulf,* Dante, Chrétien de Troyes, Chaucer, and the Pearl-Poet. Secondary reading on the social context of medieval literature. Discussion, short papers.
S. Dickman

21.061 Chaucer/Dante

Prereq.: 21.060 or one other literature subject
Year: U (2)
3-0-6

In alternate years, reading and discussion of major works by Chaucer or Dante.
S. Mullaney

21.063 Renaissance Literature: Magic and the Arts of Government

Prereq.: One subject in literature or equivalent
Year: U (1)
3-0-6

Readings include More's *Utopia,* Marlowe's *Faustus,* Shakespeare's *Tempest* and *Macbeth,* Jonson's *Alchemist,* works by Spenser, Bacon, Donne, Wyatt, as well as several relevant European texts, such as Pico's *Oration on the Dignity of Man* and Machiavelli's *Prince.* Emphasis on political and cosmological ideas.
S. Mullaney

21.064 Renaissance Poetry: Petrarch to Milton

Prereq.: One subject in literature or equivalent
Year: U (1)
3-0-6

Introduction to poetic traditions of the Renaissance through detailed discussion of major poems by such figures as Petrarch, Wyatt, Marot, Ronsard, Du Bellay, Tasso, Sidney, Spenser, Shakespeare, Donne, Jonson, Herbert, Marvell, and Milton.
(Not offered 1981-82.)
P. S. Donaldson

21.065 Seventeenth-Century Literature (New)

Prereq.: —
Year: U (2)
3-0-6

Major literary works of 17th-century Europe and England are studied in relation to the revolutionary changes taking place in religious, political and scientific thought and in society. Works by Montaigne, Bacon, Shakespeare, Donne, Herbert, Descartes, Cervantes, Calderon, Galileo, Milton, Marvell, Molière, Racine, Pascal.
S. Mullaney

21.070 Eighteenth-Century Literature

Prereq.: —
Year: U (1)
3-0-6

Study of prose and poetry by major English and continental writers of the 18th century. Attention to historical context: the development of cities, a new merchant class, science as an intellectual discipline. Readings in such figures as Mandeville, Diderot, Montesquieu, Voltaire, Swift, Pope, Richardson, Johnson. ***(Not offered 1981-82.)***
R. Perry

21.071 Major English Novels

Prereq.: One subject in literature or equivalent
Year: U (2)
3-0-9

Study of 8 to 10 major English novels of the 18th, 19th, and 20th centuries, beginning with Bunyan's *Pilgrim's Progress* and including works by such authors as Defoe, Richardson, Fielding, Sterne, Austen, the Brontës, Dickens, Hardy, Lawrence, and Joyce. Historical and critical background readings regularly assigned. Discussion, four papers.
I. Tayler

21.076 Romantic Poetry

Prereq.: One subject in literature or equivalent
Year: U (2)
3-0-6

Close readings of the major English Romantic poets (Blake, Wordsworth, Coleridge, Byron, Shelley, Keats) with some attention to their context in the lesser poetry and in the prose of the period as well as their background in continental Romanticism. Discussion and several short papers. Text: *English Romantic Writers,* edited by David Perkins. ***(Not offered 1981-82.)***
I. Tayler

21.078 The Realistic Novel

Prereq.: —
Year: U (1)
3-0-6

A study of changing narrative forms in the 19th-century European novel. The changing fortunes of the heroic and romantic ideals. The *motif* of the outsider as a means for depicting social reality. Readings in Goethe, Balzac, Stendhal, Flaubert, Tolstoy, Kafka, Dostoyevsky.
A. C. Kibel

21.079 Modern Russian Literature and Its Historical Structure

Prereq.: —
Year: U (1) HUM-D
3-0-6

Stylistic and thematic analysis of typical works, especially fiction (short or long) and drama, but some poetry, by a representative selection of the most significant Russian writers among early 19th-century romantics, mid-century realists, early 20th-century modernists — such as Pushkin, Gogol, Lermontov, Aksakov, Turgenev, Saltykov, Dostoevsky, Goncharov, Tolstoi, Leskov, Chekhov, Bunin, Akhmatova.
R. E. MacMaster

21.080 Dostoevsky, Tolstoi, Chekhov: Russia and the Modern Age

Prereq.: —
Year: U (2)
3-0-9

Studies of artistic vision in modernizing Russia. Analyses of *Notes from Underground, The Brothers Karamazov, Anna Karenina, Hadji Murad, The Seagull,* and shorter works. Discussion, with reference to critical and biographical materials, of the relation of artistic works to society, culture, and historical change.
R. E. MacMaster

21.085 Twentieth-Century Fiction

Prereq.: One subject in literature or equivalent
Year: U (2)
3-0-6

Tradition and innovation in representative fiction of the early modern period. Recurring themes: the role of the artist in the modern period, the representation of psychological and sexual experience, the virtues (and defects) of the aggressively experimental character of so many modern books. Works by Conrad, Kipling, Isaac Babel, Kafka, James, Lawrence, Ford Madox Ford, Joyce, Woolf, Faulkner, and Nabokov.
T. R. Merritt

21.086 Twentieth-Century Drama

Prereq.: One subject in literature or equivalent
Year: U (1)
3-0-6

Reading and discussion of various modern plays, from Ibsen to Beckett. Emphasis on how these plays work on stage. Reading aloud of scenes in class encouraged, along with projects connected to Dramashop productions.
R. N. Scanlan

21.087 Modernist Poetry

Prereq.: One subject in literature or equivalent
Year: U (2)
3-0-6

A study of important trends in modern thought and sensibility as reflected in the poetry of the 20th century. Readings center on Yeats, Eliot, and Stevens; followed by Auden, Williams, and Frost with some consideration of such as Roethke, Plath, Berryman, Wilbur, Rich, and Hughes.
B. Spacks

21.088 Contemporary Literature

Prereq.: One subject in literature or equivalent
Year: U (2)
3-0-6

Fiction, drama, and some poetry, mostly of the 1960s and 70s. Focus on a wide range of themes, as well as on experiments with literary and theatrical technique. Readings in such figures as Beckett, Heller, Pinter, Weiss, Solzhenitsyn, O'Neill, Pynchon, Nabokov, Bellow, and several poets. Format: lectures, discussion, weekly papers.
Staff

American Literature

See also 21.006 and 21.007, Introduction to American Literature I and II

21.101 The American Novel

Prereq.: —
Year: U (1, 2) HUM-D
3-0-9

Works by major American novelists, beginning with Hawthorne's *The Scarlet Letter* (1850) and concluding with a contemporary novelist. Major emphasis on reading novels as literary texts but attention as well to historical, intellectual, and political contexts. The syllabus varies from term to term but many of the following writers are represented: Hawthorne, Melville, Twain, Cather, Wharton, James, Hemingway, Fitzgerald, Faulkner, Ellison, Nabokov, Bellow.
Term 1: *C. G. Wolff*
Term 2: *A. Lang*

21.103J Literature, Ideology and National Experience in the United States

(Same subject as STS 601J)
Prereq.: —
Year: U (2) HUM-D
3-0-6

Study of the interplay among imaginative literature, the prevailing belief systems (or ideology), and collective experience in what is now the United States, with emphasis upon the critical reading of literature within an historical context. Traces the emergence of a conflict between the idea of America as an embodiment of the progress of civilization and the mastery of nature on the one hand, and of the recovery of natural (or pastoral) harmony, innocence, and happiness on the other. The bearing of this conflict—both as cause and effect—upon the emergence of a science-based technological society is at issue. Readings chiefly drawn from classic American writers of the 19th century, but works from earlier and later periods as well as pertinent extraliterary materials included. Writers include: F. Scott Fitzgerald, Franklin, Jefferson, Emerson, Tocqueville, Thoreau, Whitman, Hawthorne, Melville, F. J. Turner, and D. H. Lawrence.
L. Marx

21.104 Race and Identity in American Literature

Prereq.: —
Year: U (1) HUM-D
3-0-6

The quest for identity in the writing of America's racial and ethnic minorities. Emphasis on the writers' problematic relation to the dominant values and traditions of the majority culture. Readings in Douglass, DuBois, Twain, Melville, Ellison, Wright, Malcolm X, Henry Roth, others. Discussion, occasional brief lecture.
Staff

21.105 American Voices

Prereq.: —
Year: U (1)
3-0-6

Considers a variety of North American literary voices attempting to define the dream of success. Materials include "high literature," folktales, slave narratives, blues, songs, jokes, Indian narratives, oral history. Reading and listening include selections from the works of

Frederick Douglass, Benjamin Franklin, Zora Neale Hurston, Charles Chesnutt, Herman Melville, Charlotte Perkins Gilman, W. E. B. Dubois, Agnes Smedley, Michael Gold, Studs Terkel, Maxine Hong Kingston. (Restricted to 25 students.)
L. Kampf

21.111 Melville and His Age (New)

Prereq.: —
Year: U (1)
3-0-6

This period, roughly 1800-1860, has been called the "golden age" of American literature. It was an age of heroic experimentation, but its experiments have become our national tradition. Major works by Brown, Cooper, Emerson, B. Alcott, Hawthorne, Melville, Thoreau, Whitman, Dickinson, Poe.
C. G. Wolff

21.112 Twain and His Age

Prereq.: One subject in literature or equivalent
Year: U (1)
3-0-6

Rise of American realism in the context of developments in European fiction and evolution of the novel in the United States during the era of industrialization — the period Mark Twain called "The Gilded Age." Emphasis may also fall on the moral and intellectual themes in Twain and other American writers. Topic for Term 1: The Godshakers, Twain, Dickinson, and Melville. ***(Not offered 1981-82.)***
Staff

21.120 Twentieth-Century American Literature

Prereq.: One subject in literature or equivalent
Year: U (1)
3-0-6

Readings from the work of several major writers of the 20th century. Specific focus for 1980: American literature of place and regional identity. Principal works by William Faulkner and Robert Frost, secondary readings in Jean Toomer, Eudora Welty, Flannery O'Connor, Sarah Orne Jewett. Format: lectures, discussions. ***(Not offered 1981-82.)***
Staff

Seminars

21.171 Literary Interpretation

Prereq.: Two subjects in literature
Year: U (1)
3-0-9

Examination of the ways in which issues arising in the interpretation of dreams, folktales, sacred texts, works of visual art, and primitive cultures have influenced the practice of interpreting literary and narrative texts. Readings in Freud, T. S. Eliot, Empson, Levi-Strauss, Barthes, Gombrich, Panofsky, Walter Benjamin, others. Topic for 1981-82: Issues in Theory. (Cambridge Humanities Seminar given at MIT. Limited to 12.)
A. C. Kibel

21.172 Advanced Studies in Fiction

Prereq.: Two subjects in literature
Year: U (1, 2)
3-0-9

Intensive study of a range of texts by a single novelist or by a limited group of novelists whose achievements are mutually illuminating. Some attention to narrative theory and biographical and cultural backgrounds. Considerable writing, oral reports. Topics for 1981-82: Term 1: Conrad, Joyce, Nabokov. Term 2: Austen. (Limted to 12.)
Term 1: *D.Thorburn*
Term 2: *R. Perry*

21.173 Advanced Studies in Drama

Prereq.: Two subjects in literature
Year: U (1)
3-0-9

Close study of two or three major dramatists, with emphasis on the evolution of their work. Some attention to historical and theoretical accounts of the nature of drama. Texts are chosen in part to coincide with current productions at MIT and in the Boston/Cambridge area. Topic for 1981-82: Shakespeare and his Contemporaries. (Limited to 12.)
S. Dickman

21.174 Advanced Studies in Poetry

Prereq.: Two subjects in literature
Year: U (1, 2)
3-0-9

Extensive reading in a few major poets. Emphasis on the evolution of each poet's work, and on questions of poetic influence and literary tradition. Topic for 1981-82: Term 1: Poetry and Linquistics. Term 2: Contemporary Poets. (Limited to 12.)
Term 1: *J. R. Ross, I. Tayler*
Term 2: *B. Spacks*

21.175 Major Authors

Prereq.: Two subjects in literature
Year: U (2)
3-0-9

Close study of a limited group of writers whose achievements are mutually illuminating. Emphasis on the ways in which generic conventions shape an author's treatment of particular themes. In some years the seminar studies a range of texts from different periods but devoted to similar themes (e.g., the quest, the idea of pilgrimage); in other years the focus is restricted to authors from a single period. Some attention to genre theory and, where appropriate, to historical and biographical contexts. Topics for 1981-82: Section 1: Emily Dickinson. Section 2: Emerson, Thoreau, Whitman. (Limited to 12. Admission also with permission of instructor.)
C. G. Wolff, A. D. Kaledin

21.177 Problems in Cultural Interpretation

Prereq.: Two subjects in literature
Year: U (1, 2)
3-0-9

Study of the relations between literary texts and the culture that encloses them. Emphasis on literature in its anthropological, sociological and historical dimensions: on the ways in which literary works absorb, reflect and, sometimes, undermine reigning attitudes toward such matters as class hierarchies, sexual differences, moral, aesthetic, and political values. In some years the syllabus draws centrally on popular or "folk" materials as well as traditional literary texts. (Limited to 12. ***Not offered 1981-82.***)
Staff

21.178 Advanced Studies in Ancient Literature

Prereq.: Two subjects in literature
Year: U (2)
3-0-9

Selected topics in the literature and thought of the ancient Near East, Palestine, Egypt, Greece, and Rome. Emphasis falls in different years on aspects of Biblical studies or on classical philosophy and literature. Work in the original languages available, by arrangement, to students with suitable background. Topic for 1981-82: Platonic Love. (Limited to 12.)
D. M. Halperin

Creative and Performance Subjects

21.180 Plays and Playwriting

Prereq.: —
Year: U (1)
3-0-6

Approaches to writing dramatic scenes and short plays. Students asked to write at least one competent one-act play during the semester, in addition to several shorter scenes. ***(Not offered 1981-82.)***
A. R. Gurney, Jr.

21.181 Acting I

Prereq.: —
Year: U (1)
3-0-6

Basic acting techniques, using video as an integral aid. Exercises, improvisations, theatre games, supplemented by readings and a weekly journal, to explore the fundamentals of role and enactment. Students expected to work towards the performance of some role, in a scene in class. (Graded Pass/Fail.)
Staff

21.182 Acting II

Prereq.: 21.181
Year: U (2)
3-0-6

Extension and application of basic acting techniques established in 21.181 (or through equivalent acting experience) leading to a total methodology for preparation and the final playing of scenes. Exercises, improvisations, theatre games applied to more detailed scene study and character development. Exercises in specific stage techniques, movement, voice and mime combined with continued use of video recording equipment to assist students in the criticism and awareness of their work. Students perform in class and are encouraged to participate in Dramashop projects. (21.181 or equivalent acting experience required. Graded Pass/Fail.)
Staff

21.183 Theatre Arts: Elementary Stagecraft and Production Studies

Prereq.: —
Year: U (1, 2)
3-0-6

Introduction to the techniques of modern theatre as a means of realizing the thematic content of drama. Tutorial discussions and laboratory exercises in the theatre. Individual study arranged with instructor in advance, dealing mainly with production methods, theatre terminology, organizational structure of the theatre.
R. N. Scanlan

21.184 Performance Workshop in Drama

Prereq.: —
Year: U (2)
3-0-6

A collaborative experimental workshop. Focused on shaping, rehearsing, and performing of student works. Qualified student actors, directors, and stage technicians will also be involved. (Permission of instructor required. ***Not offered 1981-82.***)
A. R. Gurney, Jr.

21.185 Performance Workshop in Dance

Prereq.: —
Year: U (1, 2)
3-4-2

Focuses on modern dance theory, technique, and improvisation/composition. Combines study of dance aesthetics with studio work to introduce students to the variety of contemporary dance. Improvisation/composition sessions acquaint students with their own movement vocabularies and develop improvisational exercises into specific choreographic assignments designed to heighten the student's understanding of the creative process. Student compositions included in informal performances given in the drama program. Relevant readings assigned and at least one paper on contemporary artistic issues is required.
B. Soll

21.198 Special Topics in Literature

Prereq.: Any two subjects in literature
Year: U (1)
Arr.

21.199 Special Topics in Literature

Prereq.: Any two subjects in literature
Year: U (2)
Arr.

Open to qualified students who wish to pursue special studies or projects with members of the Literature Section. Before registering for this subject, students must secure the approval of the Literature Section chairman and the Department of Humanities. (Humanities credit for Special Topics subjects awarded only by individual petitions to the Committee on Curricula. Normal maximum is six units; to count towards Humanities Requirement, nine units are required. Exceptional nine unit projects occasionally approved.)
Staff

Foreign Languages and Literatures

The subjects listed below include language and literature courses given in French, German, Greek, Russian, Spanish, and World Literature in translation. All language subjects in the III-IV sequence bear Humanities Distribution credit. A variety of literature subjects given in the original language as well as some given in English also offers Humanities Distribution credit.

For guidelines on World Literature in Translation, come to the Foreign Languages and Literatures Office, 14N-205.

All foreign language subjects I-IV are open to graduate students for credit.

For subjects in English as a Foreign Language see 21.326-21.339. For other subjects dealing with literature and texts in English see listings 21.001-21.199.

French

21.201 French I

(21.211)
Prereq.: —
Year: U (1, 2)
4-0-8

Introduction to the four basic language skills and to French culture. Emphasis on intensive oral training; practice in writing and reading; regular use of language lab. Conducted in French.
G. Furstenberg, Staff

21.202 French II

(21.212)
Prereq.: French I or equivalent
Year: U (1, 2)
4-0-8

Practice in conversation, vocabulary building. Completion of basic grammar. Readings from popular French comic books. Continued use of language laboratory. Conducted in French.
J. Hill, Staff

21.203 French III

(21.213)
Prereq.: French II or equivalent
Year: U (1, 2) HUM-D
4-0-8

Practice in spoken French to develop oral skills. Grammar review; further development of writing skills; reading and discussion of literary and cultural materials. Conducted in French.
J. Vanpée, Staff

21.204 French IV

(21.214)
Prereq.: French III or equivalent
Year: U (1, 2) HUM-D
4-0-8

Final subject in French language sequence. Prepares students for advanced subjects in French literature and civilization. Reading and discussion of contemporary novels, theatre, poetry. Perfecting of writing skills through frequent essays. Conducted in French.
F. Hodgson, Staff

21.205 French Reading, Intensive

(21.215)
Prereq.: —
Year: G (2)
4-0-8

Introduction to the reading of French. No previous knowledge of French required. Intensive study of grammar. Practice in reading simple materials. Self-paced, programmed approach. (Open to graduate students only.)
Staff

21.207 French Conversation and Composition

(21.217)
Prereq.: French IV or equivalent
Year: U (1, 2)
3-0-6

Practice in oral and written expression to improve comprehension, pronunciation, grammar, and to develop a command of idiomatic French. Discussion material consists of newspapers, magazine articles, films, and varied materials about contemporary French life. Oral reports, debates, interviews to develop oral fluency; frequent essays to practice written expression; focus on modern French culture.
G. Furstenberg

21.208 French Civilization I

(21.218)
Prereq.: French IV or equivalent
Year: U (1) HUM-D
3-0-6

Investigation of major social, ideological, and aesthetic currents and cultural myths in French civilization from its beginnings to the eve of the Revolution. Study of selected texts; class presentations covering developments in the plastic arts and in music. Conducted in French. ***(Not offered 1981-82.)***
F. Hodgson, Staff

21.209 French Civilization II

(21.219)
Prereq.: French IV or equivalent
Year: U (2) HUM-D
3-0-6

Study of major movements in politics, literature and the arts since the French Revolution. Included are the Romantic era, the Commune, Impressionism, Surrealism, Existentialism. Special emphasis on France in the last decade. Study of selected texts (Musset, Hugo, Chateaubriand, Breton, Sartre, Camus, Beauvoir, Barthes) as well as articles, slides, music, films. ***(Not offered 1981-82.)***
K. J. Crecelius

21.210 Introduction to French Literature

(21.220)
Prereq.: French IV or equivalent
Year: U (1) HUM-D
3-0-6

A basic study of major French literary genres — poetry, drama, and fiction — and an introduction to methods of literary analysis. Among the authors to be studied are Baudelaire, Rimbaud, Apollinaire, Racine, Colette, Giraudoux, Balzac.
J. Vanpée

21.211 Introduction to French Poetry

(21.221)
Prereq.: French IV or equivalent
Year: U (2)
3-0-6

Development of poetic forms, techniques, and styles. Narrative, descriptive, baroque, polemical, lyric, and pure poetry, poetry of ideas, and the prose poem. Deals with poetry of Villon, Marot, Ronsard, Boileau, La Fontaine, Chénier, Hugo, Nerval, Baudelaire, Rimbaud, Mallarmé, Apollinaire, Valery. ***(Not offered 1981-82.)***
R. E. Jones

21.212 French Film Classics

(21.222)
Prereq.: French IV or equivalent
Year: U (1)
3-0-6

History and aesthetics of French cinema from the advent of sound to the present day. Films treated in the context of technical processes, the art of narration, directorial style, role of the scriptwriter, the development of schools and movements, the impact of political events and ideologies, and the relation between French

and other national cinemas. Directors studied include Clair, Vigo, Feyder, Duvivier, Carné, Renoir, Clouzot, Ophuls, Godard, and Truffaut. Films shown with English subtitles.
E. B. Turk

21.213 French Literature in the 17th Century: Heroes and Myths

(21.223)
Prereq.: French IV or equivalent
Year: U (1)
3-0-9

Poetic, dramatic, and prose masterpieces studied in the context of social, historical, and intellectual currents during the eras of Richelieu and Louis XIV. The development of French literary art as an "institution." Conducted in French.
E. B. Turk

21.214 Classical French Theatre: Corneille, Molière, Racine

(21.224)
Prereq.: French IV or equivalent
Year: U (1)
3-0-6

Reading and interpretation of masterworks in 17th-century French drama. Topics include: the development of comedy, tragedy, and tragi-comedy as self-conscious genres; the baroque and classical aesthetics; the conception of the "hero" and "heroine" and its moral implications; the stage as a reflection of social and political events; the stage as the privileged locus of desire and fantasy; comparisons with Elizabethan and Spanish theatre. ***(Not offered 1981-82.)***
F. Hodgson

21.215 The 18th-Century Novel

(21.225)
Prereq.: French IV or equivalent
Year: U (2)
3-0-6

Beginning with *La Princesse de Clèves*, the first "modern" French novel, traces the evolution and diversification of the genre throughout the 18th century. Questions of narrative technique, psychology, and the relationship between the genre and Enlightenment society. Special attention given to the preoccupation with the trials of virtue in works by Prévost, Voltaire, Diderot, Laclos, and Sade. ***(Not offered 1981-82.)***
K. J. Crecelius

21.216 The French Novel in the 19th Century

(21.226)
Prereq.: French IV or equivalent
Year: U (1)
3-0-6

Intensive study of narrative techniques and the representation of reality in major works by Balzac, Stendhal, Flaubert, Zola. ***(Not offered 1981-82.)***
K. J. Crecelius

21.217 The French Novel in the 20th Century

(21.227)
Prereq.: French IV or equivalent
Year: U (1)
3-0-9

Development of the modern novel through close readings of works by Gide, Proust, Sarraute, Malraux, Mauriac, Celine, Bernanos, Sartre, Camus, and Robbe-Grillet. ***(Not offered 1981-82.)***
I. de Courtivron

21.218 Contemporary French Drama

(21.228)
Prereq.: French IV or equivalent
Year: U (2)
3-0-6

Study of major authors and movements in French drama since 1920: Duras, Giraudoux, Anouilh, Montherlant, Claudel, Artaud, Ionesco, Beckett, Genet.
I. de Courtivron

21.219 The Adolescent in French Literature

(21.229)
Prereq.: French IV
Year: U (1) HUM-D
3-0-6

Cultural, philosophical, and psychological questions concerning adolescence and maturation as seen through dramatic and prose writings. Authors include Molière, Voltaire, Chateaubriand, Anouilh, Alain-Fournier, Cocteau, Radiguet, Rochefort. ***(Not offered 1981-82.)***
I. de Courtivron

21.220 The Intellectual and Modern Society: Literature and Ideology

(21.230)
Prereq.: French IV or equivalent
Year: U (2) HUM-D
3-0-6

Traces the changing philosophical and political values of 20th-century France as they are reflected in the works of significant writers of the 30s, 40s, and 50s, including Malraux, Sartre, Beauvoir, St. Exupéry, Gide, Camus, Weil. Attention devoted to the role of the writer vis-a-vis major political events, the use of literature as a vehicle for disseminating political and philosophical ideas, the role of art in creating and promoting new values. Special emphasis on Existentialism in fiction and essays. ***(Not offered 1981-82.)***
I. de Courtivron

21.221 French Romanticism

(21.231)
Prereq.: One subject above French IV
Year: U (1) HUM-D
3-0-6

Inclusive study of French literature from 1800 to 1860, with emphasis on the poetry of Hugo, Vigny, Musset, Lamartine, Nerval, and Gautier, the novels of Stendhal and Balzac, and the Romantic theatre. Also, examination of the allied arts of music and painting. ***(Not offered 1981-82.)***
R. E. Jones

21.223 French Lyricism: From Literary Text to Opera
(New)

Prereq.: French IV or equivalent
Year: U (2)
3-0-9

A study of classic French stories, plays, and novels and their adaptation by French, Italian, and German librettists and composers. Reading and discussion of a specific literary text precedes consideration of its transformation into an opera. The central issue is the manner in which narrative construction, dramatic characterization, mood, and style differ in prose fiction, dramatic literature, and opera. Texts by Perrault, Corneille, Racine, Beaumarchais, Prévost, Hugo, Dumas, Mérimée, Maeterlinck, Apollinaire. Operas by Rossini, Gluck, Massenet, Mozart, Verdi, Bizet, Debussy, Puccini, and Poulenc. All French texts read in the original.
E. B. Turk

21.224 The French New Wave Cinema

(21.234)
Prereq.: French IV or equivalent
Year: U (1)
3-0-6

Examination of the best films of directors Claude Chabrol, Francois Truffaut, Jean-Luc Godard, Alain Resnais, Agnès Varda, and Eric Rohmer. Students explore and assess the attempt of these directors to supplant the "well-made" film with uniquely personal styles of motion-picture direction. All films shown with English subtitles. ***(Not offered 1981-82.)***
E. B. Turk

21.225 Nerval and Baudelaire

(21.235)
Prereq.: French IV or equivalent
Year: U (2)
3-0-6

Intensive analysis of the poetry and selected prose works. *Les Fleurs du Mal* of Baudelaire and the concept of evil and decadence. *Les Chimères* and *Aurélia* of Nerval and the problem of madness. Special attention given to the literary, art and music criticism as well as the mystic, esoteric, and syncretic beliefs of the two authors. ***(Not offered 1981-82.)***
R. E. Jones

21.226 Introduction to the French Short Story (New)

Prereq.: French IV or equivalent
Year: U (2) HUM-D
3-0-6

Study of literary movements of the last three centuries through short stories by major French authors. Special attention paid to the theme of the fantastic and the supernatural. Works by Voltaire, Balzac, Mérimée, Maupassant, Triolet and Julien Green. Conducted in French.
K. J. Crecelius

21.227 Representations of Love in French Literature (New)

Prereq.: French IV or equivalent
Year: U (2) HUM-D
3-0-6

Examines a wide variety of texts which deal explicity with the theme and the problems of love. Takes the 12th-century legend *Tristan et Iseut* as the model of passionate love, and studies the transformations and fragmentations of elements of this legend as they recur in other literary forms and periods in France. Focuses on four main periods and types of representations of love; the medieval period and its code of chivalry, the 17th century and its debate between passion and reason, the pre-romantic and romantic period and the elaboration of a rhetoric of seduction, and the final perversion of the romantic ideal. Authors read include Marie de France, Ronsard, Racine, Corneille, Mme. de Lafayette, Rousseau, Laclos, Constant, Musset, Balzac, Flaubert.
J. Vanpée

German

21.230 German Review

(21.240)
Prereq.: —
Year: U (1, 2)
4-0-8

Review of the grammar of German I and German II. Followed by some of the readings of German II. Designed for students with incomplete previous preparation in German and for those whose study of German is discontinuous. Students may register for German III upon successful completion. (Admission only by permission of instructor.)
E. Waldstein

21.231 German I

(21.241)
Prereq.: —
Year: U (1, 2)
4-0-8

Basic principles of the German language. Fundamentals of pronunciation, intonation, and grammar. Acquisition of basic vocabulary. Laboratory exercises to further communication skills.
K. Paszkolovits, J. Rosellini

21.232 German II

(21.242)
Prereq.: German I or equivalent
Year: U (1, 2)
4-0-8

Continued practice in pronunciation and intonation. Extension of vocabulary for both conversational and literary purposes. Review and extension of basic grammar. Practice in writing short essays. Introduction to the history and culture of German-speaking countries. Conducted partly in German.
M. Geisler

21.233 German III

(21.243)
Prereq.: German Review, German II or equivalent
Year: U (1, 2) HUM-D
4-0-8

Intensive review of German grammar. Reading of works by such major 20th-century authors as Durrenmatt, Brecht, Böll, and others. Compositions and discussions in German based on these works, lab materials, and video tapes on contemporary Germany. Recommended for students with two or more years of high school German.
C. J. Kramsch, E. Waldstein

21.234 German IV

(21.244)
Prereq.: German III or equivalent
Year: U (1, 2) HUM-D
4-0-8

Reading and study of major works by important German authors of the 19th and 20th centuries. German composition and special problems of German grammar, syntax, and vocabulary. The subject aims by means of the readings, lectures, discussions, and compositions to develop reading, writing, and speaking skills sufficiently to allow the student to function easily in German.
K. Paszkolovits

21.235 German Reading, Intensive

(21.245)
Prereq.: —
Year: G (1)
4-0-8

Introduction to the reading and translating of German for the Ph.D. requirement. Intensive study of grammar. No previous knowledge of German required. (Open to graduate students only.)
K. Paszkolovits

21.237 Advanced German Conversation and Composition

(21.247)
Prereq.: German IV or equivalent
Year: U (2)
4-0-8

Systematic training in speaking and writing skills to improve fluency and style. Informal discussions and analyses of tapes by native speakers, newspapers, and modern expository prose. Focus is on everyday life in present-day Germany and on controversial issues,

East and West. In addition, students select a special project on a topic of their choice. (Permission of instructor required. ***Not offered 1981-82.***)
K. Paszkolovits

21.238 German Culture and Society: 1500-1789

(21.248)
Prereq.: German IV or equivalent
Year: U (1) HUM-D
3-0-6

Epochs of German culture viewed within the context of social, political, and economic developments. Examines cliches about the German national character and traces the historical roots of the "German problem." Attempts to define what is specifically "German" in historical, not mythical, terms. Topics: the Reformation and the Peasants' War of 1524-25, the Counter-Reformation and the Thirty Years' War, the Enlightenment and the Rise of Prussia, Germany, and the French Revolution. The readings, drawn from scholarly, theological, literary, and autobiographical works, include Hutten, Luther, Muentzer, the *Faustbuch,* Grimmelshausen, Leibniz, Lessing, and Kant. Conducted entirely in German with emphasis on reading, speaking, and writing skills. ***(Not offered 1981-82.)***
J. Rosellini

21.239 German Culture and Society: 1789-1918

(21.249)
Prereq.: German IV or equivalent
Year: U (1) HUM-D
3-0-6

The rise of the "apolitical" German, the failure of liberalism, the discrepancy between economic and political development, and the increasing polarization of society as manifested in the various forms of cultural expression. The "Befreiungskriege," Metternich and restoration, the revolutions of 1848-49, Bismarck and Social Democracy in the "Kaiserreich," World War I. Selected readings from historical, philosophical, sociological, autobiographical, and literary works include Goethe, Schopenhauer, Hegel, Heine, Marx, Engels, Nietzsche, Wagner, Bismarck, Bebel, Luxemburg, Liebknecht, and Freud. Conducted entirely in German with emphasis on reading, speaking, and writing skills. ***(Not offered 1981-82.)***
J. Rosellini

21.240 German Culture and Society: 1918-1933

(21.265)
Prereq.: German IV or equivalent
Year: U (2) HUM-D
3-0-6

German culture and literature between the two wars from late expressionism (Toller) to the beginning of "Blut und Boden" (Carossa, Grimm). Emphasis on the "Neue Sachlichkeit" movement (Kästner, Tucholsky, Döblin, Fallada) and on related forms of "Gebrauchsliteratur" — reportage, documentary novel. Sessions on contemporary films *(Caligari, Kameradschaft, Berlin),* the art, architecture (Bauhaus!) and music of the period demonstrate the close links existing between the different art forms at that time; introductions into the social, political and philosophical background (Mannheim, Bloch, Oswald, Kracauer) provide a framework for an understanding of the issues behind the literature. Since we are dealing with an extremely diverse and very prolific cultural period, students are expected to contribute actively to the subject (outside material, presentations). Conducted entirely in German. Two five-page papers, one research presentation. ***(Not offered 1981-82.)***
M. Geisler

21.241 German Culture and Society: 1933-1949 (New)

Prereq.: German IV or equivalent
Year: U (2) HUM-D
3-0-6

The theory and practice of National Socialism. "Everyday life" from 1933 to 1945. German culture in exile. The anti-fascist resistance. Jews and Germans. 1945: liberation or capitulation? The zones of occupation from 1945 to 1949. Selected readings from historical, political, psychological, sociological and literary works include H. Mann, Brecht, Tucholsky, Kracauer, Reich, Hitler, Goebbels, Planck, Einstein, Adenauer and Ulbricht. Conducted entirely in German with emphasis on reading, speaking and writing skills.
J. Rosellini

21.243 Introduction to German Literature

(21.251)
Prereq.: German IV or equivalent
Year: U (2) HUM-D
3-0-6

Study of selected forms of German literature manifested in prose fiction, poetry and drama. Readings include plays by Goethe and Brecht, stories by Thomas Mann, Keller and Kafka and selected poetry from the 16th through the 20th centuries. Topics of discussion: literary language as a specialized tool of communication; its conventions and presuppositions; relation of author to audience; imitation of reality vs experimentation with reality; purpose in literature; aesthetic, analytic, parodistic and political goals. Students listen to musical settings of some poetry *(Lieder)* and view a filmed version of one play. Conducted entirely in German. ***(Not offered 1981-82.)***
D. Dollenmayer

21.244 Introduction to German Poetry

(21.252)
Prereq.: German IV or equivalent
Year: U (1) HUM-D
3-0-6

Reading and studying poetry as an expression of feeling, thinking, and being. Highlights poetry of Goethe, Schiller, Novalis, and Eichendorff; then continues with major works of two of the most influential 20th-century poets: Rilke and Celan; concludes with the sampling of the work of a current poet. Includes a careful study of recordings of professional recitations of poems, and of Lieder. Readings and instruction in German. Discussion in German and English. The paper usually in English. ***(Not offered 1981-82.)***
M. Dyck

21.245 Goethe: Faust

(21.255)
Prereq.: German IV or equivalent
Year: U (2)
3-0-6

A thorough study of both parts of Goethe's *Faust:* as a literary work of art, as part of the Faust tradition (with emphasis on the Spiess chapbook and Marlowe's version), and in more general humanistic terms as a classic concerned with the pivotal issues of living and thinking. Conducted primarily in German. Paper normally written in English. ***(Not offered 1981-82.)***
M. Dyck

21.247 Introduction to German Drama

(21.259)
Prereq.: German IV or equivalent
Year: U (2) HUM-D
3-0-6

Introduction to the classical (Lessing, Goethe, Schiller, Kleist), contemporary (Büchner, Hauptmann, Kaiser, Brecht) and current German drama (Frisch, Durrenmatt, Weiss, Handke, Hacks, and others). The general nature of drama and the special features of this genre in its German manifestations (particularly tragedy, comedy, and various modern and post-modern forms and techniques). Discussion of recordings of German productions of about half the plays covered. Conducted primarily in German.
M. Dyck

21.248 The Modern German Novel

(21.260)
Prereq.: German IV or equivalent
Year: U (1)
3-0-6

Reading and discussion of six German novels from 1890 to present. Selected titles from Thomas Mann, Heinrich Mann, Hauptmann, Broch, Musil, Junger, Kafka, Hesse, Langgasser, Grass, and one current example each from West and East Germany. Basic elements of fiction and of the novel. Students read three novels in entirety and selections from rest. Readings and instruction in German. Discussion in English and German. Paper normally in English. ***(Not offered 1981-82.)***
M. Dyck

21.249 The World of Kafka

(21.261)
Prereq.: German IV or equivalent
Year: U (1)
3-0-6

You are invited to enter the weird world of Kafka through his major and minor prose works: the novels *(Der Prozess, Das Schloss, Amerika)* and such shorter narrative pieces as *Das Urteil, Die Verwandlung, Ein Hungerkunstler,* and others. Instruction and readings in German. Paper in English.
M. Dyck

21.250 Modern German Authors: Interpreting Kafka, Broch, and Canetti

(21.263)
Prereq.: German IV or equivalent
Year: U (2)
3-0-6

Works by three modern authors—Franz Kafka, Hermann Broch, and Elias Canetti—who are concerned with the relation of abstract ideals to individual lives. In order to explore this relation, they experiment radically with traditional narrative or dramatic forms. After reading Heinrich von Kleist's novella *Michael Kohlhaas* as the spiritual ancestor of the modern works, students read major short prose of Kafka, a novel by Broch, and a play by Canetti. Dramatic reading or production of one work at the end. Conducted entirely in German. ***(Not offered 1981-82.)***
D. Dollenmayer

21.251 Heinrich Heine (New)

Prereq.: German IV or equivalent
Year: U (1)
3-0-6

Poet, satirist, "reporter," exile, friend of Marx and Rothschildt, Heine is a controversial and enigmatic figure among Germans. Studies distance between Heine's poetry, which he considered to be "art" and his prose, which he saw as a tool in the fight for political freedom. Emphasis on Heine's role as literary and political figure in post-Napoleonic Germany. Conducted entirely in German.
M. Geisler

21.252 Literature and Society in the German Democratic Republic

(21.264)
Prereq.: German IV or equivalent
Year: U (1)
3-0-6

A critical overview of developments in literature and cultural policy from the founding of the GDR (the first German state to term itself socialist) in 1949 until the present day. The unique situation of a Soviet-socialist state whose citizens have free access to Western mass media. Readings consist of selected works of fiction, drama, and poetry drawn from the following periods: "socialist construction," partial de-Stalinization and the "thaw" of 1956-58, the "Bitterfield Path," the rise of the younger generation in the 1960s and "liberalization," and finally the contradictions of the 1970s which have led — among other things — to the expatriation of certain vocal critics of the GDR's development. Emphasis placed on the interrelationship of the economic, political, and cultural spheres. Conducted entirely in German with emphasis on reading, speaking, and writing skills. (Permission of instructor required.)
J. Rosellini

21.254J Germanic Syntax (A)

(21.267J)
(Same subject as 24.936J)
Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Comparative analysis of the core syntax of the modern Germanic languages, with an attempt to trace their divergent developments from a common origin. Special emphasis on topics bearing on current issues in syntactic theory. ***(Not offered 1981-82.)***
W. O'Neil, R. P. V. Kiparsky

Greek

21.255 Classical Greek I

(21.271)
Prereq.: —
Year: U (1)
4-0-8

Study of Attic Greek as a cultural subject. Basic text Chase and Phillips, *A New Introduction to Greek* is supplemented with various readers and xeroxed passages. Through special emphasis and quotations the cultural significance of the linguistic matters treated are brought into focus: e.g., strengths and weaknesses of inflected languages; values impacted in certain linguistic traits; Greek views of fate, love, death, etc. compared and contrasted with Christian and modern ones. By the end of the first term students have read the creation-account from *Genesis* and the Christmas story from *Luke.*
H. A. T. O. Reiche

21.256 Classical Greek II

(21.272)
Prereq.: Greek I or equivalent
Year: U (2)
4-0-8

Emphasis on syntax and easy composition. In addition to Chase and Phillips students do easy selections from Lucian, Xenophon, and Plato. Attention given to the subject matter covered in the readings to bring out it significance and thus to help motivate continued

student interest. Emphasis is on recognition rather than memorization. Also, selections from Greek mathematics, medicine, and astronomy.
H. A. T. O. Reiche

21.257 Greek Literature I

(21.275)
Prereq.: Permission of Instructor
Year: U (2)
4-0-8

First exposure to complete, relatively easy, texts such as Plato's *Apology* or *Crito* or *Ion* or *Eutyphro* and, in poetry, Euripides' *Hippolytus* or Aristophanes' *Clouds.* Students are encouraged, through outside readings of distinguished secondary work and class discussion, to place the works studied in a broader context of literary, philosophical, and cultural history. Introduction to problem of style, in part through suitably chosen exercises in prose composition. Selections from *Odyssey.*
H. A. T. O. Reiche

21.258 Greek Literature II

(21.276)
Prereq.: Greek Literature I
Year: U (1)
4-0-8

Exposure to complete texts continued, but to texts of somewhat greater inherent difficulty, both prose and poetic. Some lyric poets; one or two complete books of either *Odyssey* or *Iliad;* Sophocles' *Antigone.* Selected outside reading and class discussion of distinguished secondary work (e.g., Matthew Arnold, Bowra, Jaeger, Kitto, Stanford) to supplement the linguistic side. Lysias' *Against Eratosthenes* in its historical context and as model for occasional exercises in prose composition.
H. A. T. O. Reiche

21.259 Greek Literature III

(21.277)
Prereq.: Greek Literature II
Year: U (1)
4-0-8

Selected books of *Iliad* coupled with introduction to problems of oral culture and the so-called Homeric Question. Then either Aeschylus' *Prometheus Bound* or Sophocles' *Oedipus King.* Finally, Pericles' *Funeral Oration* from the second book of Thucydides. Reading and discussion of such additional works as Cornford, *Thucydides Mythistoricus* and Nietzsche's *Birth of Tragedy* serve to raise the questions of historical "truth" and the meaning of tragedy.
H. A. T.O. Reiche

21.260 Greek Literature IV

(21.278)
Prereq.: Greek Literature III
Year: U (2)
4-0-8

Aeschylus' *Agamemnon,* Euripides' *Bacchae* (or Aristophanes' *Frogs),* and Thucydides' account of the Sicilian Expedition (Bks VI and VII) or Bks I and X of Plato's *Republic.* Attention to selected textual problems, metre, style, and idiom. Those interested may flesh out Plato's Myth of Er with selections from Plato's *Timaeus.*
H. A. T. O. Reiche

Russian

21.261 Russian I

(21.281)
Prereq.: —
Year: U (1)
4-0-8

Basic grammar and practice in the elements of Russian. Emphasis on learning to speak and understand as a prerequisite for effective communication in Russian and as a basis for learning reading and writing skills.
C. V. Chvany, Staff

21.262 Russian II

(21.282)
Prereq.: Russian I or equivalent
Year: U (2)
4-0-8

Continuation of 21.261. Development of ability to use the language through systematic study of the regularities in the grammar. Continued practice in understanding and speaking, with a gradual transition to reading and writing. The second part of the term seeks to integrate language skills and develop control of vocabulary through readings which serve as a basis for conversation and composition.
J. Alissandratos

21.263 Russian III

(21.283)
Prereq.: Russian II or equivalent
Year: U (1) HUM-D
4-0-8

Reading and discussion of historical texts, short stories, and poems. Review of Russian grammar with the help of oral and written exercises. Systematic study of word formation and other strategies to free the student from dependence on the dictionary. Development of aural comprehension through tape-recorded materials in the language laboratory. Compositions based on readings and recordings integrate communication skills and help retain content. Materials selected to provide historical and cultural background for understanding Russian literature and contemporary Soviet culture.
J. Alissandratos

21.264 Russian IV

(21.286)
Prereq.: Russian III or equivalent
Year: U (2) HUM-D
4-0-8

Reading of literary and expository texts selected to provide an understanding of Soviet life and culture. Emphasis is on development of skill and confidence in reading — rather than translating — unedited texts. Aural comprehension developed through brief lectures on Russian and Soviet culture as well as through taped materials. Discussion and brief papers based on readings. Attention to more complex problems of grammar and style, with a view to improving the student's facility in oral and written expression.
C. V. Chvany

21.265 Advanced Spoken and Written Russian

(21.287)
Prereq.: Russian IV or equivalent
Year: U (1)
4-0-8

Review and systematization of the structure of modern Russian. Intensive training in spoken and written skills to improve fluency and style. Discussions and analyses of short works of fiction and nonfiction illustrating the various styles of spoken and written Russian. Extensive use of taped materials. Major focus on contemporary Russian culture. Conducted in Russian. ***(Not offered 1981-82.)***
C. V. Chvany

21.268 Russian Culture and Civilization

(21.288)
Prereq.: Russian IV or equivalent
Year: U (2) HUM-D
3-0-6

Russian culture and intellectual history from its beginnings to the present based on original literary and historical texts, music, and art. Study of specifically Russian ideas of differences between "culture" and "civilization" and corresponding differences between East and West. Controversy about the role of Peter the Great in the development of Russia: the "Western" vs. the "Slavophile" orientation. Serfdom and the Russian nobility; the Russian intelligentsia. The special role of folklore in Russian high culture. Conducted entirely in Russian, with emphasis on speaking, reading and writing skills, and control of grammar. Individual oral and written reports on a wide choice of topics.
C. V. Chvany

21.269 Introduction to Russian Literature I

(21.289)
Prereq.: Russian IV or equivalent
Year: U (2)
3-0-9

The subject has a double aim: a) to introduce the elements of composition and stylistics; b) to acquaint the student with the foundations of modern Russian literature through the most important and characteristic works of Pushkin, in verse and in prose — *Evgenij Onegin* and *Povesti Belkina.* Critical method and literary terminology are introduced, as the texts are analyzed both historically and structurally. Conducted in Russian. ***(Not offered 1981-82.)***
K. Pomorska

21.270 Introduction to Russian Literature II

(21.290)
Prereq.: Russian IV or equivalent
Year: U (2)
3-0-9

Similar to 21.269 in framework and approach, but the literary works studied are by different authors. Turgenev and Chekhov are the main authors studied in 1980-81, and their connection with the Pushkin tradition investigated. ***(Not offered 1981-82.)***
K. Pomorska

21.271 Contemporary Russian Prose and Poetry

(21.292)
Prereq.: Russian IV or equivalent
Year: U (1)
3-0-9

A study of Russian literature from 1954 up to our time. Besides the writers of the so-called "thaw period" (V. Panova, I. Ehrenburg), such authors as A. Solzhenitsyn, L. Chukovskaya, and poet-singer B. Okudzhava are included. Lectures and readings in Russian. Discussion and papers in Russian or English, depending on individual ability.
K. Pomorska

Spanish

21.275 Spanish I

(21.295)
Prereq.: —
Year: U (1, 2)
4-0-8

Introduction to understanding, speaking, reading, and writing Spanish. Maximal use of fundamentals of grammar in active communication. Language laboratory program coordinated with and supplementary to class work.
D. Morgenstern

21.276 Spanish II

(21.296)
Prereq.: Spanish I or equivalent
Year: U (1, 2)
4-0-8

Continuation of Spanish I. Increased practice in reading. Conducted in Spanish whenever practical.
J. W. Harris

21.277 Spanish III

(21.297)
Prereq.: Spanish II or equivalent
Year: U (1, 2) HUM-D
4-0-8

Aims at consolidation and expansion of skills in oral comprehension, speaking, reading, and writing. Short texts, taped interviews, and movies used to study specific social issues of current interest in Hispanic culture.
G. Varona-Lacey

21.278 Spanish IV

(21.298)
Prereq.: Spanish III or equivalent
Year: U (1, 2) HUM-D
4-0-8

Continued improvement in oral and written comprehension and expression for literary, language, and cultural studies, as well as for non-scholarly use of Spanish. Materials include film and radio broadcasts in addition to a selection of poetry and prose by modern masters, such as Borges, García-Marquez, Rulfo, and Lorca.
M. Resnick

21.279 Spanish Conversation (New)

Prereq.: Spanish II or equivalent
Year: U (1)
3-0-6

Intermediate level class designed to give students the necessary languge skills to perform successfully in Spanish in a variety of social situations. Focus on oral communication. Popular media used for listening practice; other materials include newspapers and magazines. Systematic exchanges with native speakers arranged. Student projects involve reading, oral presentations and classroom interaction. Emphasizes communication skills students in engineering and management need for work in Latin America or Spain.
D. Morgenstern

21.281 Advanced Spanish Conversation and Composition

(21.299)
Prereq.: Spanish IV or equivalent
Year: U (2)
3-0-6

Systematic training in spoken and written skills to improve fluency and style. Oral reports by participants on individual topics. Discussions with native speakers, analyses of modern fiction, periodicals, and local Spanish-language media. Focus is on everyday life in the contemporary Spanish-speaking world. (Permission of instructor required.)
G. Varona-Lacey

21.282 Spanish for Bilingual Students

(21.300)
Prereq.: Near native fluency in spoken Spanish
Year: U (1) HUM-D
3-0-9

Designed for those who are fluent speakers of one of the dialects of Spanish but who have had little formal training in the language. The subject has two goals. One is to expand the student's skills in communication, both oral and written, through systematic review of grammar, syntax, and pronunciation of standard Spanish. The other is to give the students an awareness and appreciation of the three major Hispanic cultures in the US: the Mexican-American, the Puerto Rican, and the Cuban. Deals with questions concerning causes for immigration, adaptation to "the American way of life," the role of the family, women, education, political issues, and literature. In addition, students consider the linguistic and political relationship of the various dialects to standard Spanish and refer to the problems and advantages of bilingualism. ***(Not offered 1981-82.)***
G. Varona-Lacey

21.284 An Introduction to Latin American Culture
(New)

Prereq.: Spanish IV or equivalent
Year: U (1) HUM-D
3-0-6

Overview of Latin America's cultural, historical, and literary development from pre-Columbian time to the present as seen through music, art, film, and historical and literary texts. Discussions deal with the indigenous peoples of the Americas, from Mexico southward, both before and after the discovery, as well as with the colonial period and the legacy of Spain, the struggle for national independence, and the ongoing quest for identity. Intended as a first course in Latin American Literature. Acquisition of general information needed for more advanced work in the field, as well as development of reading skills necessary for transition from language to literary subjects. Not open to native speakers. Conducted in Spanish. (Given alternate years in place of 21.285.)
Staff

21.285 An Introduction to Spanish Culture: The People and Civilization of Spain

(21.302)
Prereq.: Spanish IV or equivalent
Year: U (1) HUM-D
3-0-6

Study of the major social, political, and aesthetic modes which have shaped Spanish civilization. Coordinates the study of literature and the arts with the historical evolution of Spain. Readings and discussion focus on such topics as: The coexistence of Christians, Moors and Jews, Imperial Spain, The First and Second Republics, and the contemporary period as background for the emergence of distinctively Spanish literary and artistic movements: the Spanish Epic, the Romancero, the picaresque novel, mysticism, Goya's vision, the Spanish grotesque, flamenco music. Intended as a first course in Spanish literature. Its goal is the acquisition of general information needed for more advanced work in the field, as well as the development of the reading skill necessary for the transition from language to literature subjects. (Not open to native speakers. ***Not offered 1981-82.***)
M. Resnick

21.287 The Modern Short Story in Spain and Latin America
(New)

Prereq.: Spanish IV or equivalent
Year: U (2)
3-0-6

Studies masterpieces of the short story produced in Spain and Latin America. Considers the short story as a genre with unique possibilities for expression, and also as a sociological phenomenon responding to particular historical circumstances affecting both writers and their readership. In addition, detailed analyses of selected short stories by writers such as Borges, Cortázar,and Matute are performed in order to use their texts as models for original short stories to be composed in Spanish by the students. Other authors studied include Rulfo, Arreola, Aub, and Martín Gaite. Conducted in Spanish.
M. Resnick

21.288 A Study of The Spanish Theatre: Life Is A Dream

(21.303)
Prereq.: Spanish IV or equivalent
Year: U (2)
3-0-6

Study of the representative works of the Spanish theatre from early liturgical drama to the present. Follows the development of the theatre as a unique genre and considers the way it has been used to foster national consciousness, to debate religious and philosophical issues, to reconcile aristocratic and popular art forms and to investigate the infinite capacity of human beings for love, folly, and rebellion. Selections from Lope de Vega, Calderón, Cervantes, Zorrilla, García Lorca, Sastre and others read. (Conducted in Spanish. ***Not offered 1981-82.***)
G. Varona-Lacey

21.289 The Novel in Spain

(21.305)
Prereq.: Spanish IV or equivalent
Year: U (2) HUM-D
3-0-9

Critics identify Spain as the birthplace of the Western novel. Explores the development of the Spanish novel from its 16th-century picaresque roots through the fiction of the Franco era. Readings and discussion focus on the unique historical conditions which shaped Spanish consciousness and affected Peninsular fiction in three major stages: 1) the novel: creative response of writers alienated from a society dominated by the repression of the Spanish Inquisition; 2) the 19th century: the fictionalization of daily life; 3) the 20th Century: a redefinition of the antagonistic relationship of the novelist to the natural, social, artistic milieu. Conducted in Spanish. Fernando de Rojas, *Lazarillo de Tormes,* Cervantes, Galdós, Pardo Bazán, Cela, Martín Santos, Goytisolo. ***(Not offered 1981-82.)***
M. Resnick

21.290 Literature and Social Conflict: Perspectives on Spain 1820-Present

(21.306)
Prereq.: Spanish IV or equivalent
Year: U (1) HUM-D
3-0-6

Considers how major literary texts illuminate principal issues in the evolution of modern Spanish society. Emphasis given to the treatment of such major questions as the exile of liberals in 1820, the concept of progress, the place of religion, urbanization, rural conservatism and changing sexual roles. Authors stud-

ied include: Pérez Galdós, Pardo Bazán, Clarín, Unamuno, Ganivet, Ortega y Gasset, Pérez de Ayala, Salinas, Lorca, Delibes and Martín Santos. Conducted in Spanish.
M. Resnick

21.292 Latin American Literature 1492-1898: Creation of a Continent

(21.307)
Prereq.: Spanish IV or equivalent
Year U (1) HUM-D
3-0-6

Traces the creation of a new literature to record and interpret a new reality. Begins with the Spanish Discovery and Conquest and studies the unfolding of the secular struggle of Spanish speakers in the Americas to give meaning to their experience through literature. Readings up to the Spanish American War of 1898: these include texts by Columbus (Colón), Bernal Dias del Castillo, Inca Garcilasso de la Vega, Sor Juana Inés de la Cruz, Esteban Echeverria, José Hernández, Richardo Palma, and José Marti. Conducted in Spanish. ***(Not offered 1981-82.)***
E. Garrels

21.293 Twentieth Century Latin American Literature: The Alchemist's Laboratory

(21.308)
Prereq.: Spanish IV or equivalent
Year: U (2) HUM-D
3-0-6

Through the reading of poetry, novels, and short stories students encounter a variety of creative responses to the complex and troubled reality of contemporary Latin America: from fantasy to social protest, from personal confession to the literary subversion of the language of demgogy and mass media. Authors studied include Darío, Quiroga, Neruda, Arguedas, Rulfo, Puig, Borges, and García Márquez. Conducted in Spanish.
E. Garrels

21.294 The Family in Spanish American Literature (New)

Prereq.: Spanish IV or equivalent
Year: U (1)
3-0-6

Considers works of modern Spanish American literature which deal with relations of power and the definition of sex roles in the Hispanic family. Also considers the use of the family as a metaphor for larger societal units, the idealization of the family, and its portrayal as a haven from society's indifference and chaos. Works include novels and short stories by Donoso, Cortázar, García Márquez, and contemporary women writers, as well as poetry by Neruda, Vallejo, and Castellanos. Conducted in Spanish. ***(Not offered 1981-82.)***
E. Garrels

Literature in Translation

21.296 Introduction to European Fictional Modes

(21.325)
Prereq.: —
Year: U (2) HUM-D
3-0-6

Study of the origins and development of the art of narration in Europe. Attention given to a variety of forms and genres. Emphasis placed on the way in which the unique history of each country shaped the imaginative responses of its writers. Authors read include Cervantes, Laclos, Flaubert, Stendhal, Maupassant, Galdós, Pardo Bazán, Mann, Gogol, Chekhov, Turgenev, Lermontov. Students who wish to do so are encouraged to read some of the works in the original.
R. E. Jones, M. Resnick, K. Pomorska

21.297 Evil and Decadence in Literature

(21.326)
Prereq.: —
Year: U (2)
3-0-6

Study of evil and decadence in literature, starting with Job and Petronius. Emphasis on French and English authors including the Marquis de Sade, Mrs. Radcliffe, Byron, Shelley, Lacious, Baudelaire, Rimbaud, Flaubert, Lautreamont, Huysmans, Swinburne, Wilde, Gide, Proust, Firbank, Corvo, Genet, Huxley, Golding. Readings and discussions in English. Students who wish to do so encouraged to read some of the texts in the original. ***(Not offered 1981-82.)***
R. E. Jones

21.298 The Avant-Garde Theatre in the 20th Century

(21.327)
Prereq.: —
Year: U (2)
3-0-6

Study of Expressionism, Surrealism, Theatre of Cruelty, Epic Theatre, Theatre of the Absurd, and concept of "total theatre." Playwrights studied include Jarry, Strindberg, Kokoschka, Hasenclever, Kaiser, Brecht, Weiss, Pirandello, O'Neill, Cocteau, Apollinaire, Vitrac, Artaud, Ionesco, Beckett, Genet, Albee, Pinter, Kopit. Special attention given to the role of director, scenic designer, new acting techniques, and new "role" of the audience. Students who wish to do so encouraged to read some of the texts in the original. ***(Not offered 1981-82.)***
R. E. Jones

21.299 The Don Juan Legend

(21.334)
Prereq.: Permission of Instructor
Year: U (1) HUM-D
3-0-6

Analysis of the Don Juan figure, tracing the development from its first appearance in 17th-century Spanish theatre through later versions in the cultures of France, Germany, and Italy. Readings include plays, stories, and poems; operas and films also considered. One section of the syllabus focuses on Don Juan's counterpart, the *femme fatale*. The subject explores why many of the greatest European writers (as well as musicians and filmmakers) have been attracted to the Don Juan character. Attention placed on the depiction of immorality within art, and on the relations between art, morality, and society. (Taught in English, but students are expected to have some reading knowledge of Spanish or French or German. ***Not offered 1981-82.)***
E. B. Turk

21.300 Sex Roles in Fiction: Europe and Latin America (New)

Prereq.: —
Year: U (2)
3-0-9

Examination of the representation of sexual roles in fiction. Works by European and Latin American authors studied in their cultural and historical contexts. Materials from other cultures, including film, used for comparative purposes. Authors include: Laclos, Fontane, Molière, Sor Juana Inés de la Cruz, Zola, Stefan, García Lorca, Wolf, Alarama, Wittig and Puig. Films by Godard, Buñuel, Kuyris, Saura, Fassbinder, Wertmüller.
M. Resnick, I. de Courtivron, E. Waldstein

21.302 French Literature in Translation: The Search for Identity in an Alien World

(21.328)
Prereq.: —
Year: U (1) HUM-D
3-0-6

The quest for self-definition in the social, sexual, religious, political, and artistic spheres of life. Among the authors studied are Marie de France, Molière, Racine, Stendhal, Nerval, Apollinaire, Proust, Gide, Malraux, Camus, and Marguérite Yourcenar. Students who wish to do so are encouraged to read some of the works in the original.
F. Hodgson

21.303 Gide and Genet

(21.340)
Prereq.: —
Year: U (1)
3-0-6

Study of selected works of Gide *(Marshlands, Prometheus Misbound, The Immoralist, Strait is the Gate, The Vatican Swindle, The Counterfeiters, If It Die)* and Genet *(Our Lady of the Flowers, The Thief's Journal, The Maids, The Blacks, The Balcony, The Screens).* Especial emphasis on the role of the artist-moralist, the sexual deviant, the alienated hero. Students who wish to do so are encouraged to read some of the texts in the original. (Given entirely in English ***Not offered 1981-82.***)
R. E. Jones

21.305 German Literature in Translation

(21.329)
Prereq.: —
Year: U (1) HUM-D
3-0-6

Major representative literary works from 1200 to the present; each work is treated in concentrated depth; all works are explored in terms of 1) the dominant literary forms in each era, 2) a thematic cluster of things distinctively and persistently German through the ages,
3) contrastively interpreted in perspectives German, European, and North American,
4) against an outline of the cultural, political, and more generally historical development of the German-speaking countries. Emphasis on the peak periods of German literature; the Middle Ages *(Nibelungenlied)*, the Enlightenment (Lessing), the Goethe Era *(Faust)*, Romanticism (Novalis), Realism (Fontane), the earlier 20th Century (Thomas Mann, Hesse, Kafka, Brecht); and post-1945 drama (Frisch, Durrenmatt, Weiss, Handke) and prose fiction (Grass and others). Individually adjusted reading loads (with the options of omitting certain titles or confining oneself to one of two chapters in some items). Designed for students without any knowledge of German. Students with some German who wish to do so are encouraged to read some of the works or chapters in the original.
M. Dyck

21.306 Rogues and Rascals: The German Picaresque and a Literary Tradition

(21.333)
Prereq.: —
Year U (1) HUM-D
3-0-6

Development of the picaresque novel (the novel of roguery) from the 16th century to the present, with emphasis on German literature. Character of the picaresque hero(ine), first-person narration and episodic structure, transformations of the picaresque in the 20th century. Authors include Quevedo, Grimmelshausen, Mark Twain, Thomas Mann, Kafka, Brecht, Jaroslav Hasek, Günther Grass, Mordechai Richler. (Conducted in English. Students who wish to do so are encouraged to read some works in the original. ***Not offered 1981-82.***)
D. Dollenmayer

21.307 The Modern German Novel

(21.336)
Prereq.: —
Year: U (2)
3-0-6

Begins with several early 20th century novels, and ends with one current novel each from the four German-speaking countries. Concentrates on the three novelists who best represent the German literary and historical scene in the 20th century: Thomas Mann (1900-1925); the transition from the glories of the Empire to the traumas of World War I Lost. Franz Kafka (1925-1950); intimations of the tides of *Angst* and *Sorge* by Kafka and Heidegger. Günter Grass (1950-1975); post-1945 grapplings with pre-1945 happenings. Evolving definitions of the German novel. (Given in English. Students who wish to do so are encouraged to complete some of the readings in the original.)
M. Dyck

21.308 The German Cinema

(21.337)
Prereq.: —
Year: U (2)
4-0-5

Overview of the German film since its beginning with special emphasis on the New German Cinema of the 70s. Weekly screenings from selected films of each period. Lectures and discussions deal with the social and historical context of the films as well as with their artistic value (technical processes, directorial styles, "narrative" techniques). Students expected to study the films, read about and research into their social and historical background, and maintain a weekly reaction journal. One substantial final paper dealing with some selected aspect of German cinema. Conducted in English. Films shown with English subtitles.
M. Geisler

21.310 Slavic Civilization: Magic, Vampires, and Sorcerers

(21.331)
Prereq.: —
Year: U (1) HUM-D
3-0-6

Introduction to the civilization of the Slavs. Focuses on Slavic folk tales and epics—heroes, heroines, and villains as well as their supernatural motivation. Slavic folk heroes are compared to equally fantastic Christian heroes in order to determine the constants of Slavic folk beliefs, which persist regardless of the dominant religion in any period. Explores recurrence of folk themes in literature and the arts. Emphasis on common Slavic linguistic and cultural heritage. Conducted in English. Students who can do so are encouraged to read some of the works in the original.
J. Alissandratos

21.311 Soviet Literature and Moral Issues

(21.335)
Prereq.: Permission of Instructor
Year: U (2)
3-0-6

After three repressive decades of "Socialist Realism" in which plots were predictable and characters one-dimensional, Soviet literature demonstrated a resurgence of artistic values in the mid-fifties, after Stalin's death. Along with this, new political and social issues came to the surface. Study of the moral challenges writers such as Solzhenitsyn, Grossman, and Chukovskaya offer to the ideological dilemmas of totalitarianism, socialism, and freedom. The new point of view on war and patriotism represented by participants in World War II such as

the balladeer Bulat Okudzhava. A. Sinjavsky-Tertz and Ju. Daniel-Arzhak and sexual issues. Poetry by Evtushenko and Voznesensky and the poet's new identity. Readings in English; conducted in English. Students with a knowledge of Russian encouraged to read some texts in the original.
K. Pomorska

21.312 Religious Trends in Soviet Thought and Literature

(21.338)
Prereq.: —
Year: U (2)
3-0-6

A new view of the Soviet period of Russian culture. In spite of the official ideology, deep religious roots have been retained in Russian thought and literature, both published and underground. Intensive study of such thinkers as Berdiaev and Florensky; the influence of the mystical philosophy of N. Fedorov and his idea of resurrection on the poet Vladimir Mayakovsky; religious mysticism of Alexander Blok. Demonology and Christianity in Mixail Bulgakov's novel *The Master and Margarita*. The hero as zealot: Boris Pasternak and *Doctor Zhivago*. Traces of medieval tradition of "deed as sacrifice" in Pasternak and Solzhenitsyn. Readings in English; conducted in English. Students with a knowledge of Russian encouraged to read some texts in the original. ***(Not offered 1981-82.)***
K. Pomorska

21.313 Russian Avant-Garde: Visual Arts, Literature

(21.339)
Prereq.: —
Year: U (2)
3-0-6

Futurist movement and its consequences in Russia (the Left Front of Art-LEF). Parallel between Futurism in literature and Cubism in painting. Influence of Cubism on the poetry and prose of Mayakovsky and Pasternak. Suprematism of K. Malevich. New ideas of time and space: new utopia. Discussions of the situation of the innovative artist in Soviet Russia. Readings and discussions in English. Students with a knowledge of Russian encouraged to read some texts in the original.
K. Pomorska

21.314 Russian Novel of the 19th Century

(21.332)
Prereq.: —
Year: U (2) HUM-D
3-0-6

A study of the development of the novel in Russia in the context of the evolving European novel. Emphasis given to the relationship among three major fictional modes in Russia: the historical novel, the psychological novel, and the satirical/realist novel and their European counterparts. In each case attention is given to the larger historical and social issues which determined the creative milieu within which these writers worked. Pushkin, Lermontov, Gogol, Tolstoy, Dostoévsky. Also Sterne, Byron, Walter Scott. Students with a knowledge of Russian encouraged to read some texts in the original. ***(Not offered 1981-82.)***
K. Pomorska

21.315 Seminar on Tolstoy's *War and Peace*

(21.342)
Prereq.: Permission of Instructor
Year: U (1)
3-0-6

War and Peace as the central work of Tolstoy; its meaning for Tolstoyan Philosophic and ethical systems and for his literary technique: an attempt to revaluate the whole previous experience of realistic style. *War and Peace* as a historical novel; history as historiosophy opposed to both Romantic and Positivist tradition. The historical novel as a projection of the past onto the writer's own time. "Truth" and "legend" in the historical novel. Taught in English. Students with a knowledge of Russian encouraged to read some texts in the original.
K. Pomorska

21.316 Seminar on the Prose of A. Solzhenitsyn

(21.343)
Prereq.: Permission of Instructor
Year: U (2)
3-0-6

Solzhenitsyn both as a cultural bridge between the 19th-century tradition of Russian classical realism, and as a challenge to the ideological and political dilemmas of our time. Problems of freedom and totalitarianism in a universal modern context as expressed in *One Day in the Life of Ivan Denisovich, Cancer Ward*, and *First Circle*. War and duty, the role of a "great personality" in *August 1914*, polemically directed against Tolstoy and at the same time developing Tolstoyan ideas in a new key. Solzhenitsyn's protagonists and the problem of "winning" and "losing." Readings in English; conducted in English. Students with a knowledge of Russian encouraged to read some texts in the original. ***(Not offered 1981-82.)***
K. Pomorska

21.317 Latin American Literature: Civilization vs Barbarism

(21.330)
Prereq.: —
Year: U (2) HUM-D
3-0-6

In 1845, Domingo F. Sarmiento published his study of contemporary Argentina, *Civilización y barbarie: Vida de Juan Facundo Quiroga*, which established the pair of opposites "civilization" and "barbarism" as widely accepted descriptive terms for Latin American reality. Studies the history of this dualistic vision—and questions its legitimacy—in fiction and expository texts from the Conquest to the present, with emphasis on 20th-century novels and short stories. Authors include Borges, García Márquez, Cortázar, Carpentier, and Rulfo. ***(Not offered 1981-82.)***
E. Garrels

Senior Seminar

21.320 Senior Seminar for Majors in Foreign Language and Literature

(21.347)
Prereq.: —
Year: U (2)
3-3-0

A workshop focusing on the specific task of thesis writing on topics in foreign literatures. Problems of methodology, organization, and critical writing addressed by means of faculty and student presentations. Special attention given to research problems in foreign literatures including the identification of bibliographic tools and the acquisition of materials from foreign sources.
Staff

Studies in Language

21.321J The Study of Language

(Same subject as 24.900J)
Prereq.: —
Year: U (1) HUM-D
3-0-6

A systematic survey, for students without prior background in linguistics, of the major concerns in the study of language. A consideration of the fundamental empirical question relating to the human capacity for language: the problem of explaining the ability of human beings to acquire the sound system and grammatical structure of a natural language. An overview of the typological diversity observed in the world's languages, genetic relationships among them, and the mechanisms of language change that give rise to linguistic variety. An examination of the relation of language to culture and society, including the reflection in language of sociocultural and other extralinguistic factors, and the position of language in human intellectual life both as a vehicle for the expression of ideas and as an object of inquiry.
J. W. Harris, W. O'Neil, J. R. Ross

21.322J Language and Its Structure

(Same subject as 24.901J)
Prereq.: 21.140J or 24.900J
Year: U (2)
3-0-6

Detailed examination of fundamental concepts and issues in linguistic theory, with emphasis on explanatory models in linguistics and their bearing on issues in philosophy and cognitive psychology. Phonology: phonetic features, the organization of phonological systems, phonological changes; examples from English and other languages. Syntax: deep and surface structures, properties of syntactic rules, syntax and semantics; a survey of the major syntactic processes of English. Study of several typologically different languages from the point of view of the relationship between syntactic structure and logical form.
J. W. Harris

21.324 Workshop in Translation

Prereq.: Knowledge of any second language at the level of III or above
Year: U (2)
3-0-6

Designed for students who wish to translate short stories, essays, or poems into English. Class includes the study of technical, historical, and theoretical aspects of translation, as well as discussion of students' work. Models of translation, both classical and contemporary, examined critically. Attention given to linguistic problems of translation. Students complete a translation project which they elaborate in consultation with the faculty. ***(Not offered 1981-82.)***
C. V. Chvany, Staff

English as a Foreign Language

21.325 Pronunciation and Comprehension of American English Sounds

(21.320)
Prereq.: —
Year: U (1, 2)

Study of the sounds, stress, rhythm, and intonation of American English. Extensive practice in both speaking and listening. (Not for credit. 2 hours in class practice plus Language Laboratory. ***Not offered 1981-82.***)
Staff

21.326 Intensive Review of English Language Skills (Revised Unit)

(21.310)
Prereq.: Permission of Instructor
Year: U (1)
4-2-6

Presentation and oral drill of important points of English grammar. Assignments reinforce class work and introduce basic writing skills. Additional conversation practice keyed to structure of the language and to various social situations and subjects of common interest. Language laboratory assignments include listening comprehension.
Staff

21.327 English Structure

(21.311)
Prereq.: 21.326
Year: U (1, 2)
4-0-5

Focuses on precision in the use of complex sentences and structures. Emphasis on oral and written communication. (Permission of instructor without 21.326 background.)
K. J Irving, Staff

21.328 Intermediate Communication Skills: English as a Foreign Language

(21.312)
Prereq.: 21.326
Year: U (1, 2)
4-0-5

Tapes and readings on contemporary issues are used as the basis for the development of vocabulary and conversational skills.
Staff

21.330 Development of Communication Skills: English as a Foreign Language (New)

Prereq.: 21.327, 21.328
Year: U (1)
3-0-6

For high intermediate and advanced English as a Foreign Language students who want to refine oral/aural communication skills. Readings, videotapes, radio programs, dialogues and interviews on America and Americans used as a vehicle for improving English skills. Topics include the melting pot, work, mass media, aging, and sex roles. Students record their dialogues and interviews and keep written journals. (Permission of instructor without 21.327, 21.328 background.)
K. J. Irving

21.331 Development of Aural/Oral Skills: English as a Foreign Language

(21.313)
Prereq.: 21.326
Year: U (2)
4-3-2

Study of the language and devices of exposition in lectures and other formal presentations. Practice in oral presentations using techniques studied. Discussion of lectures on audio and videotapes. Guest speakers. Designed to aid advanced students in lecture comprehension and in improving their ability to make oral reports.
A. Mason

21.333 Expository Writing I for Undergraduates: English as a Foreign Language

(21.314)
Prereq.: —
Year: U (1)
3-0-6

Reading, discussing, summarizing and paraphrasing articles and essays in nontechnical fields. For undergraduates whose first language is not English and who need practice in basic writing skills. Attention also given to vocabulary development and grammar. (Recommended for freshmen.)
K. J. Irving

21.334 Expository Writing II for Undergraduates: English as a Foreign Language

(21.315)
Prereq.: 21.333 or Permission of Instructor
Year: U (1, 2)
3-0-6

Organizing and formulating ideas clearly in writing. Students learn how to focus on a topic and thesis, and how to choose appropriate vocabulary and sentence structure to best achieve their purpose. Individual conferences held with the instructor to discuss papers and to work on grammar and usage problems. (Placement exam without 21.333 background.)
K. J. Irving

21.335 Expository Writing III: English as a Foreign Language

(21.316)
Prereq.: —
Year: U (1, 2)
3-0-6

Development of an idiomatic prose style through analysis of elements of exposition; production of correct and varied complex sentences; study of beginnings, closings, and linking devices; also, attention to vocabulary. Writing in class and at home. Biweekly conferences to discuss individual work. (Open to graduate students. Permission of instructor or placement exam.)
A. Mason, Staff

21.336 Scientific and Engineering Writing: English as a Foreign Language

(21.317)
Prereq.: 21.334 or 21.335
Year: U (2)
2-0-7

Analysis and practice of various forms of scientific and engineering writing. Careful consideration of the use of language for effective communication. Class presentations. Individual conferences as necessary. (Comparable to 21.760 Scientific and Engineering Writing, but methods designed for those whose native language is not English.) (Permission of Instructor or placement exam without 21.334 or 21.335 background.)
A. Mason

21.337 Workshop in Writing Research Papers: English as a Foreign Language

(21.318)
Prereq.: 21.335 or Permission of Instructor
Year: U (2)
2-0-7

Advanced subject which focuses on techniques, format and prose style necessary for research papers. Emphasis on writing as required in fields such as Economics, Political Science, Architecture. Individual conferences as necessary.
Staff

21.339 Issues in Intercultural Communication

(21.319)
Prereq.: 21.327
Year: U (2)
3-0-6

Study of issues in intercultural communication to sharpen the advanced English as a Foreign Language student's communication skills and sensitivity to cultural influences. Reading and discussion of some of the major contributors to the field. Students write papers on the topics studied which include cultural influences on the perception of our environment, aspects of non-verbal communication, patterns of thinking, behaving, and using language. (Permission of instructor without 21.327 background.)
K. J. Irving

21.348 Special Topics in Foreign Languages and Literatures

Prereq.: —
Year: U (1)
Arr.

21.349 Special Topics in Foreign Languages and Literatures

Prereq.: —
Year: U (2)
Arr.

Advanced work in foreign languages or literatures for unusually well-prepared students. Offered by members of the staff in their special fields. Students electing this subject must secure approval of the chairman of the Foreign Languages and Literatures Section and the Department of Humanities. (Humanities credit for Special Topics subjects awarded only by individual petitions to the Committee on Curricula. Normal maximum is 6 units, to count towards Humanities Requirement, 9 units are required. Exceptional 9-unit projects occasionally approved.)
Staff

History

For other subjects related to history in addition to those given below, see Special Interdisciplinary Subjects, 21.901J-21.992.

European History

European History subjects are divided into two categories: Basic Fields: 21.350-21.365, and Special Subjects and Seminars: 21.366-21.389.

Basic Fields

21.350 The Ancient World I: Ancient Near East and Greece

Prereq.: —
Year: U (1) HUM-D
3-0-6

The cultural and political history of the ancient Near East (Egypt, Mesopotamia, Persia) and Greece down to Alexander the Great. Emphasis on such topics as the interface of astro-archaeology and mythology; river cultures; the pyramids; origin of writing; fluctuations in, and importance of, East-West contacts; strategy and military science; Athen's Golden Age: the inventions of democracy, drama, history, and philosophy. Critique of the polis. Readings and class discussions based on text, Slavin's *The Way of the West*, vol. I., on primary sources drawn both from anthologized selections (Kagan) and from complete versions of original works in translation (Homer, Herodotus, Thucydides), and on outstanding scholarship in the field (e.g., Zimmern, Jaeger, Finley, Dodds). Students are encouraged to pursue areas of special interest.
H. A. T. O. Reiche

21.351 The Ancient World II: Rome

Prereq.: —
Year: U (2) HUM-D
3-0-6

Structure and dynamics of early Roman republic: an empire acquired in a fit of absent-mindedness; conservatism; improvisation. The role of Greek humanism. The breakdown of the political system by its very success: Caesar and Caesarism. The republic as facade. The Augustan compromise. The history of historiography, both ancient and modern, on this vexed subject (Sallust, Cicero, Caesar, Vergil, Tacitus, Mommsen, Spengler, Syme). Criteria of social health and decadence. The roles of barbarism and Christianity: Gibbon's thesis reexamined. Class warfare: Rostovzeff's thesis. Why no industrial revolution in the third century? Reasons for the failure of the imagination: military, political, economic. Internal and external barbarians. Nature and roles of Roman law, Christian church, and theological orthodoxy. Vulgar Latin as prelude of Romance languages. Readings and discussion based on Slavin, *The Way of the West*, vol. I and the primary sources collected in Kagan. Wide sampling of representative historiography both ancient and modern. Students encouraged to pursue areas of special interest.
H. A. T. O. Reiche

21.352 The Middle Ages I

Prereq.: —
Year: U (1) HUM-D
3-0-6

Transitions from Antiquity to "The First Europe," extending roughly from the 3rd century to the 10th. Processes of change and mutation from institutions and ideas which were late Roman, to those which became "Gallo-Roman," and then distinctively European. Early Christianity, rise of the Church and role of the monasteries; nomads, barbarian migrations, and puzzle of climate change: evolution of a subsistence economy, plow agriculture, and hereditary peasantry; origins of feudalism and rise of a hereditary aristocracy.
R. M. Douglas

21.353 The Middle Ages II

Prereq.: —
Year: U (2) HUM-D
3-0-6

Europe from the depths of the 10th century and the second wave of barbarian invasions through the multiple phenomena of expansion between 1050 and 1350: population growth, an "agricultural revolution," a "commercial revolution," the revival of cities and the advent of a new merchant class; the growth of feudal monarchies, the Crusades, the rise of universities and the formation of new elites. The 12th century seen as a period of creativity, rebellion, and a new romanticism in religion and the arts. The 13th as a century of consolidation, authority, and stability. Concluding section deals with recent studies on the "Malthusian" crisis of the early 14th century. (May be taken independently of 21.352.)
R. M. Douglas

21.356 History of the Western World I: 1500-1815

Prereq.: —
Year: U (1) HUM-D
3-0-6

The evolution of the western world between the end of the Middle Ages and the French Revolution. Topics: heritage of the Middle Ages; emergence of the new dynastic monarchies; the great explorations; the Renaissance in Italy and Northern Europe; the Protestant and Catholic Reformations; the Scientific Revolution; the Enlightenment; development of the bureaucratic state; the American and French revolutions.
D. B. Ralston

21.357 History of the Western World II: 1815-1970

Prereq.: —
Year: U (2) HUM-D
3-0-6

Survey of the West during the era of its preponderence, the 19th and early 20th centuries, and during its subsequent retreat from world domination. Among the topics considered: the Industrial Revolution and its spread; liberalism and the modern nation state; unification of Italy and Germany; the "new" imperialism; World War I and the eclipse of Europe; the Russian Revolution and its consequences; the long armistice and World War II; "Pax Americana" and the post-war international order; the resurgence of the non-western world.
D. B. Ralston

21.360 European Social History in the 19th and 20th Centuries

Prereq.: —
Year: U (1)
3-0-6

Study of the large-scale social and economic forces that changed the character of European society. Close analysis of selected topics, including: changes in population, diet, and health standards; mass migrations within and out of Europe; changes in class and family structures and in the roles of women and children; changes in the conditions of labor; the emergency of large-scale social and revolutionary movements. Readings of novels and short stories as well as works in history, sociology, and related fields. ***(Not offered 1981-82.)***
W. B. Watson

21.361 Europe, 1917-1948: The Era of Mass Politics

Prereq.: —
Year: U (1)
3-0-6

The quest for mass participation in politics as the unifying theme of European history in the period of the two World Wars. The struggle among mass movements organized by labor, the Church, parliamentary parties, and the state itself for dominance in political life. Close attention to the consequences of World War I, the failure to establish a European peace settlement, the consequences of runaway inflation and world depression, the causes of World War II, mobilization for war, and the structure of post-war Europe.
D. B. Ralston

Special Subjects and Seminars

21.365 The Renaissance in Italy

Prereq.: —
Year: U (1)
3-0-6

Comparative studies in the development of Italian society, politics, and culture from the generation of Dante to the age of Machiavelli, with principal emphasis on Florence and Venice. Reading drawn extensively from treatises and documents written by magistrates, merchants, and lawyers; artists, scholars, and men of letters of this period. Lectures and discussion; short papers.
R. M. Douglas

21.366 The Nature and Meanings of History

Prereq.: —
Year: U (2)
3-0-9

Introduction to modern historical writing with emphasis on the tendencies and countertendencies in the 20th-century European tradition. Particular concern with patterns of historical explanation as adopted by practicing historians: individual and collective biography, demography and family reconstruction, psycho-history, Marxism. (Open to qualified juniors and seniors with permission of instructor. Cambridge Humanities Seminar. Given at Wellesley College.)
J. Knudsen

21.367 Ideas of Progress

Prereq.: —
Year: U (2) HUM-D
3-0-9

Attempt to clarify answers to the questions: What is progress? How is it to be assessed? The rise of the idea of progress from the 17th century to its position as the universal religion of the modern world. Special attention to relation among ideas of scientific, moral, and artistic progress. Readings include Francis Bacon, Condorcet, Kant, Hegel, Darwin. Contemporary views by Wolflin, Gombrich, T. S. Kuhn, Karl Popper. (Cambridge Humanities Seminar. Given at MIT.)
A. C. Kibel, I. Stadler

21.369 Marx, Darwin and Freud

Prereq.: —
Year: U (1) HUM-D
3-0-6

Historical and critical study, in depth, of the attempts of Marx, Darwin and Freud to investigate the natural and cultural development of humans and society, which are treated as problems in creativity, in intellectual history, history and philosophy of the cultural sciences, and in social thought.
B. Mazlish

21.371J The Industrial Revolution: A Social and Cultural History

(Same subject as STS 315J)
Prereq.: —
Year: U (2)
3-0-6

An examination of the industrial revolution, 1750-1830, in terms of the context in which it occurred and its impact on society and culture. After a brief consideration of the industrial revolution itself, attention focused on the intellectual, emotional, artistic, literary, and social effects, including the implications for demographic and class structure and for the family. Presentations, where possible, are made in terms of individuals such as A. Smith, Malthus, Rousseau, Owen, Carlyle, St. Simon, and Fourier.
B. Mazlish

21.372 France 1789-1969: From the Revolution to Charles de Gaulle

Prereq.: —
Year: U (1)
3-0-6

The French Revolution and the nature of the revolutionary and Napoleonic settlement; the search for stable political institutions down to 1870; the factors underlying the stability of French society in the 19th century; the nature of the post-1870 republican synthesis and its breakdown in the 20th century; the efforts following World War II to reach a new political and social settlement. ***(Not offered 1981-82.)***
D. B. Ralston

21.375 The Making of Russia in the Worlds of Byzantium, Mongolia, and Europe (ca. 850-1800)

Prereq.: —
Year: U (2)
3-0-9

Lectures, discussion, writing, reading of texts, of secondary and primary sources. The Kievan state, the tsardom of Muscovy, the Petrine empire: periods of development of Russian historical identity within Byzantine, Eurasian steppe, and Western culturally or politically occupied spaces. The more lasting, defining influences of such experiences, together with geography, ethnology, and also great leaders (St. Vladimir, Genghis Khan and his Eurasian heirs, St. Sergius, Ivan the Terrible, Peter the Great, Catherine the Great) on Russian institutions and culture. Historical themes and concepts for exploration: frontiers and marches as loci of origins of cadres for empires; the ghost empire; patrimonialism and feudalism; religion and the arts in the development of historical identity; leagues of principalities and cities compared to nation states and to empires as contexts for the quality of Russian life. ***(Not offered 1981-82.)***
R. E. MacMaster

21.376 Imperial and Revolutionary Russia: Culture and Politics

Prereq.: —
Year: U (1) HUM-D
3-0-9

Conceptual and analytical study of Russia's social, cultural, and political heritage of Eurasian imperialism and autocracy as of 1850. How reform and modernization provoked the national catastrophe of defeat in World War I, the 1917 Revolution, the Civil War of 1918-1921. Particular attention to the emergence of radicalism (Populism, Communism) as a political culture and to its role in the making of a new order, the USSR, in the Russian empire

and in world history. Study of larger cultural themes concerning revolutionary consciousness in the films, literature, or social thought of such people as Dobroliubov, Nekrasov, Saltykov, Blok, Eisenstein, Gorky, Mayakovsky, Sholokhov, and Babel *(Red Cavalry)*. ***(Not offered 1981-82.)***
R. E. MacMaster

21.377 The Soviet Union: A Communist Society in Historical Perspective

Prereq.: —
Year: U (2)
3-0-9

Comparative historical analysis of the relationships between totalitarianism and modernization in post-revolutionary Russia. Study in depth of the physical and ideological setting, the rise of Stalin, collectivization and industrialization, the terror and the purges, the process of de-Stalinization under Khrushchev and his successors, the transition from developing to industrial society, contemporary movements of dissent among intellectuals, religious groups, and nationalities. Attention to the problem of evaluating the changing Soviet Union in the light of recent developments there and in other Communist regimes, especially the Yugoslav and the Chinese.
R. E. MacMaster

21.378J Seminar in the Historical and Political Evolution of the Soviet Union

(Same subject as 17.601J)
Prereq.: Permission of Instructor
Year: U (2)
3-0-6

A reading subject on the history and politics of the Soviet Union, starting with the Russian Revolution and proceeding to the Brezhnev regime and recent political events. Emphasis on internal developments rather than foreign policy. Students expected to discuss the readings weekly. All required readings are in the English language, but supplementary readings in the Russian language are available for those students wishing them. (Open to advanced undergraduates with some previous work in the Soviet area. ***Not offered 1981-82.)***
L. R. Graham

21.379 Spanish Civil War, 1936-39

Prereq.: —
Year: U (1)
3-0-6

Examination of how traditional conflicts in Spanish society — between leftist and rightist political groups, civil and military authorities, intellectuals and clerics, workers and capitalists, peasants and landowners — erupted into civil war, almost immediately provoking a worldwide response. Examination of the consequences of the Civil War for Spain and the rest of Europe in light of political, social, and economic issues selected by students and the instructor. Special attention this year to literary responses to the war.
W. B. Watson

21.381 The Origins of World War II

Prereq.: —
Year: U (1)
3-0-6

How and why war broke out in September 1939. A detailed examination of the events of the period 1919-1939, first as they are depicted by A. J. P. Taylor in his "revisionist" study, *The Origins of the Second World War*, and then as they are presented in the works of other scholars and/or critics of Taylor. Taylor's theses are considered and evaluated in the light of these other works. ***(Not offered 1981-82.)***
D. B. Ralston

21.383 Revolution in the 20th Century

Prereq.: —
Year: U (1) HUM-D
3-0-6

Introduction to history through the analysis of 20th-century revolutions. Main focus on the Russian and Chinese Revolutions. Among aspects of revolution examined: weaknesses of the old order, the development of revolutionary ideologies, the roles of radical elites, the dynamics of revolutionary movements before and after gaining power. Study of various theories of revolution, including classical Marxism and its contemporary versions. Readings in both primary sources and works of interpretation.
D. B. Ralston

21.386 History and Psychoanalysis: Life-History

Prereq.: —
Year: U (1)
3-0-6

Application of psychology, especially psychoanalysis, to understanding of history. Emphasis on individual life-histories. First part: examination of psychological theories of Freud, Erikson, and others, and then of case studies, such as of Hitler and Gandhi. Second part: reports by members of the class on their own attempts at a life-historical study.
B. Mazlish

21.387 History and Psychoanalysis: Group History

Prereq.: —
Year: U (2)
3-0-6

Application of psychology, especially psychoanalysis, to understanding of history. Emphasis on group history. First part: examination of psychological theories of the group, Freudian and otherwise, and then of efforts at actual case studies, for example, in the area of crowd behavior, revolutionary movements, colonial situations, or racism. Second part: reports by members of the class on their own attempts to study an historical event or group. ***(Not offered 1981-82.)***
B. Mazlish

21.388 The American Psyche (New)

Prereq.: —
Year: U (2)
3-0-6

A study of 1) the American National Character, i.e., the question of identity—"What is an American?"—starting with an examination of the concept itself and then of efforts (e.g., by Tocqueville, Mead, Potter, Erikson) to describe and analyze such a presumed character; and 2) the application of psychological approaches to specific individuals (e.g., Jefferson, Lincoln), to persistent themes (e.g., the frontier hero, or cowboy), and to collective phenomena and events (e.g., slavery, the American Revolution). At the end, an attempt is made to combine the two approaches into one effort.
B. Mazlish

American History

American History subjects are divided into two categories: Basic Fields: 21.390-21.429 and Special Subjects and Seminars: 21.430-21.459.

Basic Fields

Introductory Series

21.390 American History to 1865

Prereq.: —
Year: U (1) HUM-D
3-0-6

A survey of American history from the colonial period through the Civil War that emphasizes the connection of social, economic, and political development. Topics include the character of the early European settlements in North America; social and economic change in the colonies; the Revolution; regionalism and industrialization; Jacksonian politics and reform; territorial expansion; slavery, sectionalism, and the crisis of the 1850s; the conduct and impact of the Civil War. (Primarily for freshmen and sophomores or for upperclass students with little previous preparation in history or social science.)
A. Brinkley

21.391 American History since 1865

Prereq.: —
Year: U (2) HUM-D
3-0-6

A survey of American history since Reconstruction that traces the growth and modernization of social, economic, and political institutions. Topics include Reconstruction and the "racial settlement" of the late 19th century; immigration; industrial and business development; agrarian unrest and the populist movement; progressivism; World War I and its aftermath; the New Deal; World War II and the Cold War; the growth of the modern Presidency and the expansion of the role of government; the Civil Rights Movement; the Vietnam years and beyond. (Primarily for freshmen and sophomores or for upperclass students with little previous preparation in history or social science.)
A. Brinkley, P. Maier

Chronological Series

21.400 Colonial America

Prereq.: —
Year: U (2)
3-0-6

A history of British North America from the Age of Discovery to about 1763, with particular emphasis on the development of American society and politics. Topics: European discovery of America; earliest European settlements in the Chesapeake and New England; Navigation Acts and definition of the Old British Empire; chronic insurrections and witchcraft mania of the late 17th century; immigration and the evolution of American black chattel slavery; the Great Awakening; economic and social development; evolution of American politics and of political ideology in the decades before the American Revolution. Readings draw upon recent scholarship, much of which is interdisciplinary in character, invoking the methods of social science, and include writings from the colonial period.
P. Maier

21.401 The American Revolution

Prereq.: —
Year: U (2)
3-0-6

The English and American backgrounds of the Revolution; issues and arguments in the Anglo-American conflict; the resistance movement and the beginnings of American Republicanism; the Revolutionary War; constitution writing in the states and for the nation; the effects of the American Revolution. Concerned primarily with the revolutionary origins of American government; readings emphasize documents from the period — pamphlets, correspondence, the minutes or resolutions of resistance organizations, constitutional documents and debates. ***(Not offered 1981-82.)***
P. Maier

21.402 The Establishment of the American Republic, 1790-1850

Prereq.: —
Year: U (1)
3-0-6

An examination of Americans' efforts to establish the republic and work out the meaning of the American Revolution in a period that saw the beginnings of industrialism and regional economic specialization, the emergence of the West, the development of parties and of democracy, and an intensifying conflict over the issue of slavery. Readings emphasize writings from the period. ***(Not offered 1981-82.)***
Staff

21.403 The Civil War and Reconstruction

Prereq.: —
Year: U (2)
3-0-6

Anti-slavery and the intensification of sectionalism in the 1850s; the secession crisis; political and military developments in the Civil War years; the "reconstruction" of Southern politics and society in the wake of Appomattox. ***(Not offered 1981-82.)***
Staff

21.404 America in the Progressive Era, 1877-1917

Prereq.: —
Year: U (2)
3-0-6

The American response to industrialization and modernization between Reconstruction and World War I. An examination of how economic growth and social change produced major dislocations and instability, and of how a series of reform movements attempted to adapt society to new realities. Topics: industrial development and the labor response, immigration and urban machine politics, farm problems and agrarian unrest, populism, progressivism, and the emergence of the US as a world power. Readings draw not only from historical studies but from contemporary fiction and reportage.
Staff

21.405 America in the Twenties and Thirties, 1917-1941

Prereq.: —
Year: U (1)
3-0-6

American politics, society, and culture during World War I, the 1920s, and the Great Depression. An examination of efforts at social and political consolidation, both before and during the Depression, and of the many cultural and intellectual controversies that enlivened the period. Topics: impact of the war on American society, failure of post-war internationalism, economy and culture of the twenties, impact of the Depression, and significance of the New Deal. Readings in both historical and literary materials, accompanied by contemporary films.
A. Brinkley

21.406 America Since World War II, 1941 to the Present

Prereq.: —
Year: U (2)
3-0-6

The transformation of American politics and society during and after World War II. An examination of the nation's efforts to adapt to a new world order and to new social and economic domestic pressures. Topics: the deepening American involvement in world affairs, expansion of the role of government, civil rights movement and mobilization of minorities and new interest groups, political and cultural crises of the 1960s and 1970s. Readings include historical studies, contemporary literature and journalism, accompanied by films.
A. Brinkley

Topical Series

21.410 American Intellectual and Cultural History: From the Puritans to the Civil War

Prereq.: —
Year: U (1) HUM-D
3-0-6

American thought and culture from the 17th century to the Civil War, as reflected in the work of its major writers, thinkers, artists. The Puritan foundations of American culture; Enlightenment ideas in the New World; transformations of American religious thought (especially during the "Great Awakenings" of the 18th and early 19th centuries); political theory of the American Revolution and of the new republic; ideas about nature, the environment, the Indian; American romanticism and Transcendentalism; responses to the rise of democracy; Utopianism and reform at the dawn of American industrialism; the flowering of American democratic culture in the time of Emerson and Whitman. Readings include Jonathan Edwards, Benjamin Franklin, John Adams, Jefferson, Madison, Hamilton, James Fenimore Cooper, Emerson, Whitman.
A. D. Kaledin

21.411 American Intellectual and Cultural History: Civil War to 1960s

Prereq.: —
Year: U (2) HUM-D
3-0-6

Continuities and changes in American thought and culture since the Civil War, studied mainly through the ideas of a number of major figures, among them William Graham Sumner, William James, John Dewey, Thorstein Veblen, W. E. B. DuBois, Paul Goodman, B. F. Skinner, E. B. Wilson, Erik Erikson, etc.; and through important contemporary historical and cultural studies. Topics include: the breakup of "Victorian" culture; pragmatism; "biological" social thought from Social Darwinism to Sociobiology; development of Freudian and behaviorist psychology; the rise of the social sciences; professionalization of intellectual life and its consequences; tendencies in liberal and conservative political thought; the development of black consciousness and the impact of black culture; ethnicity and the new cultural pluralism; the development of mass culture; country culture and rock; evangelicalism, fundamentalism and orientalism in religious life. Concludes with an effort to understand and compare the cultural "revolts" of the '20s and '60s.
A. D. Kaledin

21.412J American Urban History

(Same subject as 11.013J)
Prereq.: —
Year: U (1) HUM-D
3-0-6

A seminar on institutions and institutional change in urban America from roughly 1890 to the present. Among the institutions considered are political machines, police departments, schools, courts, hospitals, prisons, welfare departments, and universities. Focused around readings and discussions.
R. M. Fogelson

21.413J History of the Physical Environment of Urban America

(Same subject as 11.014J)
Prereq.: —
Year: U (2)
3-0-6

Readings and discussions about the history of selected features of the physical environment of urban America. Among the features considered are: parks, cemeteries, dumbbell tenements, suburbs, civic centers, superblocks, and shopping centers.
R. M. Fogelson

21.414 Afro-American History I

Prereq.: —
Year: U (1)
3-0-6

Introduction to the Afro-American heritage from Africa through the Civil War. Topics: European expansionism in the 15th century and the African slave trade; race, slavery and the development of American democracy; a comparison of slave systems in Brazil, the West Indies, and the Southern US; the status and condition of free blacks; abolitionism; early black emigration movements; slavery and sectionalism; and the black contribution to Northern victory and Southern defeat during the Civil War. Readings in both primary materials and secondary sources. ***(Not offered 1981-82.)***
Staff

21.415 Afro-American History II

Prereq.: —
Year: U (2)
3-0-6

Introduction to the Afro-American heritage since Reconstruction. Topics: comparison of emancipation in the West Indies and the US; the birth of "Jim Crow;" philanthropy and self-help; migration, urbanization, World War I, and the "Red Summer" of 1919; the Harlem Renaissance; Pan-Africanism; the New Deal and World War II; and the Civil Rights and Black Power movements. Readings in both primary materials and secondary sources. ***(Not offered 1981-82.)***
Staff

21.416 Women's History (New)

Prereq.: —
Year: U (2)
3-0-6

A survey of women's history in the US from the colonial era to the present. Topics include the socialization of women; the transformation of women's work; social and political organization; the changing content of women's rights; alterations in family life; sexual ideas and practices.
Staff

Special Subjects and Seminars

21.432 Religion and Culture in America

Prereq.: —
Year: U (1)
3-0-6

Aspects of religious life and thought in America from the Puritans to the present. Topics: American evangelism from Jonathan Edwards to Billy Graham; the Great Revivals of the 18th and 19th centuries; the development of religious pluralism and freedom in America; the relation of religion to politics; religious movements and reform; native American religions (e.g., Mormonism, Christian Science); the religious response to science and to the growth of an industrial-urban culture. Emphasis on the 19th and 20th centuries, and on contemporary religious developments (orientialism, 'positive thinking,' mysticism, cults) and their cultural significance.
A. D. Kaledin

21.433J Industrialization and Cultural Change in 19th Century America

(Same subject as STS 310J)
Prereq.: —
Year: U (2)
3-0-6

A comparative study of 11 communities assessing the social dislocations and adjustments of an industrializing economy. Work ethic, craft customs, kinship ties, business attitudes, political ideologies, social institutions, and the growing speed and scale of mechanized production are treated. Goal is to understand why some communities entered the industrial age more easily than others. Communities studied include Pawtucket, Rhode Island; Waltham-Lowell, Massachusetts; Chicopee-Springfield, Massachusetts; Harpers Ferry, Virginia; Philadelphia-Rockdale, Pennsylvania; Wilmington, Delaware; Patterson-Newark, New Jersey; Troy, New York; Lynn, Massachusetts; Oneida, New York; and Pullman, Illinois. Members of the class submit thematic essays addressing various aspects of industrialization and culture change. ***Not offered 1981-82.)***
M. R. Smith

21.439 Fortress America: the Rise of the American Military, 1945—1975

Prereq.: —
Year: U (2)
3-0-6

Critical examination of the development of a large permanent military establishment in the post-war period and the consequences of this development for both domestic and international policies. Detailed look at the changing character of defense budgets, ideological and political justifications for these changes, impact of defense spending on the budget and on the US economy, nature of opposing threats and US responses, changing role of military institutions in foreign policy. ***(Not offered 1981-82.)***
W. B. Watson

21.449 Seminar in American Studies

Prereq.: —
Year: U (1)
2-0-7

Reading and discussion of various classic interpretations of American life (e.g., de Tocqueville's *Democracy in America*, Frederick Jackson Turner's *The Frontier in American History*, Vernon Parrington's *Maincurrents in American Thought*, etc.) and of outstanding contemporary works that illustrate different approaches to the study of American society and culture (e.g., F. O. Matthiessen's *American Renaissance*, Henry Nash Smith's *Virgin Land*, Leo Marx's *The Machine in the Garden*, Edmund Wilson's *Patriotic Gore*, Richard Hofstadter's *Anti-Intellectualism in American Life*, Charles Feidelson's *Symbolism and American Literature*, Slotkin's *Regeneration Through Violence: The Mythology of the American Frontier*, Rogin's *Fathers and Children: Andrew Jackson and the Subjugation of the American Indian*, Kammen's *People of Paradox*, Stott's *Documentary Expression and Thirties America*, Sacvan Bercovitch's *The Puritan Origins of the American Self*. ***(Not offered 1981-82.)***
A. D. Kaledin, A. Lang, L. Marx, W. Williams

History of Africa, East Asia, Latin America, and the Middle East

History of Africa

21.450 The History of Africa

Prereq.: —
Year: U (1) HUM-D
3-0-9

The history of ancient, medieval, early modern, and pre-20th century Africa with close attention to the peopling of the continent, development of culture, development of kingdoms, slave trade, assault by Europe, partition into colonies, beginnings of colonial rule, and nature of the African response.
R. I. Rotberg

21.451J Nationalism and Nation Building in 20th Century Africa

(Same subject as 17.551J)
Prereq.: —
Year: U (2) HUM-D
3-0-9

The political development of modern black Africa concentrating on an examination of colonial rule, African resistance and rebellion, the ultimate struggle for independence, and post-independence politics and readjustments.
R. I. Rotberg

21.452 Comparative African Politics: Crises in Southern Africa

Prereq.: —
Year: U (2)
3-0-6

The political and historical problems of South Africa, Namibia, Zimbabwe, and the other countries of southern Africa. Particular attention paid to the development of *apartheid* in South Africa, to its administration and modification, and to its possible future abolition. Also closely examines liberation movements and the liberation struggle in southern Africa, its successes and failures. Role of American and European policy toward southern Africa looked at critically. The position of American corporations analyzed. Overall, the seminar deals with the reality of the quest for freedom and human dignity.
R. I. Rotberg

21.455J Third World: History, Politics, and Literature

(Same subject as 17.553J)
Prereq.: —
Year: U (1)
3-0-6

Study of history, society, and politics of the black third world through a selected examination of a dozen critical novels. Some of the authors read include Abrahams, Achebe, Armah, Cary, Lamming, Hutchinson, Mulaisho, Naipaul, Ngugi, Oyonyo, Beti, Sembene, Gordimer, Paton, and Jacobson.
R. I. Rotberg

21.456 Explorers and Exploration: Accomplishments, Motives, and Methods

Prereq.: —
Year: U (2)
3-0-6

History of modern exploration with emphasis on the men and women who pushed back the frontiers of geographical and anthropological knowledge in the 18th and 19th centuries. Focuses on the opening up of Africa and Asia, and discusses such complex personalities and investigators as Livingstone, Stanley, Burton, and other larger-than-life figures. ***(Not offered 1981-82.)***
R. I. Rotberg

21.457J Research Seminar in Imperialism and Colonialism (A)

(Same subject as 17.564J)
Prereq.: One graduate subject in comparative politics or international politics
Year: G (2)
3-0-6

Topics in the economic, social, and cultural bases of imperialism and colonialism, its theory and practice. Substantial written work expected. Instruction in the form of intensive tutorials. ***(Not offered 1981-82.)***
R. I. Rotberg

History of East Asia

21.460 East Asian History: China

(21.441)
Prereq.: —
Year: U (1) HUM-D
3-0-6

History of Chinese civilization from the formative period in the Shang dynasty up through the 19th century, focusing on the relation between long-term trends of social and economic change and key periods in the crystallization of fundamental systems of thought. Topics include: the origins of Chinese civilization; the Chou synthesis; Confucianism and Taoism; the early empire: Ch'in to T'ang; the effects of Buddhism; the Tang-Sung transition and transformation of culture, society, and economy; Chu Hsi's Neo-Confucian synthesis and Wang Anshih's reforms; the rise of popular literature; Ch'ing conquest and the late empire; 19th-century rebellion and decline.
P. C. Perdue

21.461 East Asian History: Japan

(21.442)
Prereq.: —
Year: U (2) HUM-D
3-0-6

History of Japanese civilization from its origins to the present, while concentrating on the period of rapid transformation from the late Tokugawa period through the end of the American occupation (1800-1954). The distinctiveness of Japanese society and the nature of foreign influences on it are questions that are addressed throughout.
P. C. Perdue

21.462 Social and Economic Transformation in China, 900-1850

(21.444)
Prereq.: —
Year: U (1)
3-0-6

The long-term processes of social and economic change in the critical period of transformation of Chinese society from the Sung to the Ch'ing dynasty. Stress is on the role of geography in delimiting regional variations, population growth and decline, the interaction of commercial activity with State economic policy, advances in technology and transformation of agriculture, landlords, tenants and social relations on the land, changes in social stratification, popular culture, and forms of collective action and rebellion. Concludes with an assessment of the significance of these centuries in the light of modern Chinese history.
P. C. Perdue

21.463 The Chinese Revolution: 1850-1976

(21.443)
Prereq.: —
Year: U (2)
3-0-6

The protracted process of revolutionary upheaval and social transformation in China from the Taiping Rebellion of the 1850s through the death of Mao, paying attention to the interaction of domestic and foreign influences. It includes comparison of revolutionary practice with theories of revolution, Marxist and non-Marxist.
P. C. Perdue

History of Latin America

21.470 Latin American History (New)

Prereq.: —
Year: U (1)
3-0-6

Survey of Latin America from the Conquest to the present. Analysis of Latin America as a "peripheral" area in the global economy; emphasis on relationships between economic, social, and political change, and on the emergence of the authoritarian state. Case studies include Cuba, Mexico, Argentina, Brazil. ***(Not offered 1981-82.)***
P. H. Smith

21.471 History of Mexico (New)

Prereq.: —
Year: U (2)
3-0-6

Mexico from the colonial period to the present. Emphasis on the Revolution of 1910, the formation of a dominant-party regime, the composition of elites, and relations with the US — including the effects of oil and emigration.
P. H. Smith

21.472J Politics of Mexican Development (New)

(Same subject as 17.582J)
Prereq.: —
Year: G (2)
3-0-9

Development of Mexican political system and relationships between the State and commercial-industrial elites, organized labor, peasants, and the military. Special attention to effects of international environment on Mexican politics and economic development. Evaluation of

Mexican "model" of development and its implications for other Third World Nations. (Open to undergraduates with permission of instructor.)
P. H. Smith

21.475J Race Relations, Politics and Development in the Caribbean (A)

(21.453J)
(Same subject as 17.578J)
Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Comparative study of the role of color and race in the politics of the Caribbean. Attention to problems of modernization, leadership, and economic development in French, Dutch, and English speaking areas. ***(Not offered 1981-82.)***
R. I. Rotberg

History of the Middle East

21.480 The History of the Middle East Before 1945 (New)

Prereq.: —
Year: U (1)
3-0-6

From the Crusades to the breakup of the Ottoman Empire, with special attention to the reforms of Muhammad' Ali, Egypt, the rise of fundamentalism in Arabia, British and French rivalry, and the development of Persia, and the Maghreb. The second half covers the mandatory period and the rise of self-assertion, from T. E. Lawrence to Ibn Saud, with a section on the reforms of Kemal Ataturk, and another on the discovery of oil.
Staff

21.481 The History of the Modern Middle East Since 1945 (New)

Prereq.: —
Year: U (2)
3-0-6

From the demise of King Farouk and the Suez debacle to the fall of the Shah of Iran. Special attention paid to the modernization efforts of President Nasser, the Israeli-Arab wars, the influence of Marxism, the rise and fall of Pahlevi Persia, the Trucial States, and the impact of oil-based revenues.
Staff

21.490 Special Topics in History

(21.460)
Prereq.: —
Year: U (1)
Arr.

21.491 Special Topics in History

(21.461)
Prereq.: —
Year: U (2)
Arr.

Topics in history not included in other subjects. Students electing this subject must secure the approval of the History Section chairman and the Department of Humanities. (Humanities credit for Special Topics subjects awarded only by individual petitions to the Committee on Curricula. Normal maximum is six units; to count towards Humanities Requirement, nine units are required. Exceptional nine unit projects occasionally approved.)
Staff

Anthropology/Archaeology

21.50 An Introduction to Anthropology

Prereq.: —
Year: U (1) HUM-D
4-0-8

Study of a number of societies through the perspectives of cultural anthropology and archaeology. Cultures chosen to expose students to a variety of levels of sociocultural integration, including hunter-gatherers, tribal peoples, and complex societies. The comparative method encourages awareness of the role of culture in human society while the emphasis on case studies provides richness in depth. One case study, usually of a complex society such as the Maya, Inca, or a Mesopotamian society, is drawn from archaeological data. Consideration of anthropological and archaeological theory; discussion of field methods; evaluation of the social and political contexts and implications of anthropological research.
M. Diskin, W. E. Wetterstrom

21.501 Crossing Cultural Boundaries

Prereq.: —
Year: U (1) HUM-D
3-0-9

An approach to experiencing and understanding cultures. By examining anthropological research techniques, reading personal accounts of the experience of fieldwork, and carrying out research projects, students consider the general problem of gaining systematic knowledge about other people, as well as learning about the specifics of anthropological research. Topics: the personal experience of living in other societies; culture shock; ethical dilemmas of research; research design; bias and objectivity; the effects of the researcher's own values and of his or her historical milieu. Equips students to critically assess claims about human behavior and other cultures made on the basis of social science research.
J. E. Jackson

21.502 Controversies and Core Ideas in Anthropology

Prereq.: —
Year: U (2) HUM-D
3-0-6

Key problems and concepts in social science, especially those relevant to sociology, psychology, and other disciplines, but with an emphasis on anthropological contributions. Culture, evolution, exchange, values, roles, function, history and social change, human nature, model building, theory testing, structur-

alism. Emphasis on the origin and subsequent development and elaboration of basic ideas, and on the social and historical contexts of these ideas.
J. Howe

21.503 Paths to Civilization

Prereq.: —
Year: U (2) HUM-D
3-0-6

Examination of archaeological method and techniques including site selection and survey, digging and sampling, laboratory analysis of data (floral and faunal as well as lithic, ceramic, and metal) and dating techniques (seriation, dendrochronology, C^{14}, etc.) as introductory to a closer look at some of the different approaches to archaeology that have broadened our understanding of past cultures. These approaches exemplified by case studies chosen from among the following areas: Near East, Mediterranean, China, Europe, American Southwest, Mesoamerica, Peru, and historical United States. Emphasis on the different theoretical perspectives (including ecological, economic, and historical) and how they are translated into fieldwork. Finally, a consideration of fieldwork design and implementation: how to mount an archaeological excavation.
A. Steinberg, W. E. Wetterstrom

21.504 Approaches to Archaeology (New)

Prereq.: —
Year: U (1)
2-4-6

During the 5-10 million years that humans and their protohuman ancestors have lived on the earth they have littered it with traces of their buildings, tools, industries, and especially their garbage. This course looks at the tools and analytical techniques that archaeologists use to "tease" the past out of these remains. Lectures and discussions scrutinize the methods of archaeology and their theoretical underpinnings. Weekly lab sessions are devoted to analyzing artifacts and data and testing the tools of archaeology. Topics include: surveying and locating sites, excavation strategies, dating techniques, analyzing ceramic and lithic artifacts, studying organic remains, statistics, uses of inference, and experimental archaeology.
W. E. Wetterstrom

21.505 Anthropology and Technology (New)

Prereq.: —
Year: U (2) HUM-D
3-0-6

Technology as cultural subsystem and shaper of human culture. Case studies of 1) small-scale non-industrialized technology, 2) an ancient complex technology (the Inca State), 3) culture change and industrialization in the Green Revolution, and 4) high technology and a new work force in the electronics industry. Emphasis on the interactions among the technical, social, and ideological dimensions of technology.
M. Diskin, H. N. Lechtman

21.506J Seminar in Technology and Development (New)

(Same subject as 17.330J)
Prereq.: —
Year: G (2)
3-0-9

Explores issues in the development process and the technological transformation of less-industrial societies. Lectures and case studies are geared to graduate students interested in the experience and social contexts of engineering for development. Taught by an interdisciplinary faculty drawn from anthropology, engineering, political science, and economics.
Staff, N. Choucri

21.510 Anthropology and Speculative Fiction

Prereq.: —
Year: U (2)
3-0-6

Examines the basic issues addressed by anthropology through the literary genres of science fiction, utopian fiction, political satire. Topics: basic human nature; society and environment; requirements for a successful society; inequality and stratification; varieties in gender and sex roles; religion; social change (culture contact, evolution, adaptation); post-industrial society and the future. Authors include Swift, Voltaire, Wells, Orwell, Burgess, Golding, Herbert, LeGuin. ***(Not offered 1981-82.)***
J. E. Jackson

21.511 Magic, Shamanism and Witchcraft: The Dynamics of Belief and Practice

Prereq.: 21.50, 21.501 or 21.502
Year: U (2)
3-0-9

A look into several interrelated aspects of the anthropology of religion, especially those often considered "irrational" or typical of "primitive mentality": witchcraft and sorcery, magic and divination, magical curing, shamanism and hallucinogens, messianic movements, and the origins of new religions. Material drawn from non-western societies, the European past, and contemporary industrial society. ***(Not offered 1981-82.)***
J. Howe

21.512 Myth, Ritual, and Symbolism

Prereq.: —
Year: U (2)
3-0-6

Introduction to the forms and uses of symbolism in traditional and modern society. Attention focused on what symbols do in politics and social life, as well as on the structure of symbol systems. Practice in direct analysis of myths and rituals. Theories of symbolism, their relevance to practical concerns and to the central issues of social science.
J. Howe

21.513 Religious Movements and Social Change

Prereq.: —
Year: U (1) HUM-D
3-0-6

Examination of new religions and religious movements, the conditions that inspire them, and their effect on society. Messianism, apocalypse, revelation, cults, schismatic and unorthodox sects, nativism, revitalization, revivalism, peaceful and military movements. Examples from the US (revivalism, communal sects, cults), from Europe (medieval heresies and messianism), and from traditional and third world societies (the Iroquois Handsome Lake Religion, the Ghost Dance, Cargo Cults, military messiahs).
J. Howe

21.520 Mexican Society and Development (New)

Prereq.: —
Year: U (1)
3-0-6

Post-Conquest Mexico in its effort to modernize against the background of ancient civilization and present multi-cultural structure. Major historic transitions (Independence, Reform, Revolution) studied for impact on pluralistic society. Human diversity viewed both as a resource and a factor constraining development. Recent economic and political situations (petroleum revenues, Mexican Food System) also considered.
M. Diskin

21.540 Technologies in Ancient Societies

Prereq.: —
Year: U (1)
3-0-6

Case studies of how various technologies (mainly metallurgical, ceramic and building) functioned and interacted with other cultural features in ancient societies of the Mediterranean and Near and Far East. There is some focus on how ancient technologies can be studied in the field and laboratory, and a possibility of some laboratory work. ***(Not offered 1981-82.)***
A. Steinberg

21.542 Culture and the Visual Arts

Prereq.: —
Year: U (1) HUM-D
3-0-6

An anthropological perspective on the visual arts focusing on the arts as cultural media and as nonverbal means of social communication and continuity. Material presented in case study format, including visual arts of small-scale, non-Western societies, imperial arts of the Inca and Roman states, and contemporary art of the US.
H. N. Lechtman

21.544 Materials in Ancient Societies: Lithics

Prereq.: Permission of Instructor
Year: G (1, 2)
3-6-3

Seminar-laboratory subject offered by the faculty of the Center for Materials Research in Archaeology and Ethnology, an inter-institutional organization including Boston University, Brandeis, Harvard, University of Massachusetts, MIT, Tufts, and Wellesley. Primarily for archaeologists and art historians, explores the role of materials and technologies in the development of ancient societies. A major focus of both seminar and laboratory is the way in which scientific analysis of archaeological artifacts and monuments contributes to our understanding of the cultures that produced them. Examination of the kinds of information obtainable from lithic materials and techniques for obtaining such data: identification of the major types of stone, thin-section analysis and trace-element analysis. Study of production of stone artifacts including rock properties, fracture mechanics, manufacturing sequences, and techniques best suited for working different types of stone into tools, ornaments, luxury goods, or construction elements. Analysis of use-wear patterns on stone tools and weathering phenomena. All students undertake analytical projects on archaeological collections. (Senior undergraduates with sufficient preparation in anthropology/archaeology may enroll after consultation with the instructor.)
H. N. Lechtman

21.550 The Ancient Andean World

Prereq.: 21.50 or 21.503
Year: U (2)
3-0-6

A careful examination of the development of Andean civilization which culminated in the extraordinary empire established by the Inca in western South America in the 15th and 16th centuries. Approaches of archaeology, ethnography, and ethnohistory all called upon. Particular attention paid to the unusual topography of the Andean area, its influence upon local ecology, and the characteristic social, political, and technological responses of Andean peoples to life in a topographically "vertical" world. No attempt made to survey the entire range of prehistoric cultural adaptations from preceramic settlements to complex societies. Focus is on characteristic cultural styles of prehistoric Andean coastal and highland life, important early periods of pan-Andean unification, and unique Inca accomplishment of organizing and sustaining a vast and complex empire, the majority of whose peoples lived at altitudes of 12,000 feet and more. Field trips to local museums arranged to examine artifacts excavated from Andean sites that are pertinent to themes developed in the class. ***(Not offered 1981-82.)***
H. N. Lechtman

21.552 Origins of Civilization — The Aztecs, the Mayas, and their Ancestors

Prereq.: —
Year: U (1)
3-0-6

Ancient societies in Mexico and Central America from the earliest inhabitants of the New World to the Aztec, and Maya civilizations. Surveys what archaeologists have learned about these ancient people. Focus is on trying to understand and explain some of the major changes in human life in the New World. Why did the early inhabitants shift from a pattern of gathering wild foods to raising crops? How did they create corn from wild grasses? How did the technology of pottery develop? Why did the early small-scale, simple societies evolve into large, complex stratified ones? How did the civilizations of the Olmec, the Zapotec, and Maya develop? (Need not be taken in sequence with 21.553. Alternate years. ***Not offered 1981-82.***)
W. E. Wetterstrom

21.553 Origins of Civilization — Middle East

Prereq.: —
Year: U (2)
3-0-6

Focus on the rise of cities and empires in various areas of the Middle East including Anatolia, the Levant, Mesopotamia and Iran. Using archaeological and written sources we examine why such complex societies arose in this area and what ecological exigencies led to their growth. Consideration of the role of temples and religious hierarchies, of crafts and trade in luxury goods, of writing and bureaucracies, of class stratification, in the rise of early empires. (Need not be taken in sequence with 21.552. ***Not offered 1981-82.***)
Staff

21.554 The Origins of Civilization — Egypt

Prereq.: —
Year: U (2)
3-0-6

Egypt was the home of one of the first and most spectacular civilizations in the world. Focuses on how that civilization developed. Traces Egypt's past from its first inhabitants through the reign of the Pharaohs with special emphasis on 1) how complex political systems evolved from the simple villages of predynastic days; and 2) how agriculture developed in the Nile Valley and how it contributed to the growth of civilization. Also considers the development of religion, art, and writing systems.
W. E. Wetterstrom

21.555 The Origins of Civilization — China

Prereq.: —
Year: U (1)
3-0-6

The emergence of one of the world's longest lived "great societies" viewed through both the archaeological and documentary evidence. Stress on role of geographical, climatic, and cultural factors in the foundation of farming villages and their growth into the first cities with a ruling dynasty. Discussion of: place of various technologies in the perpetuation of a ruling elite; forms of urbanization; feudalization and subsequent imperial unification of China; evolution of the social order, the role of the scholar-officials and Confucianism; the influence of "barbarians" on the shape of empire. Action and reaction in laying the foundations of the imperial system which lasted for over 2,000 years. Visits to local museums, oral reports included in class work. (Need not be taken in sequence with 21.552 or 21.553. ***Not offered 1981-82.***)
A. Steinberg

21.556 Archaeology of the Greek and Roman World (New)

Prereq.: —
Year: U (1)
3-0-6

Discussion of some of the major archaeological sites of Greece and the Roman world with emphasis on what they show about their respective societies, and how they fit into the historical context. Examples from third millennium BC through third century AD. Archaeological methodology discussed including how sites are chosen and excavated, as well as how materials are analyzed. Visits to local museums.
A. Steinberg

21.559 The Decline of Empires

Prereq.: —
Year: U (2)
3-0-6

After examination of basic institutions and processes of empires from modern sociological literature and recent examples, we derive some generalities about how and why empires disintegrate. Consideration of frontiers, military power, bureaucracy, ruling elites, religions, population growth, raw materials and markets, and urbanization is central to the analysis. Generalities tested against examples chosen from ancient and medieval times including Persia, Greece, Rome, Byzantium, and China.
A. Steinberg

21.581 The Family in Contemporary Society

Prereq.: —
Year: U (2) HUM-D
3-0-6

The family from an anthropological perspective; emphasis on present-day society with some consideration of historical and cross-cultural data on family structure. Topics: origins; sex and marriage; childhood; psychodynamics; influence of class and ethnicity; work; the family in the larger society; the future. Considers the family as a factor in human evolution, as personal history, as institution, and as cultural and political symbol.
J. E. Jackson

21.583J Language and Culture

(Same subject as 24.903J)
Prereq.: —
Year: U (2)
3-0-6

An introduction to the study of those aspects of language which have been of special interest to anthropologists and sociologists. A survey of the concerns of anthropological linguistics with particular emphasis on their implications for the study of language itself. An examination of a particular language in relation to various aspects of its cultural and social setting and to the intellectual life of its speakers.
J. E. Jackson, K. L. Hale, J. R. Ross

21.584 Agrarian Society

Prereq.: —
Year: U (2) HUM-D
3-0-6

Rural society and culture in three historical epochs; the ancient world, medieval feudal society, and the modern period. Ancient (Mesopotamia, Mexico, China, Greece) and feudal cases contribute to the focus on contemporary rural people. Of central concern is the relationship between rural and urban society with state control of labor, political rights, religion, and land. Agrarian community structure, nature of the family, religious ideology and value systems. Role of agrarian society in social change from millenarian uprisings to peasant revolution.
M. Diskin

21.585 American Communes and Utopias

Prereq.: —
Year: U (2)
3-0-6

An examination of the communal movement in the US during the 19th and 20th centuries with selected case studies of Shaker, Oneida, Amish, Hutterian, Mormon, and several modern planned communities, rural and urban, religious and secular. Issues covered include: nature and degree of economic sharing; philosophical underpinnings; architecture; sexual, marital, and family arrangements; private and communal spheres; government and decision making; religion; and relations with the larger society. Several speakers discuss actual communal experiments they have either studied or in which they have participated. ***(Not offered 1981-82.)***
J. E. Jackson

21.586 Sex Roles: A Comparative Perspective

Prereq.: —
Year: U (1)
3-0-9

An examination of sex roles and sex identity in our own and other societies. Both universals and variability relating to socially and biologically given sex and gender roles examined, as well as various theorists who have addressed these issues in the past (e.g., Marx, Engels, and Freud) and in the present. Topics: child rearing in cross-cultural perspective, the sexual division of labor, sexual power, and authority, family psychodynamics, and sexual symbols in ritual. Approximately five invited outside speakers discuss various approaches to the study of sex and gender (e.g., primate studies, psychiatry, hormone research, psychohistory, sociological research).
J. E. Jackson

21.589 The Anthropology of Industrial Society (New)

Prereq.: —
Year: U (2)
3-0-6

A broad overview of anthropological studies of social and technological change in the US and other industrial societies. Topics include the effects of industrialization on small towns and rural communities, the modernization of agriculture, and the rise of the modern corporation, the defense and service industries. Also

considers the wider cultural significance of public-interest science, environmental movements, and the effects of recent energy developments on social and cultural life.
Staff

21.592J Food, People and Cultures

(Same subject as 20.029J)
Prereq.: —
Year: U (1)
3-0-6

Food and nutrition within the cultural context. First part considers: How different societies define food, meals, and adequate nutrition. Cultural solutions to the food quest in different environments. Ways in which kinship, politics, and ritual structure the food quest and influence how food is distributed among the members of a community. Role of food as a source of nutrition, a symbol, a political tool, an index of wealth. Illustrated through case studies of foraging peoples, horticulturalists, and pastoralists. Second part examines food symbolism, food technology, and human adaptation to the diet. Last segment surveys how food and diet have changed over the last 10,000 years and concludes with an anthropological view of current food problems. (Alternate years. ***Not offered 1981-82.***)
W. E. Wetterstrom, M. Diskin

21.593 Marxist Approaches in Anthropology

Prereq.: —
Year: U (2)
3-0-6

Basic introduction to Marxist concepts and their relevance to the founding and development of professional anthropology. Historical materialism and theories of social and biological evolution. The contemporary resurgence of Marxist analyses both in ethnology and archaeology. French Marxist structuralism in theory and ethnography. Political and economic context for the growth of special studies of women, peasants, and development within contemporary anthropology. ***(Not offered 1981-82.)***
M. Diskin

21.598 Special Topics in Anthropology/Archaeology

Prereq.: Any two subjects in Anthropology or Archaeology
Year: U (1)
Arr.

21.599 Special Topics in Anthropology/Archaeology

Prereq.: Any two subjects in Anthropology or Archaeology
Year: U (2)
Arr.

Topics in anthropology or archaeology not included in other subjects. Students electing this subject must secure the approval of the chairperson of the Anthropology/Archaeology Program and the Department of Humanities. (Humanities credit for Special Topics subjects awarded only by individual petitions to the Committee on Curricula. Normal maximum is six units; to count towards Humanities Requirement, nine units are required. Exceptional nine unit projects occasionally approved.)
Staff

Music

The music subjects as described below are structured into the areas of Introductory Surveys and Fundamental Skills, followed by higher-level literature and theory subjects, performance, and advanced subjects.

Although most students start with 21.60, those who have vocal or instrumental training or extensive exposure to music are urged to take the 21.60 and elementary skills *Equivalency Exams* to determine whether they belong at a higher starting level. Exams will be scheduled at the beginning of each semester. Curriculum also encourages performers to elect literature subjects (21.630s) to gain deeper familiarity with the repertoire.

Introduction to Masters and Masterworks

21.60 Introduction to Music

Prereq.: —
Year: U (1, 2) HUM-D
3-0-6

Aims to develop analytical hearing and the ability to discern different historical styles and forms. Written fundamentals taught, but the emphasis on aural perception of the musical experience. The historical development of the chief styles of western art music examined through selected works by major composers. Guide to individual instructors' methods available from Music Section office, 14N-434.
Staff

21.601 Vivaldi, Bach, and Handel

Prereq.: 21.60 or equivalent
Year: U (1) HUM-D
3-0-6

Representative works of three great composers who wrote at the culmination of the Baroque era in music are examined and related both to compositions by their precursors and to societal and intellectual developments of the time in Italy, Germany, and England.
L. E. Lindgren

21.602 Haydn, Mozart, and Beethoven

Prereq.: 21.60 or equivalent
Year: U (2) HUM-D
3-0-6

A study of the musical life during the second half of the 18th and early 19th centuries through representative works of these composers. Emphasis on harmonic, melodic, and structural development in relationship to intellectual, artistic, and social patterns of the period. Required reading and listening assignments.
J. L. Buttrick

21.603 Music from Schubert to Mahler

Prereq.: 21.60 or equivalent
Year: U (1) HUM-D
3-0-6

A survey of the principal developments in musical style during the 19th century. Works for consideration in weekly class discussions drawn from the music of Beethoven, Schubert, Schumann, Brahms, Berlioz, Chopin, Liszt, Wagner, Verdi, Richard Strauss, and Mahler. Required reading and listening assignments.
J. L. Buttrick

21.605 The Symphony

Prereq.: 21.60 or equivalent
Year: U (2) HUM-D
3-0-6

The evolution of symphonic forms from the Baroque to the 20th century. Special attention focused on the works of Haydn, Mozart, and Beethoven. Recordings and opportunities to hear live performances augmented by class discussion. ***(Not offered 1981-82.)***
S. Erdely

21.607 American Music

Prereq.: 21.60 or equivalent
Year: U (1)
3-0-6

First half focuses on the role of music in North American society (especially the Boston area) during the 18th and 19th centuries. Second half surveys the music of 20th-century North America, including "classical," Broadway show, film, and popular music, but excluding jazz. (Alternate years. ***Offered 1981-82.***)
L. E. Lindgren

21.608 Jazz

Prereq.: 21.60 or equivalent
Year: U (1)
3-0-6

Historical survey beginning with early jazz, Joplin, Morton, Armstrong, Smith; continuing with a study of the Ellington, Basie, Goodman, and Herman bands; and concluding with a number of individual performers — Parker, Rollins, Monk, Holliday, Gillespie, Mingus, Davis — and some recent developments in writing and playing. Examination of jazz source music: early blues, spirituals, show tunes. Some investigation of jazz-derived musics: post World War II pop and rock. (Alternate years. ***Not offered 1981-82.)***
Staff

Fundamental Skills and Concepts

21.611 Elements of Music

Prereq.: —
Year: U (1, 2)
3-3-3

Study of fundamental concepts and basic vocabulary of rhythm, melody, and harmony with particular emphasis on sight-singing and dictation. In support of this, a minimum of three laboratory hours in aural skills included; students who need additional training in keyboard, sight-singing, and aural skills are required to register for additional laboratory hours of 21.612.
Staff

21.612 Laboratories in Keyboard, Sight-Singing, and Aural Skills

Prereq.: —
Year: U (1, 2)
Arr.

Explicitly elected by students requiring supplementary training beyond the standard three lab hours incorporated in 21.611 and in 21.641. All such labs, basic and supplementary, consist of intensive work in the three areas of sight-singing, aural skills, and keyboard, the exact amount and distribution depending on individual need. (Does not count as a subject for music concentration but is open to any student who needs this additional background to achieve a basic proficiency.)
Staff

21.615 Introduction to Musical Acoustics

Prereq.: —
Year: U (1, 2)
3-0-6

A qualitative and introductory treatment of psychological and physical aspects of musical perception and music production. Elements of psychophysical literature on perception of loudness, pitch, timbre, and rhythm are covered. Physical principles of chordophones, aerophones, and idiophones studied and used to compare examples of musical instruments found in various cultures and time periods. Acoustical properties of rooms and concert halls, and criteria for their proper functioning discussed. Some electronic applications to music, such as sound recording and reproduction, electronic sound generation, and analog and digital sound synthesis surveyed.
A. J. M. Houtsma

21.616J Developing Musical Perception: Cognitive and Educational Implications (New)

(Same subject as SRE 244J)
Prereq.: —
Year: U (2)
3-3-6

Investigates fundamental musical structures and helps students develop their abilities to hear what gives music its coherence. Beginning with close analyses of relatively short musical compositions in various styles, students use these as models for their own experiments with pitch-time relations through the use of the LOGO computer music system. Consideration given to the underlying cognitive structures which inform and shape musical perception as well as the role of "language of description" in this process. Broader implications of this approach for education in other domains considered. Students expected to keep a continuing log of their progress, to write several short reports derived from these logs, as well as one final paper to include the analysis of a short composition and the results of an experimental project motivated by this analysis. (Limited to 10.)
J. S. Bamberger

History and Literature

21.621 History of Music to 1600

Prereq.: 21.611 or equivalent
Year: U (1) HUM-D
3-0-6

Survey of European art music from its foundation in antiquity through the Christian Middle Ages and the Italian Renaissance to the emergence of Baroque style. Music considered: 1) as a body of literature; 2) as a liberal art; 3) as history. Objectives of subject parallel those divisions: 1) developing musical literacy and the skills of style criticism; study of individual works through class discussion and listening; 2) understanding the place of music as an area of intellectual and creative activity within the tradition of the liberal arts; 3) becoming aware of the interaction between music and history — as events and as fields of study. Written assignments offer the opportunity to write about the music itself and about topics in the history of musical styles.
T. C. Aarset

21.622 History of Music, 1600-1900

Prereq.: 21.611 or equivalent
Year: U (2) HUM-D
3-0-6

A chronological survey of European art music during the Baroque, Classic, and Romantic periods. Compositions analyzed in detail, and placed within their historical context.
T. C. Aarset

21.623 Twentieth-Century Music

Prereq.: 21.611 or equivalent
Year: U (2)
3-0-6

A survey of major works of the 20th century, beginning with Schoenberg, Stravinsky, Bartok, and Ives, continuing with Varese, Webern, Hindemith, Copland, Sessions, Britten, Prokofiev, and Dallapiccola, and closing with some recent music.
J. H. Harbison

21.624 Musical Traditions in America

Prereq.: 21.611 or equivalent
Year: U (1) HUM-D
3-0-6

A study of the four branches of American musical tradition: the Amero-Indian, the Anglo-Spanish-French American, the Black American, and the diverse ethnic traditions. Emphasis is placed on the historical and broad cultural significance of this repertory. (Alternate years. ***Offered 1981-82.***)
S. Erdely

21.632 Chamber Music Literature

Prereq.: 21.611, any music HUM-D; or any subject from 21.651-21.657
Year: U (2)
3-0-6

Analysis of scores and readings in musical literature, both critical and theoretical, supplemented by live and recorded demonstrations. Composer and topic vary from year to year. Topic for 1982: String quartets of F. J. Haydn.
M. A. Thompson

21.633 Dramatic Music: Opera, Oratorio, and the Musical

Prereq.: 21.611, any music HUM-D; or any subject from 21.651-21.657
Year: U (2)
3-0-6

A chronological survey of musical drama, beginning with the medieval *Play of Daniel,* and ending with the Broadway musical *Sweeney Todd.* Focuses on operatic masterpieces, but several oratorios and Broadway musicals are also included. (Alternate years. ***Not offered 1981-82.)***
L. E. Lindgren

21.635 Period Studies

Prereq.: 21.611, any music HUM-D; or any subject from 21.651-21.657
Year: U (2)
3-0-6

Topic varies from year to year and covers a particular era of music history. (Alternate years. ***Not offered 1981-82.)***
L. E. Lindgren

21.637 Composer Studies

Prereq.: 21.611, any music HUM-D; or any subject from 21.651-21.657
Year: U (1)
3-0-6

Study of the life, compositions, times, prevailing cultural and artistic trends, and style periods surrounding the creative output of a major composer of a selected era. (Alternate years. ***Not offered 1981-82.***)
Staff

21.638 Beethoven

Prereq.: 21.611, any music HUM-D; or any subject from 21.651-21.657
Year: U (1)
3-0-6

Study of the stylistic, structural, and poetic issues of Beethoven's music with emphasis on a particular genre. Topic for 1981-82: The Piano Sonatas. (Alternate years. ***Offered 1981-82.***)
J. L. Buttrick

The Art of Writing

21.641 Harmony and Counterpoint I

Prereq.: 21.611 or equivalent
Year: U (1, 2)
3-3-6

Origins of counterpoint and harmony in the Western musical tradition. Begins with single line plainchant and progresses to two-part contrapuntal writing as evidenced in the motets of Lassus. The emergence of tonal awareness and harmonic function as seen in 17th and 18th century practice. Class activity includes written exercises and an additional segment of ear-training, and preparing for performance in class of materials presented for analysis. (Permission of instructor required.)
Staff

21.642 Harmony and Counterpoint II

Prereq.: 21.641
Year: U (1, 2)
3-0-6

Harmonic counterpoint, particularly as evidenced in the 2-part inventions of J. S. Bach. Further examination of harmonic practice, four-part realization of figured bass, and the full emergence of the common practice harmony of the classical period. Written exercises are based on models presented in class for analysis.
Staff

21.643 Chromatic Writing

Prereq.: 21.642
Year: U (1, 2)
3-0-6

Written and analytic exercises based on 19th-century small forms and harmonic practice found in music such as Schubert Landler and songs, Schumann small piano pieces and songs, and Chopin Preludes and Mazurkas.
Staff

21.645 Practical Harmony

Prereq.: 21.611 or equivalent
Year: U (2)
3-0-6

Basic harmony for students interested in acquiring practical skill in nonclassical music; also includes required listening, mainly jazz, as background for the written work. Serves as preparation for more advanced work in jazz and rock arranging and in the composition of popular songs. (Survey subject in jazz such as 21.608, is a recommended prerequisite.)
Staff

21.647 Techniques of Computer Music Synthesis

Prereq.: 21.611, 21.615 or 6.312 or 6.501 or 4.43 or 8.03
Year: U (1)
3-3-3

A practical introduction to the phenomenon of electronic music via the concepts and terminology of digital audio processing. Traces the development of digital audio techniques and their representation in music-oriented languages, with special emphasis on those aspects which have recently proved most advantageous to composers. An examination of the electronic literature that has emerged from the early centers at Cologne, Milan, and Columbia-Princeton, and of the more recent literature resulting from developments at Stanford and IRCAM, Paris. Practical application of such digital techniques as additive and subtractive synthesis, nonlinear synthesis, and linear predictive analysis/ synthesis of musical audio using the MUSIC-11 language and the facilities of the MIT Computer Music Studio. Assignments and synthesis projects.
B. L. Vercoe

21.648 Writing for Computer Performance

Prereq.: 21.643, 21.647
Year: G (2)
3-6-3

For those whose writing of music has reached a point where they can exploit digital audio as a new performance medium. Continued study of audio processing techniques, but with the goal of realizing at least one original composition during the term. Examination of representative works from 20th century music literature, with particular attention given to contemporary vocabulary and the stylistic relation between instrumental and electronic writing. Considerations of integrating these media, such as found in the works for tape and instruments by Davidovsky. Consideration also of the additional options afforded by control-level processing and by the procedural description of musical scores. Directed composition of computer-synthesized works with an eye to possible public performance.
B. L. Vercoe

The Art of Performance

21.651 Early Music Repertoire and Performance

Prereq.: Permission of Instructor
Year: U (1, 2)
0-3-3

Study and performance of Medieval, Renaissance, and Baroque music in the concert repertory of the Early Music Society. Scholars as well as performers are encouraged to participate in an integrated approach to early music. (May be elected twice for credit. May *not* be counted toward Humanities Requirement.)
T. C. Aarset

21.653 Vocal Music Repertoire and Performance

Prereq.: Permission of Instructor
Year: U (1, 2)
2-2-2

The study, rehearsal, and performance of the forms of vocal music, including opera, choral music, vocal chamber music, and song. During each term emphasis is on a specific style period. Participation with the MIT Choral Society in the performance of works related to the subject matter required. Individual performance projects encouraged. Topics for 1981-82: Term 1: German 19th-Century Vocal Music; Term 2: French Vocal: Late 19th and Early 20th Century. (May be elected twice for credit. May *not* be counted toward Humanities Requirement.)
J. S. Oliver

21.655 Chamber Music Study and Performance

Prereq.: Permission of Instructor
Year: U (1, 2)
0-3-3

Study of chamber music literature through analysis, rehearsal, and performance. Weekly seminars and coaching. Open to string, piano, brass, and woodwind players through audition. (May be elected twice for credit. May *not* be counted toward Humanities Requirement.)
M. A. Thompson, J. L. Buttrick

21.657 MIT Symphony: Study and Performance

Prereq.: Permission of Instructor
Year: U (1, 2)
0-3-3

An option available to members of the MIT Symphony Orchestra, in which particular rehearsals are committed to the analysis of works in rehearsal and preparation for performance by the orchestra. Readings of scores of particular structural or stylistic interest. (May be elected twice for credit. May *not* be counted toward Humanities Requirement.)
D. M. Epstein

Advanced Subjects

21.660 Senior Tutorial in Music

Prereq.: Permission of Instructor
Year: U (1, 2)
2-0-7

For senior music majors preparing for thesis or general exam. Serves to diagnose any deficiencies in music history, writing, or general musicianship and to provide tutorial guidance according to individual need. Should be elected both terms.
L. E. Lindgren, Staff

21.662 Research Methods of Oral Music

Prereq.: 21.624
Year: G (2)
3-0-6

Examination of the methods for documentation and analysis of orally transmitted music, beginning with the preparations for fieldwork and methods of recording, and continuing through transcription, classification, and analysis of the material for its historical and humanistic significance. (Alternate years. ***Not offered 1981-82.***)
S. Erdely

21.665 Advanced Musical Analysis

Prereq.: 21.642 or permission of instructor
Year: G (1)
3-0-6

A study of differing concepts of musical structure and organization and the role of structure in musical perception, coherence, and comprehension. Factors that provide compositional unity and uniqueness, and the role of time in musical structure (tempo, rhythm, meter) also examined extensively. Held in seminar fashion. Study of scores, listening to recordings, readings, and a research paper constitute out-of-class work.
D. M. Epstein

21.666 Seminar on the Structure of Musical Time

(21.955)
Prereq.: Permission of Instructor
Year: G (2)
3-0-6

While pitch and time are the two fundamental structural elements of music, time is the less understood — in its structure, affect, articulation, pacing, interaction with pitch. Seminar focuses on these problems which are multifaceted and interdisciplinary in nature. Approached from a number of viewpoints: theoretical questions of music structure *per se;* experiments in perception, cognition, and learning; aspects of physiology and neurology; and the relation of all these to musical expression and affective response. Students encouraged to participate through research projects, discussions, and reports. Background in music theory is necessary.
D. M. Epstein

21.670 Advanced Writing

Prereq.: 21.643
Year: G (1, 2)
3-0-6

Study of compositional procedures during the early years of the 20th century. Emphasis placed on written and analytic exercises of music which make use of elementary set operations as found in selected Debussy Preludes and Bartok Mikrokosmos, and the early atonal works of Schoenberg and Webern. Students are also expected to attend the weekly graduate seminar in composition.
Staff

21.671 Music Composition (A)

Prereq.: 21.670
Year: G (1, 2)
3-0-9

Directed composition of larger forms of original writing involving voices and/or instruments. Includes a weekly seminar in composition for the examination of major works from 20th-century music literature and for the presentation and discussion of student work in progress. Students expected to produce at least one substantive work, performed in public, by the end of the term. (Open to qualified undergraduates. May be repeated for credit.)
J. H. Harbison, B. L. Vercoe

21.672 Electronic Music Composition (A)

Prereq.: 21.647, 21.670; or 21.648
Year: G (1, 2)
3-6-3

Directed composition of larger forms of original writing using computer-processed sound, to be performed either alone or with voices and/or instruments. Includes a weekly seminar in composition for the examination of major works from 20th-century music literature and for the presentation and discussion of student works in progress. Students expected to produce at least one substantive work, performed in public, by the end of the term. (Open to qualified undergraduates. May be repeated for credit.)
B. L. Vercoe, J. H. Harbison

21.691 Special Topics in Music

Prereq.: Any two subjects in Music
Year: U (1)
Arr.

21.692 Special Topics in Music

Prereq.: Any two subjects in Music
Year: U (2)
Arr.

Open to qualified students who wish to pursue special studies or projects with members of the Music Section. Students electing this subject must secure the approval of the chairman of the Music Section and the Department of Humanities. (Humanities credit for Special Topics subjects awarded only by individual petitions to the Committee on Curricula. Normal maximum is six units; to count towards Humanities Requirement, nine units are required. Exceptional nine unit projects occasionally approved.)
S. Erdely

The Western Tradition: Issues and Texts

The Western Tradition: Issues and Texts is a special interdisciplinary program of humanities subjects. Each subject involves the close examination of original texts, intensive classroom discussion, and the writing of analytical papers. The Bible (21.710) and The Greeks (21.711) are considered foundation subjects. It is recommended that one or both of them be taken before other subjects in this program.

21.710 The Bible

Prereq.: —
Year: U (1, 2) HUM-D
3-0-6

An introduction to major Biblical texts including Genesis, Exodus, Job, the prophetic and historic books of the Old Testament, the Gospels and Epistles. The place of the Bible as foundation-text for central religious, political, sexual, and ethical ideas in Western culture is stressed. Comparative readings in related traditions (Canaanite, Egyptian, Gnostic). Examination of selected instances of the Biblical tradition in later art, music, literature.
Term 1: *A. Steinberg*
Term 2: *Staff*

21.711 The Greeks

Prereq.: —
Year: U (1, 2) HUM-D
3-0-6

Close examination of ancient Greek texts in translation. Examples selected from epic and lyric poetry, tragedy and comedy, history, science and philosophy. Study of Greek Art and Architecture through slides and Museum collections in Boston. Short papers and intensive class discussion focus on such issues as integrity, justice, causes of warfare, first methodologies of scientific and philosophical inquiry, roles of myth and logic, rules of proportion, etc. Seeks to understand the aesthetic and intellectual qualities that made these works lasting contributions to Western culture as well as revealing guides to contemporary Greek society.
Term 1: *D. M. Halperin*
Term 2: *H. A. T. O. Reiche*

21.712 The Romans (New)

Prereq.: —
Year: U (2) HUM-D
3-0-6

"Humanism" as Rome's answer to Plato's dichotomy of power and wisdom. Close study of kev texts attempting to reconcile theory and action; public and private duty; formal and substantive justice; empire and science, compassion, and inclination. Readings — in translation — in Polybius and Plutarch *(Scipio; Gracchi);* in Lucretius and Cicero *(On the Commonwealth; On Duties; Letters);* in Cicero, Sallust, and Plutarch *(Cato; Caesar);* in Lucretius, Horace, Vergil, Tacitus, and Suetonius *(Augustus; Tiberius);* and in Marcus Aurelius on moral man, immoral society. Comparison and contrast with emerging Christianity. Attention throughout to history of Roman institutions and law as collateral evidence. Students commanding some Latin are encouraged to do some of their reading in the original. Suggested secondary readings in such works as Cowell, *Cicero and the Fall of the Roman Republic,* Thornton Wilder, *The Ides of March,* Graves, *I, Claudius.*
H. A. T. O. Reiche

21.713 Major Medieval Texts

Prereq.: —
Year: U (1) HUM-D
3-0-6

Close examination of representative texts from the diverse cultures of Western Europe during the long period that built the foundation of a common European civilization. Examples selected from the Gospels and the letters of Paul, biography and autobiography, epic poetry, history, and theology. Seeks to understand the nature of spiritual life as revealed through the major texts of medieval Europe.
W. B. Watson.

21.714 The Renaissance and Reformation

Prereq.: —
Year: U (2) HUM-D
3-0-6

Relationships between society and ideas in northern Europe during a century of acute social conflict, intellectual controversy, and uncommon creativity in nearly every area of thought and imagination. The process of reformation and rebirth examined in both religious and secular contexts. Readings from both "high" culture and "low" — Thomas More, Erasmus, Luther, Calvin, Rabelais, and Montaigne as well as from anonymous tracts and novels.
R. M. Douglas

21.715 The Enlightenment

Prereq.: —
Year: U (1) HUM-D
3-0-9

Builds on historical sense of the period in Europe when science was new and rationalism was posing the first serious threat to Christian philosophy, when the first glimmerings of industrialization were restructuring class lines, and when rising literacy and improved printing procedures were making books more and more a part of everyday life. A study of the intellectual and artistic developments of the period: Decartes, Pascal, Hobbes, Locke, Pope, Swift, Handel, Voltaire, Lamettrie, Hogarth.
R. Perry

21.716 Romanticism

Prereq.: —
Year: U (1) HUM-D
3-0-6

Study of shifts in Western consciousness during the late 18th and 19th centuries reflected in aesthetic, intellectual, and psychological responses to social and political changes in Europe. Careful reading of historical, literary, and philosophical texts; complemented by study of parallel developments in painting, architecture, and music. Readings from Kant, Rousseau, Schiller, Wordsworth, Byron, Goethe, Carlyle, and Stendhal. ***(Not offered 1981-82).***
T. R. Merritt

21.717 The Modern Period: 1900-1970

Prereq.: —
Year: U (2) HUM-D
3-0-9

Role of the individual and the artist in modern society dominated by politics, war, and technology. Among subjects studied are the reactions to 19th-century values and especially those of Marx and Freud. Role of myth, concepts of illusion and reality, the sexual revolution and its implications, and the new humanism in art, music, philosophy and literature. Among the authors read are Dinesen, Breton, Gropius, Marinetti, Gide, Proust, Pirandello, Jung, Giraudoux, O'Neill, Joyce, Eliot, Kafka, Malraux, Brecht, Beckett, Lawrence, Lessing, and Solzhenitsyn. ***(Not offered 1981-82.)***
R. E. Jones

The Writing Program

The Writing Program subjects are divided as follows: 1) Introductory subjects (21.725-21.731), designed for students with little or no experience in writing; 2) Intermediate subjects (21.740-21.763), some with Humanities Distribution credit, designed for students with some writing experience and basic competence; and 3) Advanced subjects (21.770-21.797) where permission of the instructor and considerable writing experience are prerequisites.

Introductory Subjects

21.725 Introduction to Creative Writing

Prereq.: —
Year: U (1, 2)
3-0-6

For beginners who wish to gain skill in writing. Students encouraged to experiment with varied forms of expression (poetry, fiction, nonfiction). Weekly writing assignments. Reading assigned as it clarifies the interests of the class.
R. Becker, B. Hartmann

21.727 Beginning Prose and Poetry

Prereq.: —
Year: U (1, 2) HUM-D
3-0-6

Introductory subject that analyzes the principles of good writing, using classic and contemporary examples of prose and poetry. Emphasis on writing as a vehicle of social analysis and on writing as art, as well as on the evolution of the functions and modes of writing. Class discussions of students' work focus on precision in writing. Assigned readings of such authors as Shakespeare, Bacon, Yeats, and Lowell discussed in class.
B. Hartmann, Staff

21.728 Introduction to Prose Writing

Prereq.: —
Year: U (1)
3-0-6

For students who wish to develop a style in writing fiction or nonfiction. Emphasis on the techniques available to the writer for conveying her or his meaning. Group discussion provides a better awareness of what writing transmits to the reader. Although there is some reading of published texts most of the class time is devoted to criticism of students' manuscripts.
E. Chodakowska

21.730 Expository Writing

(21.727)
Prereq.: —
Year: U (1, 2)
3-0-6

For students who wish to write correct, clear, and effective prose. Particular attention paid to constructing effective sentences and paragraphs. Weekly writing assignments. Frequent class discussion of students' writing and of readings, which include essays exhibiting a wide range of rhetorical techniques.
B. Hartmann, B. Avishai, H. Ritvo, Staff

Intermediate Subjects

21.740 Fiction Workshop

Prereq.: —
Year: U (1, 2)
3-0-6

For students interested in writing fiction. May be taken as a prerequisite to the Advanced Fiction Workshop, but its main purpose is to encourage students to experiment with various techniques of fiction writing. Weekly reading and writing assignments; class discussion of students' writing and of work of professional writers.
F. Howe, F. Conroy

21.741 Poetry Workshop

Prereq.: —
Year: U (1, 2)
3-0-6

For students with little previous experience in poetry writing. Frequent assignments to stress use of language, diction, word choice, linebreaks, imagery, mood, tone. Considers the functions of memory, imagination, dreams, poetic impulses. Throughout the semester, students examine the work of published poets. Revision is expected.
R. Becker, F. Howe

21.742 Experimental Forms Workshop

Prereq.: —
Year: U (2)
3-0-6

Exploration of experimental writing in nontraditional forms, such as prose poems and concrete poetry. Major emphasis on students' writing and the discussion of it. Reading includes selections from Blake, the French surrealists, prose poems by Rimbaud and Michaux, and contemporary American writers who use experimental forms.
F. Howe

21.743 Writing and Reading Short Stories

Prereq.: —
Year: U (1, 2) HUM-D
3-0-6

Introduction to the short story. Students write stories and short descriptive sketches. Readings from European and American stories, from the 18th, 19th, and 20th centuries. Class discussion of students' writing and of the assigned stories in their historical and social context.
T. Postlewait, F. Conroy, I. Karmel, F. Howe

21.744 Writing and Reading Poems

Prereq.: —
Year: U (1, 2) HUM-D
3-0-6

Examination of the formal structural and textural variety in poetry. Extensive practice in the making of poems and the analysis of both students' manuscripts and texts from 16th through 20th century literature. Attempts to make relevant the traditional elements of poetry and their contemporary alternatives. Weekly writing assignments, including some exercises in prosody.
E. B. Voigt, R. Becker

21.745 Writing Biography and Autobiography

Prereq.: —
Year: U (2)
3-0-6

Study of writing autobiography is largely an exploration of Dostoevsky's statement: "A true autobiography is almost an impossibility . . . man is bound to lie about himself." Various stages of life, significant transitions, personal struggles and memories translated into narrative prose examined for linguistic precision and linguistic evasion. In biography students discuss the relationship of the writer to his/her subject, to history, to truth. Students write in

both modes and read examples from both modes by such authors as Lytton Strachey, Virginia Woolf, Vladimir Nabokov, Isaiah Berlin, Boris Pasternak.
E. Chodakowska

21.746 Writing Science Fiction

Prereq.: —
Year: U (1)
3-0-6

Writing and reading science fiction. Close reading, analysis, and discussion of students' stories. Emphasis on developing clear, lucid prose. The content of the stories discussed in the framework of science fiction, its moral and satirical roots *(Frankenstein, Gulliver's Travels)*, its development toward prophecy *(Canticle for Liebowitz)* and philosophical speculation *(2001)*. Readings include critics of society and technology such as Orwell and Huxley, as well as popular contemporary writers.
F. Conroy

21.750 Writing and Reading the Essay

Prereq.: —
Year: U (1, 2) HUM-D
3-0-9

An examination of how to write formal and informal essays. Extensive practice in composition, revision, and editing; wide reading in the literature of the essay form, from the Renaissance to the present. Discussion-workshop class style: weekly discussion of student work; study of examples from published works and journal articles; frequent conferences. Central concerns are possibilities and techniques of the essay; historical forms such as sermons, meditations, diaries, letters, polemics.
T. Postlewait, H. Ritvo, B. Avishai, J. Paradis

21.760 Scientific and Engineering Writing

Prereq.: —
Year: U (1, 2)
2-0-7

Introduction to all basic types of communications that scientists and engineers are called upon to write, from abstracts to journal articles. Detailed analysis of the problems of conveying technical information to specialist audience. Term project requires a written paper on a technical or semi-technical subject and an oral presentation of the subject in class.
J. Paradis, J. Yates, D. Dobrin, Staff

21.761J Writing: Technology and Society

(Same subject as STS 611J)
Prereq.: —
Year: U (1) HUM-D
3-0-6

Examination of different "voices" used to consider issues of technological and social concern. Students write frequently and choose among a variety of non-fiction forms: historical writing, social analysis, political criticism, policy reports. Instruction in expressing ideas clearly and in organizing a thesis-length work. Reading and writing on four case studies drawn from 1) the history of industrial societies; 2) the cultural study of technology and science; 3) industry studies, and 4) policy issues. ***(Not offered 1981-82.)***
E. G. Rothschild, K. Keniston, K. R. Manning, J. Paradis

21.762 The Scientific Essay

Prereq.: —
Year: U (2) HUM-D
3-0-6

A writing subject with historical emphasis, intended for students who would like to improve writing skills and to explore the evolution of scientific expression from the Renaissance to the modern era. Examines the style and purpose of selected essays of historical importance by early and modern scientists such as Newton, Faraday, Darwin, Einstein. Consideration of varieties and conventions of scientific essays; rise of the scientific journals; effects of specialization on length, style, and vocabulary; variant language systems. Weekly writing assignments on topics generated by the readings, and a longer essay in a technical or semi-technical field related to the student's subject concentration.
J. Paradis, D. Dobrin

21.763 Science Writing for the Public

Prereq.: —
Year: U (1)
3-0-6

Introduction to writing for the mass media about developments in science and engineering and their consequences. Analysis and practice for students interested in improving their ability to communicate technical information to lay audiences. Overview of journalistic traditions and the relationship between science and the media. Guest lecturers from print and broadcast journalism. Weekly written exercises, some of which are submitted for publication in local newspapers and magazines. Intended for students with basic writing competence.
Staff

Advanced Subjects

21.770 Advanced Fiction Workshop

Prereq.: Permission of Instructor
Year: U (1, 2)
3-0-6

For students with some experience in writing fiction. Concentrates on the ways an author manipulates her or his audience in the creation of a particular vision of reality. Studies style; point of view; distinctions of time and space; stream-of-consciousness; all the strategies for making a work of art. Outside readings assigned on an individual basis.
E. Chodakowska, I. Karmel

21.771 Advanced Poetry Workshop

Prereq.: Permission of Instructor
Year: U (2)
3-0-6

For students with some experience in writing poems. All students expected to look critically at the poems of class members as well as of published contemporary poets. Examines questions of form and craft. Regular reading assignments and weekly submission of manuscripts. All students expected to do a substantial amount of rewriting and revision. Classwork supplemented with individual conferences.
E. B. Voigt

21.773 Writing Longer Fiction

Prereq.: Permission of Instructor
Year: U (2)
3-0-6

For students with some experience in writing fiction who wish to experiment with its longer forms (primarily the novella). The possibilities and techniques of longer fiction studied in examples of modern European and American authors (i.e., Tolstoy, Conrad, Kafka, Bellow) and compared with the scope and the techniques exemplified by selected novels and short stories. Class discussions of students' own work with emphasis on revision. Discussions of assigned reading.
I. Karmel

21.780 Descriptions of Society

Prereq.: Permission of Instructor
Year: U (1)
3-0-6

Writing about societies and how they change. Students write essays of various lengths, using their own technical or personal knowledge to discuss social, political, and economic subjects. Readings from the essay literature of the last three centuries focus on two main topics to illustrate ways of describing society and social change. ***(Not offered 1981-82.)***
Staff

21.781 Naturalist Writing

Prereq.: Permission of Instructor
Year: U (1)
3-0-6

Students are required to write about nature in a variety of ways, aesthetic and technical, in essays and in technical documents. They study the responses to nature of 19th- and 20th-century naturalists, such as Audubon, Darwin, Thoreau, Lorenz, Carson, and Goodall. They examine local publications and films of nature societies in New England, the Northwest, and the South, as well as such modern forms as the environmental impact statement and the technical report. Several short and two longer writing assignments of a general and semi-technical variety.
J. Paradis

21.784 Advanced Essay Workshop

Prereq.: Permission of Instructor
Year: U (2)
3-0-6

For students with some experience in writing non-fiction prose. Advanced study of rhetorical strategies and techniques of prose style. Two extended essays required; considerable revision expected. In addition to analyzing the work of class members, students read and discuss the work of three or four distinguished essayists. Essayists chosen to represent a range of prose styles, subjects, and biographical patterns.
H. Ritvo

21.789 Proseminar in Science Communication: Audio-Visual Media

Prereq.: Permission of Instructor
Year: G (2)
4-2-6

Writing for and about radio, television, and film on topics in basic research, technological development, and science policy. Weekly writing assignments, auditing and viewing of science programs for radio and television, and reading assignments relevant to broadcast science news and feature reporting. An introduction to the technology of form and the broadcast media, and a consideration of the constraints it imposes on the dissemination of scientific knowledge, news, and analysis. One long paper required, analyzing broadcast media coverage of an event from the following perspectives: tone, depth, context, point of view, selection of material, and ethical implications. ***(Not offered 1981-82.)***
Staff

21.790 Proseminar in Science Communication: Print Media

Prereq.: Permission of Instructor
Year: G (1)
4-2-6

Writing for the print media on topics in basic research, technological development, and science policy. Weekly writing assignments, at least two of which are expected to be published in local media. Reading and class discussion of science articles in current newspapers and periodicals, and of studies relevant to science writing from sociology of science, science policy, history of science, communication theory, and communication research. One long paper required, analyzing print media coverage of an event from the following perspectives: tone, depth, context, point of view, selection of material and ethical implications. ***(Not offered 1981-82.)***
Staff

21.791 Science Writing Workshop

Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Students write feature articles for magazines on developments in science, technology, and science politics, with emphasis on controversial issues at the interface of science and society. Students work with the instructor and each other on developing appropriate topics for articles, gathering information, organizing ideas, writing, editing, revising, and submitting material for publication. Finished articles expected to be of publishable quality. Works by contemporary science writers discussed, as are other topics important to thorough reporting of science, such as public attitudes toward science, ethical issues in investigative writing, and problems in press coverage of controversial issues. Regular reading of selected newspapers and magazines also required.
A. R. Goodell

21.792 Science Writing Internship

Prereq.: 21.763
Year: U (2)
3-0-9

Part-time internships arranged in Boston-area media for students interested in developing professional writing and publishing skills. Students also attend weekly seminars and tutorials with the instructor, and write a final report on the intern experience. (Permission of instructor required.)
Staff

21.793 Advanced Workshop in Scientific and Engineering Writing

Prereq.: —
Year: G (1, 2)
2-0-4

Review and practice in technical report and article writing, with several writing and revising assignments adapted to the preparation of one or two major technical reports, journal articles, or software documents. Survey of the structure of technical literature, from patents and design standards to abstract journals and vendor documentation. Examination of selected proposal, report, and article formats and discussions on problems of technical style, graphics, bibliographical conventions, and article submission.
D. Dobrin, J. Paradis

21.798 Special Topics in Writing

Prereq.: —
Year: U (1)
Arr.

21.799 Special Topics in Writing

Prereq.: —
Year: U (2)
Arr.

Primarily for students pursuing writing projects with the assistance of a member of the Writing Program. Students electing this subject must secure the approval of the Director of the Writing Program and the Department of Humanities. (Humanities credit for Special Topics subjects awarded only by individual petitions to the Committee on Curricula. Normal maximum is six units; to count towards Humanities Requirement, nine units are required. Exceptional nine unit projects occasionally approved.)
Staff

Special Interdisciplinary Subjects

21.901J Reading Seminar in Humanities, Science and Technology I

(Same subject as STS 100J)
Prereq.: —
Year: U (1)
2-0-7

21.902J Reading Seminar in Humanities, Science and Technology II

(Same subject as STS 101J)
Prereq.: —
Year: U (2)
2-0-7

Reading and discussion of major primary and secondary works which illustrate or examine the interactions of science, technology and society. Topic Term 1: Classic Interpretations in the History of Ideas. Term 2: Ideas of Progress. (Primarily for students enrolled in XXI-A and XXI-B, 1 Option 2; open to others by permission of instructor.)
Term 1: *A. Kibel*
Term 2: *K. R. Manning*

21.910 Youth and Industrial Society

Prereq.: —
Year: U (1)
3-0-6

An analysis of self-transformative and political youth movements in America during the 1960s and 1970s. Comparisons made with youth movements in pre-Hitler Germany and Tsarist Russia. Special emphasis on the role of youth groups as critics and supporters of industrial-technological societies. ***(Not offered 1981-82.)***
K. Keniston

21.913 Marx and Marxism

Prereq.: —
Year: U (1)
3-0-6

An introduction to the Marxist analysis of human activity, society, the family, the individual, work, the political process. Special emphasis on current problems in the United States. Readings from the works of Marx, Engels, and recent Marxists like H. Braverman, S. Rowbotham. B. and J. Ehrenreich. ***Not offered 1981-82.)***
L. Kampf

21.914 Sports and Physical Training

Prereq.: Permission of Instructor
Year: U (1)
3-0-6

Social function of sports and physical training in modern times, especially in the United States. Readings, films, discussions. Group research projects. (Limited enrollment.)
L. Kampf

21.915 Intellectuals and Social Change

Prereq.: Permission of Instructor
Year: U (2)
3-0-6

Role and responsibility of individuals who challenge the assumptions of the established political and social order, and who are concerned with ideas and their consequences. Discussion of current issues that have given rise to action and protest. Questions of individual commitment, and the available alternatives for action. Historical background, with emphasis on socialist, anarchist, populist, and liberal responses to recurrent problems which have faced the committed individual. Study of the conditioning of these responses by the relation of intellectuals to established institutions such as government and the universities. Group research on topics of particular current significance. (Limited enrollment.)
N. A. Chomsky, L. Kampf

21.916 Contemporary Issues in Politics and Ideology

Prereq.: —
Year: U (2)
3-0-6

Selected topics in domestic and international affairs. Emphasis on their relationship to US political, economic, and ideological institutions. Critical analysis of capitalist ideology. Consideration of strategies for social change. ***(Not offered 1981-82.)***
L. Kampf, N. A. Chomsky

21.917 Seminar I: International Students and Participation in Development

Prereq.: —
Year: U (1)
Arr.

Identification of and searching for solutions to common problems (e.g., social, economic, political, technological, and professional) faced by International students planning to return home and other individuals seeking integration into a different culture. Content includes examination of current theories of development and discussion of practical alternatives, along with the role of technology in social change. Emphasis on the role of the returned student in effecting changes for improvement and development. Individual or group projects in areas of interest. (Humanities credit for this subject awarded only by individual petitions to the Committee on Curricula. Normal maximum is six units; to count towards Humanities Requirement, nine units are required. Exceptional nine-unit projects occasionally approved.)
Staff

21.918 Seminar II: International Students and Participation in Development

Prereq.: —
Year: U (2)
Arr.

Focus on issues emerging from the examination of developmental experiences and problems in 21.917. Exploration of methodological issues in the study of the development process (peasant economies, urban infrastructure investment, food and population interaction), and on alternatives in technology in light of the experiences and methods anlayzed earlier (cooperatives as an alternative in this system of socioeconomic organization, water/waste technology, recycling in materials technology, alternatives in education for the developing world). Examination of personal and professional basis for work in home societies as well as critical examination of methods and alternatives available to shape that process today. (Humanities credit for this subject awarded only by individual petitions to the Committee on Curricula. Normal maximum is six units; to count towards Humanities Requirement, nine units are required. Exceptional nine-unit projects occasionally approved.)
Staff

21.919J The Finite Earth: Agendas for a More Just, Sustainable and Participatory Society

(Same subject as 4.761J, 11.486J, 17.440J, 22.83J)
Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Problems such as food supply, energy, material resources, global environment, and rapid changes in third world countries often tend to be looked on as separate; but each affects the other, and the connective tissue between them is too often lost. Subject explores several of these issues (especially food, energy, technology transfer, world security and the views from alternative social systems) in context. Each topic cannot be developed in depth; purpose of subject is to introduce interested students to these issues; to ways in which they interactively influence the quality of social life for

many in today's world; and to assess choices and directions for the future, both generally and as they may affect the student's own personal and professional interests. Content developed via a combination of lectures and discussion groups.
M. Diskin, N. B. Herman, J. Beinart, W. R. Johnson, D. J. Rose

The following Wellesley subject is offered at MIT:

Wellesley Religion 108 Introduction to Asian Religions

Prereq.: —
Year: U (2) HUM-D
3-0-9

An introduction to the major religions of India, Tibet, China, and Japan with particular attention to universal questions, such as how to overcome the human predicament, how to perceive the ultimate reality, and what is the meaning of death and the end of the world. Materials taken from Islam, Hinduism, Buddhism, Confucianism, Taoism, and Shinto. Comparisons made, when appropriate, to Hebrew and Christian scriptures. (For MIT students only.)
J. T. Kodera, H. Reynolds

21.930 Greek Philosophy and Science: The Presocratics, Plato and Aristotle

Prereq.: —
Year: U (2)
3-0-6

Close study of selected texts of Anaximander, Pythagoreanism, Heraclitus, Parmenides, Zeno, Empedocles, Democritus, Plato, and Aristotle. Readings in such works as Kirk and Raven, *The Presocratic Philosophers;* Plato, *Timaeus;* Karl Popper, "Back to the Presocratics" (in *Conjectures and Refutations);* Schroedinger, "Nature and the Greeks" (in *What Is Life);* Collingwood, *The Idea of Nature;* D'Arcy Thompson, "Aristotle as Biologist" (in *Science and the Classics*). Attention to the interface of science and philosophy. Astronomy, mathematics, music, kinematics in search of their conceptual foundations. Changing ideas of "Nature" and of the human place in it. ***(Not offered 1981-82.)***
H. A. T. O. Reiche

21.932 Introduction to Phenomenology

Prereq.: —
Year: U (1)
3-0-6

A broad survey of phenomenology and existentialism. Selection of topics of current interest including: intentionality, being-in-the world, existential description, space and temporality, transcendence. Readings from Husserl, Ortega y Gasset, and J. P. Sartre.
G. C. Rota

21.933 Being and Time: I

Prereq.: —
Year: U (1)
3-0-6

The philosophy of Martin Heidegger and its influence on contemporary thought, stressing existential views on the foundations of science, the critique of classical logic, and Cartesian thought. Readings from Heidegger's "Being and Time." ***(Not offered 1981-82.)***
G. C. Rota

21.934 Being and Time: II

Prereq.: —
Year: U (1)
3-0-6

The philosophy of Martin Heidegger — a continuation of 21.933. Readings from "Being and Time," Part II. ***(Not offered 1981-82.)***
G. C. Rota

21.940 Rhetoric and Journalism

Prereq.: —
Year: U (2)
3-0-6

Critical analysis and practical exercises in reporting, writing, and editing for print and broadcasting. Both historical and current texts used to study such journalistic categories as news, opinion, features, editorials, commentaries, documentaries. Special attention paid to the specialist journalist. Organizational influences on graphics, headlines, pictures, production. Consideration of biasing and antibiasing techniques (objectivity); roles of journalist and historian; economics of publishing and broadcasting. Students responsible for creating a substantial body of work for publication and/or display in campus or extra-campus media. Examples of student work, as well as professional models, discussed and criticized in class and by the seminar leader. Content varies from year to year. (Permission of instructor required. ***Not offered 1981-82.***)
E. Diamond

21.953J Cognitive Aspects of Musical Development and Learning (A)

(Same subject as SRE 215J)
Prereq.: Background in music theory, some familiarity with cognitive psychology
Year: G (1, 2)
3-6-3

Cognitive developmental processes related to musical understanding, including the interactions among perception, cognition, and representation. Comparisons made between "figural" and "formal" internal representations and their relations to languages for describing musical structure, e.g., in music theory and in computational systems. The relation of cognitive development in music to cognitive development in other domains
J. S. Bamberger

21.956J Aesthetics

(Same subject as 24.621J)
Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Philosophical problems about the history and theory of art. Topics: art as a mode of communication; ways in which art may or may not be a cluster of "languages" or "symbolic systems," cognitive and noncognitive elements in art. Particular emphasis on the "expression theory of art" and the nature of "artistic truth." Seminar designed for undergraduates in various fields as well as graduate students.
J. H. Harbison, I. Singer

21.979 The Theory and Practice of Metaphor

Prereq.: —
Year: U (2)
3-0-6

A "discovery course," tracing the function of metaphor in literature, the sciences, and human creativity in general. Theoretical analysis of metaphorical thinking as well as studies of the role of some specific metaphors in past and present are included. (Cambridge Humanities Seminar Subject given at Wellesley.)
L. Janek

21.980 Painters and Philosophical Issues in Modernism

Prereq.: —
Year: U (1)
3-0-9

Twelve major painters of the last 100 years, from Manet to Olitski, studied. Equal emphasis given to their stylistic development through a close reading of individual paintings and to the critical issues raised by their work, especially as these issues relate to the history of Modernist thought. Readings include writings of the artists themselves, as well as relevant critical and philosophical texts. (Cambridge Humanities Seminar Subject. ***Not offered 1981-82.***)
J. Ablow, I. Stadler

21.981 On Quality in Art

Prereq.: —
Year: U (2)
3-0-9

An exploration of recent and older attempts at formalizing critical and comparative judgments of works of visual art. Traces the subject back to its roots in the isolation during the 16th century of a distinct aesthetic realm, in order to investigate the extent to which we can arrive at objectivity of such judgment. Readings coordinated with analysis of art works to which they refer. Authors include selections from: Vasari, Winckelmann, Baudelaire, Burkhardt, Hildebrand, Meier-Graefe, Berenson, Roger Fry, Apollinaire, Breton, Focillon, Panofsky, Gombrich, Jacob Rosenberg, Rhys Carpenter, James Ackerman. (Cambridge Humanities Seminar subject given at MIT.)
M. Martin

21.982 Iconography and Ideology

Prereq.: —
Year: U (2)
3-0-9

Survey of the development of Christian and secular iconography in western art, with particular attention to works serving political or ideological purposes. Through a series of case studies of works from the early Christian to the modern era, the subject considers methods of iconographic research and the problem of the generation and demise of symbolic codes used for political legitimation and descent. (Cambridge Humanities Seminar given at Wellesley.)
M. Carroll

21.983 Literature and History (New)

Prereq.: Two subjects in literature
Year: U (1)
3-0-6

Intensive study of the ways in which the disciplined studies of literature and of history reinforce and oppose each other. Examination of major contemporary theoretical positions in which the antagonistic relation between literary and historical understanding is particularly marked. Readings in theoretical works concerning the general problems of literary analysis and historical understanding, including works by Aristotle, Marx, Freud, Sartre, Foucault, Dilthey, Northrop Frye, Roland Barthes, Claude Levi-Strauss. (Cambridge Humanities Seminar given at Boston University.)
M. McKeon

21.984 Theory of the Novel (New)

Prereq.: Two subjects in literature
Year: U (2)
3-0-6

A study of major statements in the theory of the novel, including selections form the works of Aristotle, Luckacs, Auerbach, Watt, Barthes, Gerette. Readings in novels by Dickens, Tolstoy, Joyce, and Proust to help judge theory in the light of practice. (Cambridge Humanities Seminar given at Boston University.)
E. Goodheart

21.991 Special Topics in Interdisciplinary Studies

Prereq.: Any two subjects in Humanities
Year: U (1)
Arr.

21.992 Special Topics in Interdisciplinary Studies

Prereq.: Any two subjects in Humanities
Year: U (2)
Arr.

Special topics involving interdisciplinary study sponsored by members of the Department of Humanities or Institute faculty. Subjects varying from year to year. Must have the approval of the Department of Humanities. (Humanities credit for Special Topics subjects awarded only by individual petitions to the Committee on Curricula. Normal maximum is six units; to count towards Humanities Requirement, nine units are required. Exceptional nine-unit projects occasionally approved.)
P. H. Smith

Please note: Philosophy subjects are listed under Course 24, Linguistics and Philosophy.

Subjects in Science, Technology, and Society are listed under that heading in this chapter.

Information and subject listings in the following programs may be found within the description of the Department of Humanities in this catalogue.

American Studies
Russian Studies
Ancient and Medieval Studies
Drama
Cambridge Humanities Seminar

22 Nuclear Engineering

Undergraduate Subjects

22.UR Undergraduate Research Opportunities Program

Prereq.: —
Year: U (1, 2)
Arr.

The Undergraduate Research Opportunities Program and the Undergraduate Seminars are excellent ways for undergraduate students to become familiar with the Department of Nuclear Engineering. Students attend seminars related to the Nuclear Engineering Department teaching and research work. Student research as a UROP project has been conducted in areas of fission reactor studies, utilization of fusion devices, applied radiation research and biomedical applications. Some projects include the study of engineering aspects for both fusion and fission energy sources. UROP Department Coordinator:
D. D. Lanning

22.001 Seminar in Nuclear Engineering

Prereq.: —
Year: U (1)
2-0-4

Survey of the range of topics covered by the Nuclear Engineering Department. Introductory discussion of the basic phenomena of fission and fusion power and related aspects of reactor design. The many applications of Nuclear Engineering for research in biology, earth sciences, medicine, and physics discussed by guest lecturers from the appropriate discipline. A demonstration of the MIT Reactor as a research tool is given.
D. D. Lanning

22.002 Management in Engineering

Prereq.: —
Year: U (1)
3-0-9

Introduction to the concepts of management of the engineering function, as found in a variety of industrial and non-industrial settings. Aim is to help student acquire: 1) recognition of the role of engineering and its relationship to other functions in getting a job done, 2) familiarity with some of the managerial tools and concepts employed in engineering organizations, 3) practice in dealing with both short- and long-term managerial problems in a range of real-life circumstances, and 4) incentive to develop a career strategy relevant to engineering training. Topics: financial principles; management of innovation; engineering project planning, scheduling and control; human factors; career planning; contracts; patents; and technical strategy for firms. Taught, in part, by case method, which emphasizes student participation in discussion. (Intended for juniors, seniors, or graduate students; others should consult the instructor in charge.) This subject is an Engineering School-Wide Elective.
R. T. Lund, D. P. Hoult, H. S. Marcus

22.003J In Pursuit of Arms Control: Analysis of the Past and Choices for the Future

(Same subject as 17.465J)
Prereq.: —
Year: U (2)
3-0-6

Review and analysis of nuclear and nonnuclear arms and efforts at arms control since World War II. Focus on the interaction of technological factors, changing strategic concepts, intelligence estimates, and political judgments in the decision-making process. Topics: nuclear proliferation, Strategic Arms Limitation Talks, Mutual and Balanced Force Reductions, new military technology, and current trends in US and Soviet weapons programs. Students learn to evaluate and to design alternatives to current government arms control and national security policy. (May be counted toward Humanities Requirement.)
N. C. Rasmussen, T. R. I. Greenwood

22.006 Computer Models of Physical and Engineering Systems (Revised Unit)

Prereq.: 18.02, 8.01
Year: U (1) SD
3-0-9

Reduction of physical and engineering systems to simplified physical and mathematical models; representation using networks; graphs and finite element methods. Process simulations using random variables (Monte-Carlo techniques) and Linear and Dynamic Programming. Manipulation of the resulting models using algorithms on digital computers. Examples drawn from fields primarily of interest to scientists and engineers, with some attention to styles of problem solving. Extensive "hands-on" computing experience. (Working knowledge of FORTRAN expected.) This subject is an Engineering School-Wide Elective.
B. Schumacker, R. Kaplow, K. J. Bathe

22.02 Introduction to Applied Nuclear Physics

Prereq.: 8.02, 18.02
Year: U (1) SD
3-0-9

Introduction to nuclear physics and neutron physics with emphasis on those aspects of the subject which are applied in nuclear engineering. Elementary results of quantum theory and special relativity. Detection of atomic and nuclear particles. Properties of atomic nuclei: isotopes and isotopic masses; nuclear reactions; natural and artificially induced radioactivity; cross sections for nuclear reactions; alpha-, beta-, and γ - decay. Nuclear models; shell-model; liquid-drop model. Nuclear fission: properties of fission and their relation to the feasibility of nuclear power and to its problems. Slowing down and diffusion of neutrons. Neutron induced chain reactions. Thermonuclear reactions and the possibility of energy from nuclear fusion. Introduction to radiation dosimetry.
I. Kaplan

22.021 Nuclear Reactor Physics

Prereq.: 22.02, 18.03
Year: U (1)
4-0-8

Introduction to fission reactor physics covering reactions induced by neutrons, nuclear fission, slowing down of neutrons in infinite media, diffusion theory, the few-group approximation, and point kinetics. Emphasis placed on the nuclear physics bases of reactor design and their relation to reactor engineering problems. Three lecture hours per week meeting concurrently with 22.211, plus a separate recitation; assignments and quizzes are different from those in 22.211.
R. K. Lester

22.03 Engineering Design of Nuclear Power Systems

Prereq.: —
Year: U (1) SD
3-0-9

Principles of component and system design, and operating characteristics of nuclear reactors for central station and marine power generation. Application of the various engineering disciplines contributing to reactor design to examine trade-offs involved in realization of system performance objectives. Examples selected from current and projected US reactor designs.
N. E. Todreas

22.031 Engineering Analysis of Nuclear Reactors

Prereq.: 22.03, 18.03
Year: U (1)
4-0-8

Engineering analysis of nuclear reactors, with emphasis on power reactors. Power plant thermodynamics, reactor heat generation and removal (single-phase as well as two-phase coolant flow and heat transfer) and structural mechanics. Engineering considerations in reactor design. Three lecture hours per week meet concurrently with 22.312, plus a separate recitation. (Primarily for Course XXII undergraduates; others admitted by permission of instructor.)
M. S. Kazimi

22.033 Nuclear Systems Design Project

Prereq.: 22.021, 22.031
Year: U (2)
2-6-4

Group design project involving integration of reactor physics, control, heat transfer, safety, materials, power production, fuel cycle management, environmental impact, and economic optimization. Provides the student with the opportunity to synthesize knowledge acquired in other subjects and apply this knowledge to practical problems of interest in the reactor design field. (Meets concurrently with 22.33, but assignments differ.)
Staff

22.04 Radiation Effects and Uses

Prereq.: —
Year: U (2) SD
2-1-9

Current problems in science, technology, health and environment which involve radiation effects and their utilization. Material properties under nuclear radiations. Medical and industrial applications of radioisotopes. Radiations and lasers in research. Radioactive pollutants and demographic effects. Laboratory demonstrations of methods and instruments in radiation measurements at the MIT Reactor. Material presented in an essentially descriptive manner and suitable for students interested in a general appreciation of the physical phenomena and their uses.
S. H. Chen

22.069 Undergraduate Plasma Laboratory

Prereq.: 8.02
Year: U (1) LAB
1-8-3

Basic engineering and scientific principles associated with experimental plasma physics. Investigation of vacuum pumping phenomena and gauge operation, normal and superconducting magnetic field coils, microwave interactions with plasmas, laboratory plasma production including electrical breakdown phenomena, Langmuir probe characteristics and spectroscopy. (Meets concurrently with 22.69, but assignments differ.)
Staff

22.07 Basic Plasma Physics

Prereq.: 8.03, 18.03
Year: U (2)
3-0-9

Introduction to fusion processes and potential for energy production. Fundamental concepts of plasma physics and introduction to the elementary electromagnetic theory needed to describe plasma behavior. Physical processes in ionized gases and discussion of fusion reactor concepts and designs. Elementary theory of plasma single-particle motions and MHD equations.
J. P. Freidberg

22.070J Materials for Nuclear Applications (New)

(Same subject as 3.070J)
Prereq.: 3.091 or 3.14 or 22.071
Year: U (2)
3-0-9

Introductory subject for students who are not specializing in nuclear materials. Applications and selection of materials for use in nuclear applications. Radiation damage, radiation effects and their effects on performance of materials in fission and fusion environments. (Meets concurrently with 22.70J but assignments differ.)
Staff

22.071J Physical Metallurgy Principles for Engineers (New)

(Same subject as 3.071J)
Prereq.: 3.091
Year: U (1)
3-0-9

Crystallography and microstructure of engineering materials. Thermodynamics of alloys, structural theory of metallic phases. Rate processes in metals: solidification, solid state diffusion, oxidation, and phase transformations. Defect properties: point defects, dislocations, and radiation damage. Mechanical properties: plastic deformation, work hardening, strengthening mechanisms, and fracture. Recovery and recrystallization. Emphasis on structure-properties relationships, their physical interpretation, and quantification. (Meets concurrently with 22.71J, but assignments differ.)
I-W. Chen

22.08 Energy

Prereq.: —
Year: U (1)
3-0-9

Energy from a holistic point of view: provision, rational utilization and conservation, regulation, environmental effects, and impact on other societal sectors. Resources of petroleum, natural gas, coal, nuclear and other energy forms. Technologies of providing energy from these forms. Utilization of energy in various sectors: transportation, industrial, commercial, and domestic, including especially opportunities for increased efficiency and energy conservation. Regulatory, tax, and other institutional arrangements that affect production and use patterns. Environmental costs and opportunities associated with exercising various energy strategies, both existing and proposed. Domestic and international political, strategic, and economic implications.
D. J. Rose

22.084 Inventions and Patents (New)

Prereq.: 14.02
Year: U (1)
3-0-6

History of private and public rights in scientific discoveries and applied engineering leading to the development of worldwide patent systems. The classes of invention protectable under the patent laws of the US, including the procedures in protecting inventions in the Patent Office and in the courts. Reviews of past cases involving inventions and patents in: a) the chemical process industry and medical field;

Nuclear Physics

b) devices in the mechanical, ocean exploration, civil, and/or aeronautical fields; and c) the electrical and electronic areas including key radio, solid-state, and computer inventions. This subject is an Engineering School-Wide Elective.
R. H. Rines

22.085 Introduction to Technology and Law

Prereq.: —
Year: U (1)
3-0-9

Introduction to the basic principles and functions of law, using legal cases and materials arising from scientific and technical issues. Provides an understanding of the law and legal processes as they impact upon the work of engineers and scientists. Study of judicial law making focuses on elementary civil procedure and how change in legal doctrine takes place. Examination of statutory law making shows how Federal and state power to govern grows as technology grows. Administrative law making focuses on the regulatory agencies' role in controlling and supporting technology as well as the extent and curbs on their power. Study of law cases, using so-called "Socratic method," and of legal processes and doctrines provides insight into the lawyer's working methods. Law's task of resolving conflicts found in scientific and engineering alternatives sensitizes students to choice of values questions. This subject is an Engineering School-Wide Elective. ***(Not offered 1981-82.)***
J. D. Nyhart

22.09 Introductory Nuclear Measurements Laboratory

Prereq.: 22.02
Year: U (2) LAB
2-6-4

Basic principles of interaction of nuclear radiation with matter. Statistical methods of data analysis; introduction to electronics in nuclear instrumentation; counting experiments using Geiger-Muller counter, gas filled proportional counter, scintillation counter, and semiconductor detectors. A term project emphasizes applications to experimental neutron physics, radiation physics, health physics, and reactor technology. (Meets concurrently with 22.29, but assignments differ.)
S. H. Chen

22.091 Special Topics in Nuclear Engineering

Prereq.: —
Year: U (1, 2, S)
Arr.

For undergraduates who desire to carry out a one-term project of theoretical or experimental nature in the field of nuclear engineering in close cooperation with individual staff members. The topics and hours are arranged to fit students requirements.
M. S. Kazimi

22.092 Engineering Internship

Prereq.: —
Year: U (1, 2, S)
0-6-0

Provides academic credit for the first two Work Assignments of XXII-A students affiliated with the Engineering Internship Program. Students register for this subject twice. Students must complete both Work Assignments in order to receive the academic credit for this subject. (Enrollment limited to students registered in Course XXII-A.)
J. E. Meyer

22.111 Nuclear Physics for Engineers I (A)

Prereq.: 22.02
Year: G (1)
3-0-9

Fundamentals of nuclear physics for engineering students. Basic properties of the nucleus and nuclear radiations. Elementary quantum mechanical calculations of bound-states and barrier transmission probability. Nuclear shell model. Binding energy and nuclear stability. Interactions of charged particles, neutrons, and gamma rays with matter. Radioactive decays. Energetics and general cross-section behavior in nuclear reactions.
S. Yip

22.112 Nuclear Physics for Engineers II (A)

Prereq.: 22.111
Year: G (2)
3-0-9

Continuation of 22.111 with emphasis on nuclear data and studies of reactions relevant to current nuclear technologies. Neutron cross-section calculations using optical models. Radiative capture, inelastic scattering, and thermalization. Charged particle and photonuclear reactions. Availability of nuclear data files.
S. Yip

Nuclear Reactor Physics

22.211 Nuclear Reactor Physics I (A)

Prereq.: 8.272, 18.076
Year: G (1, 2)
3-0-9

Introduction to problems of fission reactor physics covering nuclear reactions induced by neutrons, nuclear fission, slowing down of neutrons in infinite media, diffusion theory, the few group approximation, and point kinetics. Emphasis placed on the nuclear physical bases of reactor design and their relation to reactor engineering problems.
R. K. Lester, N. C. Rasmussen

22.212 Nuclear Reactor Physics II (A)

Prereq.: 22.211
Year: G (2)
3-0-9

Problems relating to the operation of nuclear reactors at power including few group and multigroup theory, heterogeneous reactors, control rods, poisons, depletion phenomena, and elementary neutron kinetics. Attention directed to the application of reactor theory to actual reactor systems.
A. F. Henry

22.213 Nuclear Reactor Physics III (A)

Prereq.: 22.212
Year: G (1)
3-0-9

Current methods for predicting neutron behavior in complex geometrical and material configurations. The transport equation and methods for solving it; systematic derivation of group diffusion theory. Homogenization, synthesis, finite element, response matrix techniques and nodal methods applied to reactor analysis.
A. F. Henry

22.22 Nuclear Reactor Dynamics (A)

Prereq.: 22.212, 18.075
Year: G (2)
3-0-9

Formulation of nuclear plant dynamics and methods of analysis and control. Point kinetics formalism, Leplace transforms, experimental methods for measuring dynamic characteristics, and control of reactor transients. Space-time formalism and numerical methods of analysis. Xenon oscillations. Digital computer control. Special transients with safety implications. Statistics of reactor noise. (Alternate years. ***Not offered 1981-82.***)
E. P. Gyftopoulos, A. F. Henry

22.29 Nuclear Measurements Laboratory (A)

Prereq.: *22.211*
Year: G (2)
2-6-4

Basic principles of interaction of nuclear radiations with matter. Principles underlying instrumental methods for detection and energy determination of gamma rays, neutrons and charged particles. Applications to applied radiation physics, health physics, and reactor technology. Laboratory experiments on gas-filled, scintillation, and semiconductor detectors; nuclear electronics such as pulse amplifiers, multichannel analysers, and coincidence techniques; applications to neutron activation analysis, X-ray fluorescence measurement, thermal neutron cross sections, radiation dosimetry, decay scheme determination, pulse neutron experiments, and subcritical assembly measurement. (Meets concurrently with 22.09, but assignments differ.)
S. H. Chen

Nuclear Reactor Engineering

22.311 Engineering Principles for Energy Engineers

Prereq.: —
Year: G (1)
3-0-9

Fundamentals of engineering thermodynamics, fluid flow, heat transfer, elasticity and thermoelasticity. Applications to various energy sources. Introductory subject for graduate students without previous engineering background.
M. W. Golay

22.312 Engineering of Nuclear Reactors (A)

Prereq.: *22.211*, 22.311
Year: G (1, 2)
3-0-9

Engineering principles of nuclear reactors with emphasis on applications in central station power reactors. Power plant thermodynamics; energy distribution and transport by conduction and convection of incompressible one- and two- phase fluid flow in reactor cores; mechanical analysis and design.
M. S. Kazimi, N. E. Todreas

22.313 Advanced Engineering of Nuclear Reactors (A)

Prereq.: *22.212*, 22.312
Year: G (2)
3-0-9

Advanced topics in nuclear engineering with special emphasis on thermo-fluid dynamic design methods and criteria for reactor cores of various reactor types. Fundamentals of analytic and numerical evaluations of transient heat transfer and fluid flow under operational and accidental conditions; LOCA and Core Heatup analyses. Detailed analysis of liquid metal flow and heat transfer in complex geometries.
M. S. Kazimi

22.314J Structural Mechanics in Nuclear Power Technology (A)

(Same subject as 1.565J, 2.084J, 3.82J, 13.14J, 16.261J)
Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Structural components in nuclear power plant systems: their functional purposes; mechanical, thermal, and nuclear operating conditions; mechanical-structural design requirements. Mechanics of continuous media are combined with models of material behavior to determine adequacy of component design. Effects considered include: mechanical loading, hydraulic forces, elevated temperatures, and neutron

irradiation; normal operation, accident situations, and seismic effects. Lectures are given by several members of Institute faculty and by guest lecturers from nuclear power industry.
J. E. Meyer, A. S. Argon, O. Buyukozturk, R. M. N. Pelloux, T. H. H. Pian, P. C. Xirouchakis

22.32 Nuclear Power Reactors (A)

Prereq.: 22.211, 22.312
Year: G (1)
3-0-9

A descriptive survey of engineering and physics aspects of current nuclear power reactors. Design details discussed including requirements for safety of light and heavy water reactors, high temperature gas-cooled reactors, fast reactors both liquid-metal and gas-cooled, and the molten salt breeder reactors. Reactor characteristics compared both in class and by individual student projects. Development problems discussed and potentials for future improvements assessed.
D. D. Lanning

22.33 Nuclear Engineering Design (A)

Prereq.: 22.212, 22.312
Year: G (2)
2-6-4

Group design project involving integration of reactor physics, control, heat transfer, safety, materials, power production, fuel cycle management, environmental impact, and economic optimization. Provides the student with the opportunity to synthesize knowledge acquired in other subjects and apply this knowledge to practical problems of interest in the reactor design field. (Meets concurrently with 22.033, but assignments differ.)
Staff

22.34 Economics of Nuclear Power (A)

Prereq.: 22.311
Year: G (1)
3-0-9

Principles of engineering economics, with applications to nuclear power systems. Capital and operating costs of nuclear power plants. Economics of the nuclear fuel cycle. Uranium resources, requirements, and costs. Breeder reactor economics. Economic comparison of nuclear and fossil fueled plants.
M. J. Driscoll

22.35 Nuclear Fuel Management (A)

Prereq.: 22.211
Year: G (2)
3-0-9

Characterization of the space-time history of nuclear fuels and the effects upon fuel costs. Physical and material constraints upon fuels and their effects on fuel management policies. Methods of analysis for the optimization of fuel costs. Qualitative description of current methods of management and areas of future development.
M. J. Driscoll

22.36J Two-Phase Flow and Boiling Heat Transfer (A)

(Same subject as 2.57J)
Prereq.: 22.312
Year: G (2)
3-0-9

Phase change in bulk stagnant systems. Kinematics and dynamics of adiabatic two-phase flow. Dynamics and thermodynamics of forced-convection two-phase flow with boiling and/or evaporation. Thermal and hydrodynamic stability of two-phase flows. Associated topics, such as condensation and atomization. Both water and liquid metal applications considered under each topic where data exists.
J. E. Meyer, P. Griffith, W. M. Rohsenow

22.37 Environmental Impact of Electric Power Production (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

An assessment of the various environmental impacts of producing thermal and electric power with currently available technology. Impacts compared throughout both the fossil and nuclear fuel cycles. Topics include fuel resources and extraction, power station effluents, waste heat disposal, reactor safety, and radioactive waste disposal.
M. W. Golay

22.38 Reliability Analysis Methods (A)

Prereq.: —
Year: G (1)
3-0-9

Principles of the methods of reliability analyses including fault trees, decision trees, and reliability block diagrams. Discussion of the techniques for developing the logic diagrams for reliability assessment, the mathematical techniques for analyzing them, and statistical analysis of required experience data. Practical examples of their application to nuclear power reactors and other industrial operations discussed. (Open to qualified undergraduates.)
C. D. Heising-Goodman, N. C. Rasmussen

22.39 Nuclear Reactor Operations and Safety (A)

Prereq.: 22.211, *22.312*
Year: G (2)
3-5-4

Principles of operating power and research reactors in a safe and effective manner. Practical experience provided through demonstrations and experiments with the MIT Reactor. Other topics taken up include operating experience with power reactors; control and instrumentation; criticality and startup considerations; and refueling from the reactor operational standpoint. All topics combined with reactor safety. Past accident experience discussed with emphasis on safety lessons learned. The reactor licensing procedures reviewed with consideration of safety analysis reports, technical specification, and other NRC licensing regulations.
D. D. Lanning

22.40 Advanced Reliability Analysis (A) (New)

Prereq.: 22.38 or 22.82
Year: G (2)
3-0-9

Extended application and use of reliability and probabilistic risk analysis methods. Advanced reliability analysis. Methods for common mode failure analysis and treatment of dependencies. Bayesian statistics applied to reactor safety problems. Error sensitivity analysis. Application of selected reliability analysis computer codes. Case studies of safety analyses performed in nuclear and nonnuclear areas: LWR safety, fusion reactor safety, and aerospace/chemical engineering applications. Term project required.
C. D. Heising-Goodman

Numerical and Mathematical Methods

22.41 Numerical Methods of Radiation Transport (A)

Prereq.: 18.076, 22.212
Year: G (2)
3-0-9

Mathematical methods for the solution of neutron/photon transport problems: detailed development of discrete ordinates and Monte Carlo methods for applications in radiation shielding, reactor analysis, and biomedical dosimetry. Discussion of iteration techniques for solution of coupled difference equations. Group projects on solving original transport problems by design and implementation of computer codes. (Alternate years. ***Not offered 1981-82.***)
Staff

22.42 Numerical Methods of Reactor Analysis (A)

Prereq.: 22.211
Year: G (1)
3-0-9

Applications of digital computers to nuclear engineering topics. Review of specific mathematical techniques for solving reactor physics and engineering problems including matrix algebra, finite difference equations, and numerical solution of equations. Special topics such as multigroup diffusion methods.
A. F. Henry

22.43 Numerical Methods in Reactor Engineering Analysis (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Numerical methods used in analysis of nuclear reactor engineering problems studied. Topics include finite difference and finite element formulations in solution of heat conduction, fluid dynamics, structural component design, and transient system analysis problems. (Students who have taken 22.42 are qualified. Alternate years. ***Offered 1981-82.***)
Staff

22.51 Radiation Interactions and Applications (A)

Prereq.: 8.05, 8.07, 22.111
Year: G (1)
3-0-9

Basic principles of interaction of electromagnetic radiation, thermal neutrons, and charged particles with matter. Introduction to classical electrodynamics, quantum theory of radiation field and time-dependent perturbation theory. Emphasis on the development of transition probabilities and cross sections describing interaction of various radiations with atomic systems. Applications include emission and absorption of light, theory of gas lasers, Rayleigh, Brillouin, and Raman scattering, X-ray diffraction, photoelectric effect, Compton scattering, Bremsstrahlung, and interaction of intense light with plasma. The last part deals with use of thermal neutron scattering as a tool in condensed matter research. ***(Not offered 1981-82.)***
S. H. Chen

22.55J Biological and Medical Applications of Radiation and Radioisotopes I (A)

(Same subject as HST 560J)
Prereq.: 8.271 or 22.111
Year: G (1)
4-0-8

Principles of radiation production and interactions. Radiation dosimetry with emphasis on applications and health hazards. Shielding of beta, gamma, and neutron radiation from isotope and machine sources. Detection and spectroscopy of beta, gamma, and neutron radiation. Neutron activation analysis. Production of radioisotopes and radiopharmaceuticals. Principles of nuclear medicine. A comprehensive term paper and presentation are required.
G. L. Brownell, Staff

22.56J Principles of Medical Imaging (A)

(Same subject as 2.761J, HST 561J)
Prereq.: Permission of Instructor
Year: G (2)
4-0-8

Principles of medical imaging including X-ray, nuclear medicine, ultrasound, NMR, emission and transmission-computed tomography, and other modalities. Two-dimensional and three-dimensional imaging techniques and displays. Fundamentals of image formation, physiology of image perception, physics of radiation and ultrasound interaction and detection, and physics of NMR. Quantitation of images and reconstruction algorithms. Medical applications, biological hazards and cost-benefit analysis of imaging modalities. A comprehensive term paper required.
G. L. Brownell, P. P. Lele, Staff

22.57J Radiation Biophysics (A) (New)

(Same subject as HST 568J)
Prereq.: 8.271 or 22.111
Year: G (1)
4-0-8

Effects of ionizing radiation, ultraviolet radiation, and heat on biological materials, cells and tissues of mammals. *In vivo* and *in vitro* mammalian systems examined in detail, and mathematical models for cell survival explored with particular emphasis on prediction. Microstructural damage to cell components such as membranes, organelles, enzymes, and DNA studied thoroughly. Radiation syndromes in man, mutagenesis, and carcinogenesis also investigated. Concludes with discussion on new directions for cancer therapy using heavy ion radiation.
A. C. Nelson

22.571J General Thermodynamics I (A)

(Same subject as 2.451J)
Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Presentation of foundations of thermodynamics in a general way, followed by the application of thermodynamic principles to energy conversion systems and industrial processes. First part: the first and second laws are introduced together with the definitions of work, energy, stable equilibrium, available work, entropy, thermodynamic potentials, and interactions (work, nonwork, heat, mass transfer). Second part: thermodynamic analyses of stable equilibrium properties of materials, bulk flow, energy conversion processes, chemical equilibria, combustion, and industrial manufacturing processes.
E. P. Gyftopoulos

22.572J General Thermodynamics II (A)

(Same subject as 2.452J)
Prereq.: 2.451J or 22.571J
Year: G (2)
3-0-9

Continuation of application of thermodynamic principles to practical problems, followed by a presentation of quantum statistical foundations of thermodynamics. First part: thermodynamic analyses of ideal and nonideal solutions, electrolytes, surface phenomena, and gas-solid interfaces; linear rate processes and phenomenological equations. Second part: Gibbsian and quantum probabilities, and corresponding definitions of states. Derivations of canonical distributions, and Bose-Einstein, Fermi-Dirac, and Boltzmann statistics, and quantum-statistics of semiperfect and perfect gases, including one-particle systems, and Einstein and Debye theories of crystals.
E. P. Gyftopoulos

Plasmas and Controlled Fusion

22.610 Controlled Fusion Power (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Survey of energy for the future, including resources, demand and cost, with emphasis on the 21st century. Introduction to controlled fusion concepts: fusion reactions, basic methods of producing and confining fusion plasmas; extraction of energy and regeneration of fuel. Introduction to technologies related to controlled fusion power: large magnetic field structures, lasers, heat transfer, materials. Description and critique of proposed fusion reactor schemes. The outlook for controlled fusion power in the post AD 2000 period. Includes appropriate reviews of electromagnetic theory and other necessary skills, to prepare an entering graduate student for more specialized fusion studies in the Department of Nuclear Engineeering.
L. M. Lidsky

22.611J Introduction to Plasma Physics I (A)

(Same subject as 6.651J, 8.613J)
Prereq.: 6.014 or 8.07, 6.018 or 8.04, 18.04 or 18.975
Year: G (1)
3-0-9

Introduction to plasma phenomena relevant to energy generation by controlled thermonuclear fusion and to astrophysics. Coulomb collisions and transport processes. Motion of charged particles in magnetic fields; plasma confinement schemes. Low-frequency plasma dynamics: MHD models; simple equilibrium and stability analysis. Two-fluid hydrodynamic plasma models; wave propagation in a magnetic field. Introduction to kinetic theory; Vlasov plasma model; electron plasma waves and Landau damping; ion-acoustic waves; streaming instabilities; derivation of the collision operator; Spitzer conductivity.
K. Molvig, A. Bers, M. Porkolab

22.612J Introduction to Plasma Physics II (A) (Revised Content)

(Same subject as 6.652J, 8.614J, 16.59J)
Prereq.: 6.651J or 8.613J or 22.611J, 18.075
Year: G (2)
3-0-9

Linear waves and instabilities in magnetized plasma; solutions of Vlasov-Maxwell equations in homogeneous and inhomogeneous plasmas; conservation principles for energy and momentum; negative energy waves; absolute and convective instabilities. Quasi-linear theory and conservation principles; evolution of unstable particle distribution functions. Collisional transport theory; Fokker-Planck equations; particle diffusion, thermal conductivity, and viscosity in magnetized plasma.
A. Bers, R. C. Davidson, J. E. McCune, K. Molvig

22.615 MHD Theory of Magnetic Fusion Systems (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Theory and applications of ideal MHD theory to magnetic fusion systems. Includes a derivation of the MHD equations, illustrating the physics described by the model and the range of validity. Provides a basic description of equilibrium and stability of current magnetic fusion systems such as tokamak, stellarator/toratron, and reverse field pinch.
J. P. Freidberg

22.621 Thermonuclear Reactor Design (A)

Prereq.: 22.311; 22.610 or 22.611J
Year: G (2)
3-0-9

Systems analysis and design of controlled thermonuclear reactors, development of criteria for CTR feasibility on basis of economic and technical considerations, detailed critical review of DOE's prototype reference reactor designs, non-Maxwellian reactors, laser-induced fusion, blanket neutronics, fission-fusion symbiosis, radiation damage, environmental hazards.
L. M. Lidsky

22.622 Special Topics in Thermonuclear Reactor Design (A)

Prereq.: 22.621
Year: G (1)
3-5-4

Engineering physics of CTR subsystem: large superconducting magnet materials and design, neutral beam generation and control, divertors and gas blankets, energy storage and recovery, structural material behavior. A group design project chosen from topics of current interest, based on and extending the formal lectures. Object of the design project to study the integration of the wide range of plasma physics, technological and economic reality in a large-scale research device such as a mirror reactor neutron source or break-even two component tokamak.
L. M. Lidsky

22.63 Engineering Principles for Fusion Reactors

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Introductory subject for advanced undergraduate and graduate students without previous background in principles and practices of systems relevant to controlled fusion. Mechanism and techniques for plasma production. Vacuum engineering based on considerations of free molecular flow, surface physics, and standard design practices. Magnetic field generation by normal, cryogenic, and superconducting coils: electrical, heat transfer, and structural requirements. High voltage engineering and practices. Methods of plasma heating: ion, electron, and neutral beam production, microwave and laser systems. Applications to fusion systems. (Open to qualified undergraduates.)
Staff

22.64J Plasma Kinetic Theory (A)

(Same subject as 8.621J)
Prereq.: 8.613 or 16.59J
Year: G (1)
3-0-9

Content varying from year to year. Typical subjects: the linearized Vlasov equation, Fokker-Planck and diffusion approximations for the average distribution function, autocorrelation functions, resonant and nonresonant diffusion, free energy, energy and momentum conservation, resonant wave coupling, nonlinear Landau damping, strong turbulence theories. Selected applications to enhanced diffusion, stochastic acceleration, turbulent resistivity, shock waves, radio emission.
T. H. Dupree

22.65J Advanced Topics in Plasma Kinetic Theory (A)

(Same subject as 8.622J)
Prereq.: 8.621J or 22.64J
Year: G (2)
3-0-9

Varying content including topics of current interest. Typical subjects: theories of collective phenomena such as linear instability and nonlinear saturation mechanisms in plasma, particularly in regimes described by the Vlasov-Maxwell equations. Effects of wave-particle resonance; trapping and scattering of particles by waves. Linear theory of instabilities in inhomogeneous plasmas. Reflection and eigen-

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mode problems in bounded systems. Diffusion phenomena and anomalous resistivity associated with wave-particle interaction. Discussion of experiments.
T. H. Dupree

22.66 Transport Phenomena in Toroidal Systems (A)

Prereq.: 22.611J or 6.651J or 8.613J, 22.64J or 8.621J
Year: G (2)
3-0-9

The degree to which the first generation of fusion burning tokamak or stellarator experiments will produce significant energy gain depends on the totality of and interaction between various transport phenomena of particles and energy across the confining toroidal magnetic field. A survey is presented of the plasma phenomena pertaining to the various loss channels, and their synthesis in reactor transport codes modeling the approach to ignition. Attempts are made to compare predictions of transport theory and results from the major tokamak and stellarator experiments. The theoretical phenomena surveyed include: classical and neo-classical collisional transport of hydrogen and impurity ions in a toroidal magnetic field; finite beta anomalous electron transport due to magnetic islands and stochastic field lines caused by tearing and resistive ballooning and drift modes; anomalous alpha particle transport due to Alfven modes driven by the strong spatial gradient of the alpha pressure in the plasma core and by the non-Maxwellian alpha distribution in velocity space, including the loss effects due to large orbits and field ripple.
D. J. Sigmar

22.67 Plasma Diagnostics (A)

Prereq.: 22.611J or 6.651J or 8.613J
Year: G (1)
3-0-9

Diagnostic systems for measurement of plasma properties and behavior with emphasis on thermonuclear plasmas. Measurements of time averaged and fluctuating values of particle densities, particle energies, electric and magnetic fields. Techniques of electric and magnetic probes; methods involving emission, absorption, and scattering of r-f, microwave, optical, and X-ray radiation by plasmas; schemes involving emission or scattering of particles by plasmas.
Staff

22.69 Plasma Laboratory (A)

Prereq.: 22.611J or 6.651J or 8.613J or 22.63
Year: G (1)
1-4-4

Introduction to the advanced experimental techniques needed for research in plasma physics and useful in experimental atomic and nuclear physics. Laboratory work on vacuum systems, plasma generation and diagnostics, physics of ionized gases, ion sources and beam optics, cryogenics, magnetic field generation, and other topics of current interest; brief lectures and literature references to elucidate the physical bases of the laboratory work. (Meets concurrently with 22.069, but assignments differ.)
Staff

22.70J Materials for Nuclear Applications (A) (New)

(Same subject as 3.711J)
Prereq.: 22.71J or 3.71J or 3.14
Year: G (2)
3-0-9

Introductory subject for students who are not specializing in nuclear materials. Applications and selection of materials for use in nuclear applications. Radiation damage, radiation effects, and their effects on performance of materials in fission and fusion environments. (Meets concurrently with 22.070J, but assignments differ.)
Staff

22.71J Physical Metallurgy Principles for Engineers (A)

(Same subject as 3.71J)
Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Crystallography and microstructure of engineering materials. Thermodynamics of alloys, structural theory of metallic phases. Rate processes in metals: solidification, solid state diffusion, oxidation, and phase transformation. Defect properties: point defects, dislocations, and radiation damage. Mechanical properties: plastic deformation, work hardening, strengthening mechanisms, and fracture. Recovery and recrystallization. Emphasis on structure-properties relationships, their physical interpretation, and quantification. (Meets concurrently with 22.071J, but assignments differ.)
I-W. Chen

22.72J Nuclear Fuels (A)

(Same subject as 3.72J)
Prereq.: 3.13 or 3.14 or 22.71J or 3.71J
Year: G (1)
3-0-9

Behavior of nuclear fuels and fuel element cladding materials in reactor cores. Experimental observations; phenomenological and theoretical modeling of radiation; and thermal-induced effects such as fuel and cladding swelling, fission gas release, and radiation-induced creep. Fuel design, performance modeling, and reliability analysis using state-of-the-art computer codes. Recent developments in advanced nuclear and fusion related core materials.
Staff

General

22.73J Radiation Effects in Crystalline Solids (A)

(Same subject as 3.721J)
Prereq.: 3.02 or 3.71J or 22.071J or 22.71J
Year: G (2)
3-0-9

Unified treatment based on governing principles for radiation effects in crystalline solids with the focus on metals. Collision theory of displacement damage: displacement processes, energy dissipation, and crystallographic effects. Evolution of damage state: primary damage state, recovery of damage related to mobility, and structure of crystalline imperfection, defect configurations. Rate processes enhanced by radiation: solute redistribution, phase transformations, gas bubbles, void swelling, and phase stability. Mechanical properties: deformation resistance, irradiation creep, irradiation growth, and fracture.
I-W. Chen

22.75J Radiation Effects in Reactor Structural Materials (A)

(Same subject as 3.75J)
Prereq.: 3.71J or 22.71J
Year: G (2)
3-0-9

Classes and characteristics of structural materials used in the core and primary circuits of fission and fusion reactor systems. Effects of radiation on strength, brittle fracture, high-temperature embrittlement, creep and growth, and void swelling on engineering properties. Materials specifications, design principles, and quality assurance. Materials problems in reactor safeguard analysis. Case studies of reactor materials failures.
K. C. Russell

22.76J Introduction to Nuclear Chemical Engineering (A)

(Same subject as 10.79J)
Prereq.: 22.311 or 10.302
Year: G (1)
3-0-9

Applications of chemical engineering to the processing of materials for and from nuclear reactors. Fuel cycles for nuclear reactors; chemistry of uranium, thorium, zirconium, plutonium and fission products; extraction and purification of uranium and thorium from their ores; processing of irradiated nuclear fuel; solvent extraction and ion exchange as applied to nuclear materials; management of radioactive wastes; principles of and processes for isotope separation. (Open to qualified undergraduates. Alternate years. ***Offered 1981-82.***)
Staff

22.77 Nuclear Waste Management (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

A general introduction to the scientific and engineering aspects of the management of spent fuel, reprocessed high-level waste, mill tailings and transuranic and low-level wastes and retired nuclear facilities. Fundamental processes and governing equations of radiation and radionuclide transport. Selection criteria for multibarrier system components for long-term waste storage. Analysis of interim storage, processing, and transportation technologies. Analytical methods for risk assessment of waste management and disposal.
R. K. Lester

22.80 National Socio-Technological Problems and Responses (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Designed to acquaint the student with large socio-technological problems and our capabilities regarding them in ways beyond discipline-oriented research. The structure and content of national problems; connectivity between problems and sectors. Review of present organizations at the working level (universities, national laboratories, industrial laboratories, etc.) extent to which they relate to the decision-making levels, and extent to which they match or mismatch their programs to the true scale of problems. Recent efforts to make new organizations or to re-orient present ones. Recent debates, programs, and proposals related to energy and the environment used as particular examples.
D. J. Rose

22.81 Energy Assessment (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-9

An introduction to the broad field of energy, including technological, social, environmental, economic, and political aspects. Energy provision, transformation, and utilization. Development of energy options for the future, and analyses of present regional, national, and international energy programs. Intended for graduate students entering specific energy fields or fields in which energy is important and who desire a holistic overview. (Meets concurrently with the undergraduate subject 22.08, but assignments differ.)
D. J. Rose

22.82 Engineering Risk-Benefit Analysis (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Risk evaluation and cost-benefit analysis techniques for the assessment of engineering projects involving risks. Emphasis on the public sector. Balancing risks and benefits with concern for financial uncertainties, environmental risks, and especially, issues of human safety. Introduction to decision analysis, value of information, problems with multiple goals and issues related to collective decisions. Issues of public policy and regulation. Case studies with attention to the nature of public discussion. Cases drawn from dam safety, safety of nuclear reactors, transport and storage of liquefied natural gas, seismic risk problems, and off-shore oil exploration. Some background in

elementary probability assumed. (This subject is intended mainly for graduate and upper-class students in the School of Engineering, and is an Engineering School-Wide Elective subject.)
M. E. Patè, A. W. Drake

22.821 Engineering Systems Analysis (A) (New)

Prereq.: Permission of Instructor
Year: G (1)
3-0-6

Synthesis of the analytic procedures for the identification and selection of optimal systems. Review of the economic framework for analysis. Systematic survey of theory and applications of mathematical optimization to engineering problems. Evaluation procedures for single and multi-attributed problems covering utility theory and decision analysis in addition to standard procedures. The application of this material to real problems in planning and design stressed throughout the term. (Open to qualified undergraduates. Knowledge of probability, microeconomics, and computer systems at an undergraduate level required.) This subject is an Engineering School-Wide Elective.
R. de Neufville, J. P. Clark

22.83J The Finite Earth: Agendas for a More Just, Sustainable and Participatory Society

(Same subject as 4.761J, 11.486J, 17.440J, 21.919J)
Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Problems such as food supply, energy, material resources, global environment, and rapid changes in third world countries often tend to be looked on as separate; but each affects the other, and the connective tissue between them is too often lost. Subject explores several of these issues (especially food, energy, technology transfer, world security and the views from alternative social systems) in context. Each topic cannot be developed in depth; purpose of the subject is to introduce interested students to these issues; to ways in which they interactively influence the quality of social life for many in today's world; and to assess choices and directions for the future, both generally and as they may affect the student's own personal and professional interests. Content is developed via a combination of lectures and discussion groups.
D. J. Rose, J. Beinart, N. B. Herman, W. R. Johnson, M. Diskin

22.84 Nuclear Energy Policy Analysis (A)

Prereq.: Permission of Instructor
Year G (2)
3-0-9

Technology assessment and policy analysis of nuclear fuel cycle topics. Overview of selected fuel cycle technologies. Quantitative and qualitative assessments of the social, political, and environmental consequences of nuclear energy policy decisions. Functions and organization of institutions participating in research and development, management and regulation. Institutional alternatives. Topics: nuclear waste management and regulation; nuclear fuel supply; development of advanced reactor and fuel cycle systems; and the relationships between nuclear power and nuclear weapons proliferation. Term paper required. (Alternate years. ***Not offered 1981-82.***)
R. K. Lester

22.86 Entrepreneurship

Prereq.: —
Year: G (2)
4-0-5

Introduction to the various issues faced by technical innovators who are interested in becoming entrepreneurs. Lectures and discussions are held on concept evaluation, patents, licensing, contract negotiation, marketing, business planning, financing, accounting and small business management. Students encouraged to use their own innovative ideas as the object of study topics. This subject is an Engineering School-Wide Elective (open to undergraduates by permission of instructor.)
D. G. Jansson

22.87J Current Issues in Engineering

(Same subject as 1.491J, 3.562J, 6.941J, 13.682J)
Prereq.: —
Year: G (S)
3-0-6

Review of a selection of technological developments of great significance to industrialized societies, choosing from current areas such as electronic materials and microprocessors, conventional and new energy technology, and practical aspects of cell manipulation. Key features of the technologies, and their relationships to social, economic, and managerial issues that their development implies.
T. H. Lee

22.88J Cases and Projects in Engineering Management (A) (New)

(Same subject as 1.492J, 3.563J, 6.942J, 13.683J)
Prereq.: 22.87J
Year: G (1)
3-1-5

Continuation of 22.87J with a shift from macro-level of technologies toward micro-level of projects. Case studies of and student projects involving several real engineering and scientific programs in industrial firms and government agencies. Cases chosen from new ventures as well as mature firms, in both product and process development. All aspects of projects assessed.
T. H. Lee

22.89 Basic Electronics

Prereq.: —
Year: G (S)
3-4-5

For science and engineering research students with little or no background in electronics, who need a working knowledge of electronic circuits and devices. Topics include network theory, active devices and circuits, operational and instrumentation amplifiers, and digital electronics. Equal emphasis on laboratory and classroom work.
L. M. Lidsky

22.901-22.904 Special Problems in Nuclear Engineering (A)

Prereq.: Permission of Instructor
Year: G (1, 2)
Arr.

For graduate and advanced undergraduate students who wish to carry out a one-term project of a theoretical or experimental nature in the nuclear engineering field in close cooperation with individual staff members. Arrangement of topic and hours to fit student requirements.
A. F. Henry

22.911 Seminar in Nuclear Engineering

Prereq.: —
Year: G (1)
2-0-1

22.912 Seminar in Nuclear Engineering

Prereq.: —
Year: G (2)
2-0-1

Restricted to graduate students engaged in doctoral thesis research.
J. E. Meyer

22.913 Graduate Seminar in Energy Assessment

Prereq.: Permission of Instructor
Year: G (1)
2-0-1

Primarily designed as a communication medium among students conducting research in energy-related areas, and as a means for obtaining critical evaluation of their ongoing research work. Covers topics ranging from technological comparisons to environmental, social, resource, and political impacts, depending on current student and faculty interest.
R. K. Lester

22.914 Graduate Seminar in Energy Assessment

Prereq.: Permission of Instructor
Year: G (2)
2-0-1

Continuation of 22.913.
R. K. Lester

22.915 Seminar in Reactor Safety

Prereq.: Permission of Instructor
Year: G (1)
2-0-4

A survey of general considerations and methodology of safety analysis as applied to commercial and advanced reactor designs. Specific topics selected for review and discussion by the participating students. Invited speakers lecture on the status of current safety research.
M. S. Kazimi, C. D. Heising-Goodman

22.92 Advanced Engineering Internship

Prereq.: 22.092
Year: G (1, 2, S)
0-6-0

Provides credit for the third and fourth Work Assignments for students affiliated with the Engineering Internship Program. Students register for this subject twice. Students must complete both Work Assignments to receive the academic credit for this subject. (Enrollment limited to students in the Engineering Internship Program.)
J. E. Meyer

22.93 Teaching Experience in Nuclear Engineering (A) (New)

Prereq.: Permission of Department
Year: G (1, 2, S)
Arr.

For qualified graduate students interested in teaching as a career. Classroom, laboratory, or tutorial teaching under the supervision of a faculty member. Students selected by interview. Enrollment limited by the availability of suitable assignments. (Credits for this subject may not be used toward Master's or Engineer's degrees.)
N. C. Rasmussen

24 Linguistics and Philosophy

Philosophy

24.UR Undergraduate Research

Prereq.: —
Year: U (1, 2)
Arr.

Undergraduate research opportunities in Linguistics and Philosophy. For further information consult the Departmental Coordinators:
S. J. Keyser: Linguistics
G. S. Boolos: Philosophy

24.01 Contemporary Moral Issues

Prereq.: —
Year: U (1, 2) HUM-D
3-0-6

An examination of some practical issues in moral and social philosophy as they occur in theoretical controversies related to contemporary experience. This year's topics center about moral questions of life and death: abortion, the ethics of killing, suicide, problems in sexual morality, human rights, preferential hiring, and war. Readings from great writers in the history of philosophy as well as from contemporary philosophers.
Term 1: *J. W. DeCew*
Term 2: *I. Singer*

24.02 Philosophy of Art: Classic and Contemporary

Prereq.: —
Year: U (1) HUM-D
3-0-6

Introduction to philosophical attempts to explain the nature of art in general and various specific arts in particular. Traditional approaches in history of philosophy studied in relation to contemporary critiques of these approaches. Topics include problems in theory of painting, film theory, literary theory, music theory, etc., as well as analyses of artistic creativity, aesthetic experience, conflicts in taste, and nature of criticism. Readings from thinkers such as Plato, Aristotle, Kant, Hegel, Schopenhauer, Nietzsche, and Tolstoy as well as recent philosophers who deal with similar problems in ways that are different from their classical forebears but also continuous. ***(Not offered 1981-82.)***
I. Singer

24.03 Logic, Language and Values

Prereq.: —
Year: U (1, 2) HUM-D
3-0-6

Introduction to that part of philosophy that deals with *truth, meaning,* and *proof.* Application of logic and analysis to perennial philosophical problems such as the existence of God, the difference between deduction and induction, the definition of *good,* and validity in reasoning. Fallacies and paradoxes. Readings from such authors as Plato, Locke, Hume, Bertrand Russell, W.V. Quine.
Term 1: *J. A. Fodor*
Term 2: *P. G. Horwich*

24.04 Problems of Philosophy

Prereq.: —
Year: U (1, 2) HUM-D
3-0-6

An introduction to the problems of philosophy, in particular, to problems in ethics, metaphysics, theory of knowledge, and philosophy of logic, language, and science. A systematic rather than historical approach. Readings from classical and contemporary sources, but emphasis on examination and evaluation of proposed solutions to the problems.
Term 1: *S. Bromberger, J. F. Thomson*
Term 2: *S. Bromberger, J. F. Thomson, J. J. Thomson*

24.05J Nature of Scientific Knowledge

(Same subject as STS 205J)
Prereq.: —
Year: U (1, 2) HUM-D
3-0-6

An introduction to fundamental philosophical problems concerning the nature of science and its development. How, for example, is scientific knowledge arrived at; in what circumstances are theories rejected and replaced; what criteria or values govern these processes; and what gives their outcome such reliability? Are facts given once and for all, independent of theory, or does change of theory change what it is to be a fact? Do scientific theories describe an underlying reality, or do they merely provide an economical systematization of concrete experimental results?
Term 1: *P. G. Horwich*
Term 2: *T. S. Kuhn*

24.06 Philosophy of Plato

Prereq.: —
Year: U (2)
3-0-6

An introductory study of many of Plato's major dialogues. Emphasis on the role of Plato's thought as a foundation and source of a broad range of modern philosophical problems. Topics: the Socratic method and the philosophy of Socrates; Plato's ethics and political philosophy; the metaphysics and epistemology of Plato's Forms; Plato's contributions to logic and semantics. ***(Not offered 1981-82.)***
R. L. Cartwright

24.07 Classics in the History of Philosophy

Prereq.: —
Year: U (2) HUM-D
3-0-9

An introduction to philosophy through its history. Readings in primary sources such as: Plato's *Republic,* Aristotle's *Ethics,* Descartes' *Meditations,* Hume's *Inquiries.* Emphasis on becoming closely acquainted with important historical texts and examining fundamental philosophical issues as they appear in works that have been unusually influential in the historical development of Western philosophy.
E. W. McCann

24.09 Freedom and Authority

Prereq.: —
Year: U (1) HUM-D
3-0-6

Examination of the proper characterization and relation of such terms as freedom, autonomy, authority, and democracy; the extent to which political institutions can legitimately regulate individual conduct; the nature and source of the obligation to comply with directives of these institutions. Use of theoretical material from classical sources in political and social philosophy, and accounts of more specific issues from contemporary work in philosophy, law, and social science.
J. Cohen

24.112 Modern Social Theory

Prereq.: —
Year: U (1)
3-0-6

The theory of the state. Focus on three stages in the development of the modern state: political absolutism, the property-contract state, and the corporate-welfare state. In each section close attention given to key texts in political theory and to their relationship to the corresponding historical period. ***(Not offered 1981-82.)***
J. Cohen

24.113 Existentialism and Phenomenology

Prereq.: —
Year: U (2)
3-0-6

An introduction to the methods, views, and development of the existential and phenomenological movements in philosophy; their backgrounds and mutual relationship; their contributions to psychology, social science, literature, and religion as well as to other traditional branches of philosophy such as metaphysics, epistemology, and ethics. Some topics: life-world, ego, self, intersubjectivity, intentionality, human freedom. ***(Not offered 1981-82.)***
E. W. McCann

24.114 Concepts of Love in the Western World

Prereq.: —
Year: U (2)
3-0-9

Writings in philosophy, literature, psychology, and behavioral biology studied for their relevance to various concepts of love. Topics: Platonic eros; types of Judaeo-Christian love; courtly, romantic, and naturalistic theories of sexual love; literary myths about male and female sexuality; and scientific investigations into the nature of affective bonding. Readings from recent sources as well as major texts in the history of ideas.
I. Singer

24.115 Concepts of Genetic Determination

Prereq.: —
Year: U (2)
3-0-6

Critical examination of concepts of genetic determination involved in: a) controversies over innate knowledge in rationalism-empiricism debate, in linguistics, and in psychology; b) controversies over heritability of intelligence and personality; c) sociobiology controversies with special attention to arguments over genetic determination of altruism and sex differences.
N. Block

24.116J Introduction to Cognitive Science

(Same subject as 9.62J, SRE 108J)
Prereq.: —
Year: U (1)
3-0-9

Survey of major issues that occupy contemporary cognitive science. Topics: induction and inductive logics as psychological theories; formal learning theory in linguistics; Is English a finite state language?; deduction and deductive logics as psychological theories; concepts and conceptual composition; the problem of natural concepts; images and percepts. Emphasis on clear formulation of questions and theoretical criteria of adequacy. Examination of specific proposals in response to these questions.
D. N. Osherson

24.117 Philosophy of Mind and Psychology

Prereq.: —
Year: U (1)
3-0-9

Traditional topics in philosophy of mind, such as behaviorism, materialism, and functionalism; and conceptual issues more closely related to psychology and linguistics, such as psychological reality of grammar, tacit knowledge, the competence-performance distinction, nativism, and mind-machine issues.
T. Burge

24.119 Minds and Machines

Prereq.: —
Year: U (2)
3-0-9

Examination of problems in the intersection of artificial intelligence, psychology, and philosophy. Issues discussed: whether people are Turing Machines, whether computers can be conscious, limitations on what computers can do, computation and neurophysiology, the Turing test, the analog/digital distinction, Gödel's theorem and mechanism, the relation between simulation and explanation, whether some aspects of mentality are more resistant to programming than others.
N. Block

24.151 Introduction to Philosophy of Language

Prereq.: —
Year: U (2)
3-0-6

Examination of views on the nature of meaning, reference, truth, and their relationships. Other topics may include relationships between language and logic, language and knowledge, language and reality, language and acts performed through its use. No knowledge of logic or linguistics presupposed.
S. Bromberger

24.161 Classics in the Philosophy of Science

Prereq.: —
Year: U (2)
3-0-6

The subject addresses itself to some of the major writings by philosophers and scientists concerned with the task of elucidating the nature, goals, structure, methods, and limitations of the natural sciences. Actual authors chosen determined to some extent by the interests of the class but emphasis put (at least initially) on works by Mach, Poincare, Duhem, Meyerson, Campbell, and other recent but not contemporary writers whose views have shaped those of many contemporary scientists. ***(Not offered 1981-82.)***
P. G. Horwich

24.200 Ancient Philosophy

Prereq.: One Philosophy subject
Year: U (1)
3-0-9

Philosophic thought in Greece from its beginnings in the 6th century BC through the post-Aristotelian schools of the Hellenistic period. Emphasis on the philosophies of Socrates, Plato, and Aristotle.
R. L. Cartwright

24.201 Medieval Philosophy

Prereq.: One Philosophy subject
Year: U (1)
3-0-9

Western philosophy from the 5th century through the 14th. Emphasis given to medieval contributions to philosophy of religion, metaphysics, theory of knowledge, and philosophy of logic. Special attention to the philosophies of Augustine, Anselm, Aquinas, and Ockham. ***(Not offered 1981-82.)***
R. L. Cartwright

24.202 Modern Philosophy: Descartes to Kant

Prereq.: One Philosophy subject
Year: U (2)
3-0-9

Philosophic thought in Europe during the 17th and 18th centuries. The continental rationalists: Descartes, Spinoza, and Leibniz; the British empiricists: Locke, Berkeley, and Hume; Kant.
J. Cohen

24.206 Continental Philosophy: Schopenhauer, Nietzsche, Freud, Sartre

Prereq.: One Philosophy subject or Permission of Instructor
Year: U (1)
3-0-9

Major works of these four thinkers studied in themselves and in relation to romantic and existentialist philosophies of the 19th and 20th centuries.
I. Singer

24.208 Wittgenstein

Prereq.: One Philosophy subject
Year: U (2)
3-0-6

Study of Wittgenstein's later philosophy, with special attention to his views about language, knowledge, and the nature of philosophy. ***(Not offered 1981-82.)***
P. G. Horwich

24.211 Theory of Knowledge

Prereq.: One Philosophy subject
Year: U (2)
3-0-9

Study of problems concerning our concept of knowledge, our knowledge of the past, our knowledge of the thoughts and feelings of ourselves and others, and our knowledge of the existence and properties of physical objects in our immediate environment.
J. F. Thomson

24.221 Metaphysics

Prereq.: One Philosophy subject
Year: U (1)
3-0-9

Problems involved in basic metaphysical concepts; substance, essence, existence, universality, causality, and spatio-temporality. Classical and contemporary analysis of these concepts.
J. J. Thomson

24.231 Ethics

Prereq.: One Philosophy subject
Year: U (2)
3-0-9

Systematic study of some central problems in ethics, such as the relation between fact and value, the nature of obligation, the relevance to moral evaluation of pleasure, desire, intention, etc.
J. J. Thomson

24.233J Political Philosophy

(Same subject as 17.105J)
Prereq.: One Philosophy subject
Year: U (1)
3-0-9

Freedom and the social order. An analysis of central works of modern political philosophy focusing on their efforts to develop political theories based on the idea of freedom. Readings from Hobbes, Rousseau, Marx, and Mill. ***(Not offered 1931-82.)***
J. Cohen

24.235 Philosophy of Law

Prereq.: One Philosophy subject or Permission of Instructor
Year: U (1)
3-0-9

Examination of fundamental issues in philosophy of law such as the nature and limits of law and a legal system and the relation of law to morality, with particular emphasis on the philosophical issues and problems associated with privacy, liberty, justice, punishment, and responsibility. Historical and contemporary readings, including court cases.
J. W. DeCew

24.241 Symbolic Logic

Prereq.: —
Year: U (1)
3-0-9

Introduction to the aims and techniques of formal logic. The logic of truth-functions and quantifiers. Formal systems: consistency and completeness. The decision-problem for a formal system. Applications of formal logic, the place of logic in philosophy.
G. S. Boolos

24.251 Philosophy of Science

Prereq.: One Philosophy subject
Year: U (1)
3-0-6

Discussion of problems concerning the principles and methods of scientific activity, and their possible philosophical justifications. Analysis of hypothesis formation, testing, and choice. Role of induction, probability, simplicity, utility, and their difficulties. Character of scientific explanation and concept formation. Relation of observations to laws, theories, models, and the ontology of physical reality. Status of reductionism, unity of science, causality, and determinism.
P. G. Horwich

24.253 Induction and Probability

Prereq.: One Philosophy subject
Year: U (2)
3-0-6

The classical problem of justifying induction ('Hume's problem'). Discussion of some attempts to solve or dissolve the problem. The principles of probability. Conceptions of probability. The relationship between probability and induction. The new problem of induction ('Goodman's problem'). ***(Not offered 1981-82.)***
J. F. Thomson

24.261 Philosophy of Religion

Prereq.: One philosophy subject
Year: U (2)
3-0-6

An examination of such issues as: Is there any reason to believe that God exists? Can predicates normally applicable to human beings be meaningfully applied to God? Can God's foreknowledge be reconciled with the existence of free will and God's providence with the existence of evil? Is it meaningful to believe in the immortality of the soul and the resurrection of the body? The reading drawn from medieval theologians, 18th-century philosophers, and recent writers in the analytic tradition. ***(Not offered 1981-82.)***
R. L. Cartwright

24.270J Topics in the History of Physical Science

(Same subject as STS 221J)
Prereq.: —
Year: U (2)
3-0-9

By careful reading and analysis of selected scientific papers, the class attempts to reconstruct some significant episode in the evolution of physical science. Topic varies from year to year. ***(Not offered 1981-82.)***
T. S. Kuhn

24.292 Special Topics in Philosophy

Prereq.: Any two subjects in philosophy
Year: U (1)
Arr.

Open to qualified students who wish to pursue special studies or projects. Students electing this subject must consult the Department Head.
Staff

24.293 Special Topics in Philosophy

Prereq.: Any two subjects in philosophy
Year: U (2)
Arr.

Open to qualified students who wish to pursue special studies or projects. Students electing this subject must consult the Department Head.
Staff

24.301-24.302 Reading Seminar in Philosophy

Prereq.: —
Year: G (1, 2)
Arr.

Reading and discussion of special topics in the fields of philosophy. (Open to first-year graduate students in the Department and to others by permission of instructor.)
Staff

24.403 Aristotle (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

A study of some of Aristotle's most important works on metaphysics and logic. ***(Not offered 1981-82.)***
Staff

24.410 Topics in the History of Philosophy (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Intensive study of a philosopher or philosophical movement. Content varies from year to year, and subject may be taken repeatedly with permission of instructor and advisor. Topic 1981-82: Kant's *Critique of Pure Realism.*
E. W. McCann

24.421 Background of Contemporary Philosophy (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-9

The early philosophies of Moore and Russell; associated continental movements; logical atomism.
R. L. Cartwright

24.501 Problems in Metaphysics (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Metaphysical problems centering around concepts such as existence, substance, attribute, relation, identity, and change. Readings from both classical and contemporary sources. ***(Not offered 1981-82.)***
R. L. Cartwright

24.502 Space, Time, and Causality (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Examination of such problems and topics in metaphysics as causal theories of time, the direction of causation, spatial and temporal analogies, time travel, time without change, and Zeno's paradoxes. ***(Not offered 1981-82.)***
P. G. Horwich, J. J. Thomson

24.511 Problems in Theory of Knowledge (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Study of problems concerning the foundation of knowledge, with special attention to our concepts of evidence, belief, doubt, knowledge, and certainty. (Content varies from year to year; subject may be taken repeatedly with permission of instructor and advisor.)
S. Bromberger, J. T. Higginbotham

24.513 Phenomenology (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Anti-psychologism in Husserl, Frege, Bolzano. Concept of intentionality in Brentano, Meinong, and Husserl; its development as a theory of meaning in Husserl; its relation to contemporary theories of meaning and reference. ***(Not offered 1981-82.)***

24.517J Cognitive Theories (A)

(Same subject as 9.653J)
Prereq.: Permission of Instructors
Year: G (1)
3-0-9

Problems and topics in contemporary and historical approaches to higher cognitive processes. Material from the history of philosophy and from current work in psychology, philosophy, and linguistics examined from the point of view of its bearing on such issues as: What is the nature of the conceptual systems which internally represent knowledge and belief? How are such systems acquired and how are they employed in action, perception, and recall? To what extent is the nature of such systems discoverable from the examination of semantic and syntactic phenomena of natural languages? ***(Not offered 1981-82.)***
N. A. Chomsky, J. A. Fodor

24.518 Philosophy of Mind and Psychology (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Examination of such issues as: reductionism and physicalism, and the constraints they place on theories in psychology; functional analysis in psychological explanation; whether mental states are functional states; methodological solipsism; machine views of the mind; whether mental computation requires mental representation; the language of thought hypothesis; meaning as conceptual role; what concepts are; what images are; the subject matter of grammar; what it is for an aspect of the mind to be innate; the relation between logical behaviorism and Skinnerian behaviorism. ***(Not offered 1981-82.)***
J. A. Fodor

24.521 Topics in Philosophy of Mind (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Major theories of mind, with special emphasis on functional and representational theories. Brief survey of problems of identity theories of mind, such as problems posed by the indiscernibility of identicals, whether identities can be contingent (Kripke's objection to materialism), correlation vs. identity, type identity vs. token identity, identification vs. elimination. Discussions of versions of functionalism descended from behaviorism, and versions of functionalism descended from mind-machine analogies. Discussion of whether functionalism is compatible with materialism. Historical exposition of representational theories of mind. Relation of functionalist theories of mind to functionalist theories of the meaning of mental representations. Discussion of whether functionalism is compatible with representationalism.
J. A. Fodor

24.525 Topics in the Theory of Action (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

The nature of human action. Problems regarding the description of an act and its consequences. Identity-conditions for acts. Intention. Explanation of actions by appeal to motives, reasons, and causes. The logical form of action sentences. Readings from selected texts and current journals. ***(Not offered 1981-82.)***
J. J. Thomson

24.601 Topics in Moral Philosophy

Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Systematic examination of selected problems in moral philosophy. Content varies from year to year; subject may be taken repeatedly with permission of instructor and advisor.
J. J. Thomson

24.602 Seminar on Moral Psychology (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Examination of historical and contemporary views on topics such as egoism and altruism, moral scepticism, sympathy, moral deliberation, the nature of moral feelings and their role in moral theory. Readings from such authors as Aristotle, Hume, Kant, Rawls. ***(Not offered 1981-82.)***

24.603 Twentieth-Century Ethics (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Examination of major theories of rightness, including utilitarianism, intuitionism, emotivism and contractualism, and contrasting theories of the good, focusing on problems such as the open question argument and the naturalistic fallacy. Readings from such authors as Moore, Hare, Brandt, Ross, Rawls. ***(Not offered 1981-82.)***
J. W. DeCew

24.611 Topics in Political Philosophy (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Examination of such topics as liberty, equality, fraternity, social contract, political obligation, rights, property, distributive justice. Varying content from year to year, and may be taken repeatedly with consent of instructor.
J. Cohen

24.621J Aesthetics

(Same subject as 21.956J)
Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Philosophical problems about the history and theory of art. Topics: art as a mode of communication; ways in which art may or may not be a cluster of "languages" or "symbolic systems"; cognitive and non-cognitive elements in art. Particular emphasis on the "expression theory of art" and the nature of "artistic truth." Seminar designed for undergraduates in various fields as well as graduate students.
I. Singer, J. H. Harbison

24.701 Topics in Logic (A)

Prereq.: 24.241
Year: G (2)
3-0-9

Soundness, completeness, and compactness of first-order logic, Löwenheim-Skolem theorems, Craig interpolation lemma, Beth definability theorem, decidability of monadic logic with identity, Turing machines, recursive functions and their definitions, Gödel incompleteness theorems and extensions, undecidability of dyadic logic, Tarski's theorem, nonstandard models of arithmetic. ***(Not offered 1981-82.)***
G. S. Boolos

24.703 Set Theory (A)

Prereq.: 24.241
Year: G (1)
3-0-9

Zermelo-Fraenkel set theory. Topics: the paradoxes and their resolutions, relations, functions, orderings, ordinals, the "reduction" of arithmetic to set theory, types and the general structure of the universe of set theory, cardinals, orders of infinity, continuum question, Konig's theorem, concept of truth, Löwenheim-Skolem theorem, reflection principle, measurable and inaccessible cardinals. ***(Not offered 1981-82.)***
G. S. Boolos

24.711 Philosophy of Logic (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-9

The concept of truth; other topics include: reference, meaning, modality, identity, ontological commitment, the indeterminacy of translation. ***(Not offered 1981-82.)***
R. L. Cartwright

24.712 Algorithms, Grammars, and Syntax (A)

Prereq.: 24.241
Year: G (1)
3-0-9

Survey of results about the relationships between finite state automata, their associated algorithms, and formal grammars (in the sense of Chomsky, Scott, and others). Study of some open problems. Informal and algebraic approach. (Permission of instructor required.)
J. F. Thomson

24.721 Reference (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Historical and critical discussion of such topics as: apparent references to the non-existent, the abstract, the past, and the future; proper names, definite and indefinite descriptions, nonsingular referring expressions, and indexical terms; reference and identity; identification and re-identification; sense and reference; reference and propositional attitudes; reference and modality; so-called incomplete symbols and systematically misleading expressions; reference, quantification, and ontological commitment; the alleged inscrutability of reference. Readings from such philosophers as Meinong, Frege, Russell, Quine, and Kripke.
T. Burge

24.725 Meaning (A)

Prereq.: Permission of Instructors
Year: G (2)
3-0-9

Systematic and critical examination of empirical and philosophical issues about meaning such as: meaning and use, meaning and intention, meaning and intension, meaning and possible worlds, sentence meaning and speaker's meaning, the nature of semantic theory, semantic and pragmatic competence, logical form and grammatical form, the nature of empirical evidence bearing on questions of meaning and logical form. ***(Not offered 1981-82.)***
S. Bromberger, N. A. Chomsky

24.727 Logic and Language (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Logic and language: an investigation of the relation between the syntactic and semantic representations of natural language sentences provided by generative grammars and the formal representations provided by standard logical theories. Some of the specific topics chosen for the term discussed at the first meeting. Some acquaintance with the standard works in generative syntax and analytic philosophy of language presupposed. ***(Not offered 1981-82.)***

24.801 Philosophy of Mathematics (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Examination of major philosophies of mathematics — logicism, formalism, intuitionism — on the nature of mathematical proof, existence of mathematical entities, and related issues. (It is strongly recommended that students have taken 24.241 or equivalent.)
G. S. Boolos

24.811 Philosophy of Physics (A)

Prereq.: 8.04
Year: G (2)
3-0-9

Discussion of philosophical problems concerning the foundations of classical mechanics, special relativity, general relativity, and quantum mechanics. Special consideration of such basic concepts as space, time, and causality. Analysis of both standard and nonorthodox accounts, and emphasis on the ontologies that emerge from these theories. (Undergraduates admitted by consent of instructor.)
P. G. Horwich

24.831 Topics in Philosophy of Psychology (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Systematic philosophical examination of a psychologist or psychological school. Content varies from term to term and year to year; subject may be taken repeatedly with permission of instructor and advisor.
N. Block

24.851 Problems of Explanation and Theory Formation (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Problems about the nature of explanation, the evaluation of competing explanations, and the relation of observation to theory. ***(Not offered 1981-82.)***
N. Block, P. G. Horwich

24.852 Topics in Scientific Method (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Problems surrounding the notions of objectivity and justification in the social and natural sciences. Such topics as: theoretical underdetermination, conventionalism, claims that social sciences and moral theory are fundamentally different from the natural sciences. Readings from Reichenbach, Quine, Chomsky, Weber, Kant, Rawls, etc. ***(Not offered 1981-82.)***
P. G. Horwich

24.853 Philosophy of Scientific Development (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Study of problems presented by the conceptual changes that accompany scientific advance. To what extent, for example, do such changes preserve the meaning (or the reference) of scientific terms? Can the cognitive content of a discarded theory be represented in a language adapted to use with its successor? If not, what sort of communication is possible between the proponents of competing theories, and what sense can be made of the notion of scientific progress? ***(Not offered 1981-82.)***
T. S. Kuhn

24.854J Historical Interpretation of Scientific Thought (A)

(Same subject as STS 222J)
Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Close reading of selected primary sources in order to reconstruct a significant chapter in the development of scientific thought. Attention given not only to the concepts, methods, and theories disclosed by the texts but, where possible, also to the experience of historical interpretation. ***(Not offered 1981-82.)***
T. S. Kuhn

Linguistics

24.855 Problems in Philosophy of History (A) (New)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

An examination of major views about problems raised by historical explanation. How can an apparently descriptive enterprise be explanatory? Does its success presuppose laws of human behavior? Does its practice demand an empathy or *Verstehen* unknown in the natural sciences? Readings from such authors as Collingwood, Geertz, Hempel, Taylor, White.
T. S. Kuhn

24.891 Special Graduate Topics in Philosophy

Prereq.: —
Year: G (1)
Arr.

Open to qualified graduate students in philosophy who wish to pursue special studies or projects.
Staff

24.892 Special Graduate Topics in Philosophy

Prereq.: —
Year: G (2)
Arr.

Open to qualified graduate students in philosophy who wish to pursue special studies or projects.
Staff

(Note: See description of subjects 21.932 Introduction to Phenomenology, 21.933 Being and Time: I, 21.934 Being and Time: II, in the Department of Humanities under Special Interdisciplinary Subjects.)

24.900J The Study of Language

(Same subject as 21.321J)
Prereq.: —
Year: U (1) HUM-D
3-0-6

A systematic survey, for students without prior background in linguistics, of the major concerns in the study of language. A consideration of the fundamental empirical question relating to the human capacity for language: the problem of explaining the ability of human beings to acquire the sound system and grammatical structure of a natural language. An overview of the typological diversity observed in the world's languages, genetic relationships among them, and the mechanisms of language change that give rise to linguistic variety. An examination of the relation of language to culture and society, including the reflection in language of sociocultural and other extralinguistic factors, and the position of language in human intellectual life both as a vehicle for the expression of ideas and as an object of inquiry.
J. W. Harris, W. O'Neil, J. R. Ross

24.901J Language and Its Structure

(Same subject as 21.322J)
Prereq.: 24.900J
Year: U (2)
3-0-6

Detailed examination of fundamental concepts and issues in linguistic theory, with emphasis on explanatory models in linguistics and their bearing on issues in philosophy and cognitive psychology. Phonology: phonetic features, the organization of phonological systems, phonological change; examples from English and other languages. Syntax: deep and surface structures, properties of syntactic rules, syntax and semantics; a survey of the major syntactic processes of English. Study of several typologically different languages from the point of view of the relationship between syntactic structure and logical form.
J. W. Harris

24.903J Language and Culture

(Same subject as 21.583J)
Prereq.: —
Year: U (2)
3-0-6

An introduction to the study of those aspects of language which have been of special interest to anthropologists and sociologists. A survey of the concerns of anthropological linguistics with particular emphasis on their implications for the study of language itself. An examination of a particular language in relation to various aspects of its cultural and social setting and to the intellectual life of its speakers.
J. R. Ross, K. L. Hale, J. E. Jackson

24.905 Seminar on Poetic Form

Prereq.: —
Year: G (2)
Arr.

Study of the organization of linguistic elements in metrical verse. Content varies from term to term and year to year; subject may be taken repeatedly with permission of instructor. ***(Not offered 1981-82.)***
J. R. Ross

24.908 Readings in Old and Middle English (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-9

An introduction to the grammar of early English, with readings in Old and Middle English prose and poetry. Study of other Germanic languages with emphasis on Old Norse/Icelandic, with some attention to the other older Germanic languages. Comparative Germanic grammar. For students of Medieval English literature and of English language history. ***(Not offered 1981-82.)***
W. O'Neil

24.921 Special Graduate Topics in Linguistics (A)

Prereq.: —
Year: G (1)
Arr.

Open to qualified graduate students in linguistics who wish to pursue special studies or projects.
Staff

24.922 Special Graduate Topics in Linguistics (A)

Prereq.: —
Year: G (2)
Arr.

Open to qualified graduate students in linguistics who wish to pursue special studies or projects.
Staff

24.931 Linguistic Structures: Romance (A)

Prereq.: 24.951, 24.961
Year: G (2)
3-0-9

Topics in the syntax, phonology, and morphology of the Romance languages, with emphasis on the application of modern theory to classical problems of Romance linguistics and the implications of data drawn from the Romance languages for general linguistic theory. (Some knowledge of a Romance language required.)
J. W. Harris

24.933 History of the English Language (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Selected topics in the history of English syntax, morphology, and phonology from Old English to the present, formulated within an attempt at a general theory of linguistic change. (Some knowledge of Old and Middle English desirable. ***Not offered 1981-82.***)
W. O'Neil, S. J. Keyser

24.936J Germanic Syntax (A)

(Same subject as 21.254J)
Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Comparative analysis of the core syntax of the modern Germanic languages, with an attempt to trace their divergent developments from a common origin. Special emphasis on topics bearing on current issues in syntactic theory. ***(Not offered 1981-82.)***
R. P. V. Kiparsky, W. O'Neil

24.941 Topics in the Grammar of a Non-Indo-European Language (A)

Prereq.: 24.951
Year: G (1)
3-0-6

24.942 Topics in the Grammar of a Non-Indo-European Language (A)

Prereq.: 24.951
Year: G (2)
3-0-6

Detailed examination of the grammar of a language whose structure is significantly different from English, with special emphasis on problems of interest in the study of linguistic universals. A native speaker of the language assists when possible. ***(24.941 not offered 1981-82.)***
K. L. Hale

24.943 Studies in American Indian Linguistics (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-9

24.944 Studies in American Indian Linguistics (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Detailed examination of specific topics in the structure of an American Indian language, with special emphasis on linguistic problems which bear on the educational concerns of the community from which the student comes. Topic varies from term to term and year to year. Subject may be taken repeatedly with permission of instructor. (Native command of an American Indian language required.)
K. L. Hale

24.945 Language Typology (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Detailed cross-linguistic examination of selected subsystems of grammar in relation to the problem of constraining theories of linguistic knowledge. At each offering, concentration on one or a coherent subset of the following topics in languages which adequately represent the typological diversity known to exist in the world: parts of speech, base structure, the lexicon and morphology, methods of synthesis, transformational systems, systems of coreference and construal, case, agreement, logical operators, quantifiers, and modality. ***(Not offered 1981-82.)***
K. L. Hale

24.946 Workshop in Linguistics and Education (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

An exploration of the educational potential of the theoretical study of language in elementary and secondary education, focusing upon the use of linguistic data and linguistic problems as a medium for the teaching of scientific method; design of language-based games, game-like activities, and research projects appropriate for elementary and secondary school years; a consideration of the design of language-based science curricula in bi- and multilingual communities; the relationship between a language-based science curriculum and other areas of general educational concern — other sciences, reading, language arts.
W. O'Neil

24.947 Syntax and Mental Representation (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Grammatical constraints on the mental representation of natural language. The role of grammars in psycholinguistic models of language processing. Evaluation of algorithms for associating representations of meaningful grammatical relations from sequences of lexical words. Topics vary from year to year; subject may be repeated for credit. ***(Not offered 1981-82.)***
J. W. Bresnan

24.951 Introduction to Linguistics I: Syntax (A)

Prereq.: 24.901J
Year: G (1)
3-0-9

Introduction to formal properties of lexical grammars; lexical, syntactic, and functional rules; coherence and completeness; bounded and unbounded grammatical relations; analysis of major structures of English within a unified grammatical theory. This subject is a core offering in Cognitive Science at MIT.
K. L. Hale

24.952 Introduction to Linguistics III: Theory of Grammar (A)

Prereq.: 24.951
Year: G (2)
3-0-9

Problems in constructing an explanatory theory of grammatical representation. Topics drawn from current work on lexical rules and representations, complementation, control, casemarking, syntactic binding, ellipsis, anaphora, and adjunction. Study of language-particular parameters in the formulation of linguistic universals.
J. W. Bresnan

24.953 Advanced Grammar I: An Introduction to the Extended Standard Theory of Grammar (A)

Prereq.: —
Year: G (1)
3-0-9

Development of the Extended (and Revised Extended) Standard theory of grammar. Beginning roughly with the Standard Theory as represented in Chomsky's *Aspects of the Theory of Syntax*, exploration of the major issues and results within the generative-transformational framework during the years subsequent to *Aspects* and prior to the most recent proposals, such as those in Chomsky's *On Binding* and *Markedness and Core Grammar* and in Bresnan's *A Realistic Transformational Grammar*. Focus on the study of constraints and conditions on rules of grammar; examination of the development of current conceptions of such additional topics as 1) the role of transformations, 2) the position and nature of the lexicon and lexical rules, 3) systems of control, anaphora, and semantic interpretation, 4) grammatical relations and case, 5) the position of the cycle in the theory of grammar, 6) trace theory, 7) structure preservation, phrase structure, and X-Bar theory, and 8) questions concerning the cross-linguistic validity of general principles of grammar. Designed to prepare the student to read with relative ease the work currently being written within this general framework. ***(Not offered 1981-82.)***

24.954 Advanced Grammar II (A)

Prereq.: 24.952
Year: G (2)
3-0-9

Selected topics in phonology, syntax, and semantics. ***(Not offered 1981-82.)***

24.955 Computational Psycholinguistics: The Syntactic Component (A)

Prereq.: —
Year: G (1)
3-0-9

Examination of connections between linguistic competence and performance models of grammatical processing. Discussion of linguistic theories which reduce or eliminate standard transformational derivations: Bresnan's extended lexical grammars and Kaplan's augmented transition networks. Description of a processing model (Kaplan's general syntactic processor) for such theories. Exploration of psychological implications of the model. ***(Not offered 1981-82.)***
J. W. Bresnan

24.956 Introduction to Linguistics IV: Universal Grammar (A)

Prereq.: 24.951
Year: G (1)
3-0-9

The nature of linguistic universals, which make it possible for languages to differ and place limits on these differences. Study of selected problem areas which show how data from particular languages contribute to the development of a strong theory of universal grammar and how such a theory dictates solutions to traditional problems in the syntax of particular languages.
J. W. Bresnan

24.957 Introduction to Linguistic Theory at an Advanced Level (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Discussion of conceptual and methodological issues: goals of linguistic theory and its place in the study of thought and behavior; descriptive and explanatory theories; the nature, use, and acquisition of knowledge of language as compared with other cognitive systems; relations of form, meaning, and use of language. Review of traditional and contemporary debate over these issues. Examination of theories of transformational generative grammar as they have evolved and are now being pursued: theory of base, transformations, semantic interpretation of formal structures, logical form, and conditions on the form and functioning of rules of grammar.
N. A. Chomsky

24.958 Linguistic Structure (A)

Prereq.: 24.952 or 24.957
Year: G (1)
3-0-9

Current work on topics in syntax and semantics. (Permission of instructor required.)
N. A. Chomsky

24.959 Workshop in Syntax (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-9

An intensive group tutorial/seminar for discussion of research being conducted by participants. No auditors allowed.
J. W. Bresnan

24.961 Introduction to Linguistics II: Phonology

Prereq.: —
Year: G (1)
3-0-5

Aims and principles of a scientific description of the phonic aspect of language. The mechanism and acoustics of speech. Distinctive features as the descriptive framework. The phoneme. The phonemic system of a language. The interrelations between phonology and other linguistic levels. Some problems of historical phonology. Practical exercises. This subject is a core offering in Cognitive Science at MIT.
S. J. Keyser, M. Halle

24.962 Advanced Phonology (A)

Prereq.: 24.961
Year: G (2)
3-0-9

Continuation of 24.961. Special emphasis on problem solving.
M. Halle

24.963 Studies in Indo-European Accentology (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Examination of the accentual systems of a number of different Indo-European languages. Reconstruction of the accentual system of the proto-language. ***(Not offered 1981-82.)***
M. Halle, R. P. V. Kiparsky

24.964 Theory of Phonology (A)

Prereq.: 24.961
Year: G (2)
3-0-9

Phonological representations, the organization of the phonological component, morphology. The relation of structure, function, and change.
R. P. V. Kiparsky

24.966J Laboratory on the Physiology, Acoustics and Perception of Speech (A)

(Same subject as 6.542J)
Prereq.: Permission of Instructor
Year: G (1)
2-2-8

Experimental investigations of speech processes. Topics: a) interpretation of X-ray motion pictures, b) measurement of pressure and volume velocity, c) computer-aided waveform analysis and spectral analysis of speech, d) synthesis of speech with an articulatory model and with a terminal analog model, e) identification and discrimination of speech-like sounds, f) the perceptual reality of phonetic features, and other topics. (Recommended prerequisites: engineering and science students, 6.501; linguistics students, mathematical background equivalent to 6.002 or 18.03. Alternate years. ***Offered 1981-82.***)
M. Halle, D. H. Klatt

24.968J Speech Communication (A)

(Same subject as 6.541J)
Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Survey of structural properties of natural languages with special emphasis on the sound pattern. Survey of physiology of speech production, articulatory phonetics. Acoustical theory of speech production: the vocal tract as a generator of acoustical signals; acoustical correlates of vocal-tract configurations, both stationary and dynamic; acoustical and articulatory descriptions of phonetic features. Perception of speech: the auditory capabilities of humans; evidence for perceptual correlates of phonetic categories. Mechanical recognition and generation of speech. (Recommended prerequisites: engineering and science students, 6.501; linguistics students, mathematical background equivalent to 6.015 or 18.05. ***Not offered 1981-82.)***
S. J. Keyser, K. N. Stevens, M. Halle

24.969 Workshop in Phonology (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-9

An intensive group tutorial/seminar for discussion of research being conducted by participants. No auditors will be allowed.
R. P. V. Kiparsky

24.972 Formal Foundations of Linguistic Theory (A)

Prereq.: 24.241
Year: G (1)
3-0-9

Study of mathematical formalisms for specification of languages. Presentation of formalisms accompanied by some discussion of linguistic considerations for restricting or extending the apparatus available in grammars. Formalisms covered include both phrase structure grammars (e.g., context-free and context-sensitive rewriting systems, categorical grammars) and grammars which assign more abstract sorts of structural descriptions (e.g., transformational grammars, tree-grammars, and Montague-style grammars). Machinery from automata theory imported where helpful. This subject is a core offering in Cognitive Science at MIT.
J. T. Higginbotham

24.973 Topics in Logic and Semantics (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Topics in logic and semantics, with particular attention to issues and techniques in linguistic analysis. Formal systems, satisfaction, and truth; restricted and branching quantifiers; binding and opacity; modal and intensional notions. Conceptions of logical form in philosophy and linguistics.
J. T. Higginbotham

24.982 Linguistic Change (A)

Prereq.: 24.951, 24.961
Year: G (2)
3-0-9

Review of instances of change in phonology, morphology, and syntax. Examples to be drawn from various language families, Indo-European, as well as others. An attempt to develop a general theory of linguistic change.
R. P. V. Kiparsky

24.985J Serial and Temporal Factors in Language Processing (A)

(Same subject as 9.590J)
Prereq.: 24.901J or 9.55
Year: G (2)
3-0-9

Examination of recent linguistic and psycholinguistic evidence for serial effects in the processing of language for comprehension and production. (Permission of instructor required. ***Not offered 1981-82.***)
J. R. Ross, M. F. Garrett

24.992 Survey of General Linguistics I (Revised Content)

Prereq.: *24.951, 24.961*
Year: G (1)
3-0-9

Reading and discussion of certain important papers in syntax, semantics, and phonology designed to familiarize the student with central ideas in current linguistic research. Selection of papers and organization of discussion is primarily in the hands of the seminar participants.
M. Halle

24.993 Tutorial in Linguistics and Related Fields (A)

Prereq.: Permission of Instructor
Year: G (1, 2)
Arr.

Individual or small group tutorial in which students under the guidance of a faculty member explore the interrelations with linguistics of some specified area.
Staff

CTS Center for Transportation Studies

CTS 100J Basic Concepts in the Analysis of Transportation Systems (A)

(Same subject as 1.201J)
Prereq.: Permission of Instructor
Year: G (1)
2-0-4

Introduction to the analysis of transportation systems. Interaction of demand for service and system performance. Determinants of demand and models for demand forecasting. Performance characteristics of transportation systems and models of performance. Analysis of transportation networks including prediction of flow patterns and service quality. Evaluation of impacts and decision making in public and private transportation organizations. The basic analysis concepts illustrated through case studies in which different transportation problems are analyzed.
N. H. M. Wilson

CTS 110J Applied Microeconomic Analysis (A)

(Same subject as 1.182J, 14.110J)
Prereq.: 14.01
Year: G (1)
3-0-6

Designed for students with primary interests outside of economics but who wish to acquire some expertise in applied economic analysis. The development of microeconomic theory at an intermediate level, including consumer and producer theory, imperfect competition, capital and welfare economics, with emphasis on applications of particular relevance to engineers, such as problems related to transportation, energy, water resources, and constructed facilities. (Credit not given for this subject and 14.03, 14.04.)
C. Winston, D. L. McFadden

CTS 120J Transportation Institutional Analysis and Policy (A)

(Same subject as 1.251J, 11.382J)
Prereq.: Permission of Instructor
Year: G (1)
3-0-6

Introduction to policy and institutional analysis in the transportation sector. Principal policy-making actors and interest groups at national, state, and local levels. Emphasis placed on developing a basic understanding of organizational behavior and implications for policy formulation and implementation. General policy analysis framework developed with specific attention given to problem definition, selection of alternatives, and implementation considerations. Comparison made between strategic planning in the private sector and policy analysis in the public sector.
M. D. Meyer

CTS 130J Issues in Transportation Management (A)

(Same subjects as 1.285J, 13.681J)
Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Introduction to problems facing transportation management. A brief description of basic managerial tools and the industry characteristics of each transportation mode. Focus on specific managerial issues facing the transportation industry, including technological, economic, marketing, labor-related, legal, institutional, and political aspects. Similarities and dissimilarities among the modes analyzed. Problems viewed from the managerial perspective of both private and public sectors.
H. S. Marcus, F. O. Roberts

CTS 140J Transportation Performance and Technology (A)

(Same subject as 1.290J, 2.120J)
Prereq.: CTS 100J or 1.201J
Year: G (2)
3-0-6

Transportation system performance measures: energy, pollution, safety, noise, ride quality, speed, reliability. Vehicle technology: propulsion systems, vehicle dynamics (ground, ocean, and air vehicle performance), automatic control and guidance. Vehicle flow in channels: traffic flow, scheduled carrier flow. Intersections and terminals: nonsignalized intersections, queueing phenomena, terminal operations. Transportation Networks — the traffic assignment problem. Operating Plans — scheduled carrier networks. (Subject assumes knowledge of probability and statistical inference at an introductory level.)
Y. Sheffi, J. K. Hedrick

CTS 150J Transportation Demand and Activity Analysis (A)

(Same subject as 1.202J)
Prereq.: CTS 110J; CTS 100J or 1.201J or 1.211
Year: G (2)
3-0-6

Introduction to the analysis and forecasting of demand for transportation services and location of activites. Subject is explicitly multimodal and includes urban, intercity, freight, and passenger demand. Activity analysis includes firm and household location at urban and regional scale. Topics: theory of transportation demand for individuals and firms, location theory, aggregate and disaggregate methods for location and demand analysis, forecasting methods, applications to various sectors such as air passenger demand, retail firm location, freight demand, residential location, and urban travel demand. A term paper is required. (Subject assumes knowledge of probability and statistical inference at an introductory level. Prerequisites may be met by subjects equivalent to those listed.)
S. R. Lerman

HST Health Sciences and Technology

Some HST subjects start the Wednesday following Labor Day which is before MIT's fall semester commences.

Students wishing to take HST 010-190 and 304 and 900 must file an application in Room 16-512.

HST 010 Functional Anatomy of Man (A)

Prereq.: Permission of Instructor
Year: G (1)
2-9-10

A series of lectures, laboratory dissections, and demonstrations designed to provide a thorough grounding in the structure of the human body and in certain of its functions. Intended for undergraduates and graduate students aspiring to careers in vertebrate biology (including physical anthropology), bioengineering, medicine, physical medicine and rehabilitation, and other health-related occupations. (Enrollment limited.)
F. A. Jenkins, Jr., J. I. Clark, J. W. Mills

HST 020 Bone and Connective Tissue (A)

Prereq.: Permission of Instructor
Year: G (2)
1-2-4

Growth and development of normal bone and joints, the process of mineralizaton, the biophysics of bone and response to stress and fracture, calcium and phosphate homeostasis and regulation by parathyroid hormone and vitamin D, and the pathogenesis of metabolic bone diseases and disease of connective tissue and joints with consideration of possible mechanisms and underlying metabolic derangements. (Meets first half of the term. Enrollment limited.)
D. R. Robinson, J. T. Potts, Jr., R. M. Rose, A. L. Schiller

HST 030 Human Pathology (A)

Prereq.: 5.41 or 5.42; 7.01, 8.01, 8.02
Year: G (1)
4-4-8

Introduction to the organization, structure, and function of normal cells and tissues; pathologic principles of cellular injury, inflammation, circulatory disorders, immunologic injury, infection, nutritional disorders, growth disorders, neoplasia, and radiation injury in humans. Lectures, conferences, laboratories with examination of microscopic and gross specimens, and autopsy case studies. (Enrollment limited. Permission of instructor required.)
H. Goldman, A. K. Abbas, G. R. Dickersin, Associates

HST 040 Mechanisms of Microbial Pathogenesis (A)

Prereq.: 7.01, 7.05
Year: G (1)
3-6-5

Deals with the mechanisms of pathogenesis of fungi, bacteria, mycoplasma, and viruses. Approach polarized towards mechanisms at biochemical and immunological levels without neglecting epidemiology and selected clinical aspects of diseases. Topics selected for intrinsic interest and cover the demonstrated spectrum of pathophysiologic mechanisms. (Enrollment limited. Permission of instructor required.)
J. Murphy, G. Jacoby, P. Schaffer, Associates

HST 050 Topics in Quantitative Physiology (A)

Prereq.: 8.01, 8.02; 18.01
Year: G (1)
3-0-7

Selected topics illustrating the use and results of a quantitative approach to physiological problems. Items discussed include a) Stochastic processes, applied to genetic mutations, cardiac electrophysiology, strategies of drug administration. b) Diffusive transport of gases in lung and tissues; osmotic fluid transport, electro-diffusion of ions and active transport. c) Excitable cell membranes, action potential and models of the axon. d) Homeostasis; principles of feedback control systems; gain, response time, stability; case studies. Weekly assignments of problems for practice are an important part of the subject.
F. M. H. Villars, R. J. Cohen, T. F. Weiss, D. J. Litster

HST 060 Endocrinology (A)

Prereq.: 7.01, 7.05
Year: G (2)
6-0-6

Physiology and pathophysiology of the human endocrine system. Four hours of lectures each week concern individual members of this system. Topics also covered include system modeling, assay techniques, physiological integration, etc. At a weekly clinic patients are demonstrated who represent problems considered in the accompanying lectures. (Enrollment limited. Permission of instructor required.)
S. H. Ingbar, W. Kettyle

HST 070 Human Reproductive Biology (A)

Prereq.: 7.01, 7.05
Year: G (2)
2-4-3

Lectures, laboratory sessions, and case dicussions designed to provide the student with a clear understanding of the physiology, endocrinology, and pathology of human reproduction. In addition, designed to involve student in analysis of the wider aspects of reproduction, such as the social and psychological aspects of human sexual behavior, contraception, unwanted pregnancy, and the menopause. (Meets second half of the term. Enrollment limited. Permission of instructor required.)
M. Phillippe, M. Dym, P. Gordon, J. Kitzmiller, I. Schiff

HST 080 Hematology (A)

Prereq.: 7.05
Year: G (2)
3-6-4

An intensive survey of the biology, physiology, and pathophysiology of blood and the blood-forming organs with systematic consideration of hematopoiesis, the "formed elements," blood coagulation, blood groups and immunoglobulins, and other plasma proteins. Emphasis given equally to didactic discussion and analysis of clinical problems. (Meets second half of the term. Enrollment limited. Permission of instructor required.)
W. S. Beck, J. T. Truman, Associates

HST 090 Cardiovascular Pathophysiology (A)

Prereq.: 7.01 or 18.01, 18.02
Year: G (2)
3-3-9

Normal and pathologic physiology of the heart and vascular system. Emphasis includes hemodynamics, electrophysiology, gross and microscopic pathology, and clinical correlates of cardiovascular function in healthy and in a variety of disease states. Special attention will be given to congenital, rheumatic, hypertensive, arteriosclerotic, and coronary heart disease. (Enrollment: Lectures - open; Laboratory - limited. Permission of instructor required.)
W. H. Abelmann, R. J. Cohen, W. Gamble, J. Fallon, R. G. Mark

HST 091 Cardiovascular Pathophysiology (A)

Prereq.: 7.01 or 18.01, 18.02
Year: G (2)
3-0-9

Same as HST 090 but without the laboratory.
W. H. Abelmann, R. Cohen, J. Fallon, W. Gamble, R. G. Mark

HST 100 Respiratory Pathophysiology (A)

Prereq.: 7.01, 7.05, 8.01
Year: G (1)
1-2-5

Lectures, seminars, and laboratory sessions which cover the development of the lung as an organ of gas exchange, its histology and cellular function, physics of gases, pulmonary physiology and gas exchange as it relates to health and disease. Problems of gas transport and acid base balance reviewed and pathophysiology of common respiratory disorders presented. Some laboratory sessions with patients with lung disease. Intended for M.D. candidates and other students with background in science. (Enrollment limited. Permission of instructor required.)
D. C. Shannon, H. Kazemi, E. Mark, C. A. Hales, B. Hoop, J. C. Weaver

HST 110 Renal Pathophysiology (A)

Prereq.: 7.01, 7.05
Year: G (1)
2-1-5

Topics include the normal and pathologic functioning of the kidney. Emphasis on electrolyte and water metabolism — the role of Na+, K+, H+, and water. Included also the pathophysiology of clinical renal disorders such as acute and chronic glomerulonephritis, pyelonephritis and vascular disease. (Enrollment limited. Permission of instructor required.)
C. Coggins, A. Leaf, H. Rennke, L. Fang, R. S. Langer, Jr.

HST 120 Gastroenterology (A)

Prereq.: 7.01, 7.05, 8.01
Year: G (2)
3-6-4

The most recent knowledge of the anatomy, physiology, biochemistry, biophysics, and bioengineering of the gastrointestinal tract and the associated pancreatic, liver, and biliary tract systems is presented and discussed. The molecular basis underlying the pathophysiology of each disease process is emphasized where known. Gross and microscopic pathology and clinical aspects of important gastroenterological diseases are then presented with emphasis on integrating the molecular, cellular, and pathophysiological aspects of the disease processes to their related symptoms and signs. Subject is highlighted by selected patient presentations in clinic and mini-case format in order to demonstrate how an understanding of the basic and clinical sciences of gastroenterology are essential to rational diagnosis and therapeutic decisions. Throughout, formal lectures given by the core faculty with some guest lectures by local experts. Selected seminars conducted by students with supervision by faculty members. (Enrollment limited. Permission of instructor required.)
M. C. Carey, D. Antonioli, R. H. Schapiro, J. Wands

HST 130J The Human Nervous System (A)

(Same subject as 9.016J, 20.514J)
Prereq.: Permission of Instructor
Year: G (1)
6-3-6

Subject encompasses a) the *gross anatomy, internal organization,* and *fine structure* (light- and electron-microscopic) of the mammalian nervous system with particular emphasis, wherever possible, on the human nervous system and its functional disorders; b) *neurophysiology* from the level of the single cell to that of complex neural organizations, in particular, perceptual, motor, and associative systems; c) *neuropharmacology* and *neuroendocrinology.* (Enrollment limited.)
W. J. H. Nauta, E. Bizzi, A. M. Graybiel, R. J. Wurtman

HST 131J Pathophysiology of the Nervous System (A)

(Same subject as 9.018J)
Prereq.: HST 130J
Year: G (2)
3-0-6

Discussion of physiological and biochemical mechanisms underlying diseases of the peripheral and central nervous systems. Lectures emphasize recent advances in the basic sciences as they apply to the following phenomena and representative disease states: muscle contraction and relaxation (muscular dystrophy), neuromuscular transmission (myasthenia and related syndromes), peripheral nerve conduction (peripheral neuropathies), pain and nociception, suprasegmental control of movement (tremor and Parkinson's disease), myelin formation and breakdown (multiple sclerosis), sleep and other biological rhythms (narcolepsy), cortico-cortical interactions (behavior and language disorders), neuronal excitability (epilepsy), cerebral circulation (stroke). (Enrollment limited. Permission of instructor required.)
M. A. Moskowitz, N. Geschwind

HST 141 Molecular Basis of Some Clinical Disorders (A)

Prereq.: 7.05
Year: G (1)
4-0-6

Conducted as a seminar in which students study a variety of human diseases and the underlying molecular and biologic basis for the pathogenesis and pathophysiology of the disorders. Covers the molecular biology of mammalian cells with emphasis on genes, their structure, function, and manipulation. Lectures by faculty and seminars conducted by the students with tutorial instruction and supervision by faculty members. Appropriate for students who have had a course in biochemistry and/or molecular biology, and are simultaneously taking histology or pathology.
P. M. Gallop, I. M. London, N. H. Hopkins, P. A. Sharp, Associates

HST 190 Statistical Planning and Analysis of Biomedical Investigations (A)

Prereq.: Knowledge of calculus
Year: G (J)
3-0-3

Lectures dicuss statistical methodology and concepts in the context of planning and analysis of biomedical investigations. Aims to acquaint the student with sufficient background to critically read the scientific and medical literature. Topics: randomization, replication, and local control; therapeutic investigations; key ideas of statistical inference; confidence procedures; distribution-free procedures; analysis of discrete data; elements of survival distributions; ideas of probability modeling. Examples and readings selected from the recent literature.
J. H. Ware, M. Zelen

HST 200 Physical Diagnosis and Introductory Clinical Experience (A)

Prereq.: Permission of Instructor
Year: G (2)
9-25-12

February through May, Monday, Wednesday, Friday. Students learn the basic skills involved in examination of the patient and are introduced to history taking and patient interview. Students exposed to clinical problems in medicine, surgery, and pediatrics in groups of two or three students under one faculty member. Students expected to follow the patient closely

and to study the course of the disease. Findings reported through history taking and oral presentations of the cases to the class. An intensive subject serving as prerequisite to clinical clerkships. (Enrollment limited to students in M. D. Program)
E. Braunwald, W. H. Churchill, R. Christian, J. Pennington, Associates

HST 201 Introduction to Clinical Medicine and Medical Engineering I (A)

Prereq.: HST 010, HST 030, HST 060J, HST 090, HST 100, HST 110, HST 130J, 7.05
Year: G (1)
9-27-12

Required for doctoral students in Medical Engineering and Medical Physics Program. Requires full time throughout the fall term. Students are expected to: 1) develop skill in patient interviewing and physical examination; 2) become proficient at organizing and communicating clinical information in both written and oral forms; 3) begin integrating history, physical and laboratory data with pathophysiologic principles in preparing written case assessments and diagnostic plans; 4) investigate a variety of important diagnostic instruments and techniques from both the engineering and clinical points of view; 5) become familiar with role of physician, including an understanding of the clinical decision-making process and broad economic, ethical, and sociological issues involved in patient care; and 6) learn, through participation, the principles of the practice of medicine in the hospital, clinic, office, and community. (Enrollment limited to students who have successfully completed the first two years of the Medical Engineering and Medical Physics doctoral program. Permission of instructor required.)
W. H. Abelmann, C. J. Hatem, R. G. Mark, Associates

HST 202 Introduction to Clinical Medicine and Medical Engineering II (A)

Prereq.: HST 201
Year: G (J)
3-9-0

Strengthens clinical skills developed in HST 201 through a full-time clerkship in medicine. Students serve as members of a ward team in the teaching hospital and participate in longitudinal patient care. In addition, students participate in regularly scheduled teaching conferences focused on principles of patient management. Full time during the month of January.
C. J. Hatem, R. G. Mark, Associates

HST 203 Clinical Experience in Medical Engineering (A)

Prereq.: HST 201, HST 202
Year: G (1, 2, S)
9-36-15

Students engage in clinical investigation, directed study, and didactic lectures in hospital settings. Students are actively involved in patient care, particularly those aspects which utilize technology in major ways.
E. G. Cravalho, Associates

HST 304 Five Views of Medicine

Prereq.: —
Year: G (1, 2)
1-0-3

Over the centuries, particularly in our times, medicine has been considered from certain views that illuminate its diverse functions and purpose. This course explores five such views, chosen to help students understand some of the most significant and troublesome problems of modern medicine: the technologic view, the biologic, the nihilistic, the economic, and the professional view. Each is considered in two separate sessions: the first, for which about 20-30 pages of readings are assigned as preparation is devoted to group discussion of the main features of the view; the second is devoted to a debate between experts on a question that clarifies issues central to the view being considered, and which provides students with a forum to test their own beliefs, and those of the experts. (Meets alternate Thursdays 6-7:30 pm. Seminars and assigned reading. Minimum 10 students, maximum 30 students. Must be taken both terms to receive credit. ***Not offered 1981-82.***)
S. J. Reiser, Associates

HST 500J Physics I

(Same subject as 8.013J)
Prereq.: —
Year: U (1)
5-1-6

The sequence HST 500J and HST 501J is designed for students interested in medicine and the life sciences. Elementary kinematics and vector algebra. Newton's laws of motion. Conditions of static equilibrium; forces acting on the human body. Elasticity and strength of materials. Momentum conservation; application to ballistocardiogrphy and to fracture and concussion during impacts. Work, kinetic and potential energy, and law of energy conservation; first law of thermodynamics; applications to metabolism and work done by various organs of the body. Harmonic motion; damped and driven oscillators; resonance. Angular momentum and torque. Introduction to the principles of feedback and control systems with examples in physiology.
Staff

HST 501J Physics II

(Same subject as 8.023J)
Prereq.: 8.01 or 8.012 or 8.013J; 18.01
Year: U (2)
5-1-6

Electrostatics: Coulomb's Law, electric fields; Gauss' Law; the electrostatic potential, Laplace's equation. Capacitors, work and energy. Dielectrics, molecular dipoles. Currents, Ohm's Law; R-C circuits; flow of charge in three dimensions; electrocardiography. Nernst-Planck equation; diffusion potentials; Debye shielding; electrophoresis of cells and proteins. Electrodes, electrochemical cells; pH measurements. Bioelectricity: cell membrane potentials; the Hodgkin-Huxley axon. Magnetic fields; Lorentz force, Ampère's and Biot-Savart's laws. Faraday's law of induction; self- and mutual inductance, LC circuits and transformers. Maxwell's equations; electromagnetic waves.
Staff

HST 505J Statistical and Biological Physics

(Same subject as 8.201J)
Prereq.: HST 501J, 18.01
Year: U (1) SD
5-0-7

Elements of probability theory. Random walk, Brownian motion and diffusion. Diffusion equation and Fick's Law. Permeability of capillary walls; artificial kidney. Equilibrium and diffusion in external fields; ultracentrifugation. Osmotic pressure; coupled flow of solute and solvents across membranes. Poisson statistics and fundamental limits on detection of light by the eye; the Delbrück-Luria experiment. Thermal motion; molecular distribution of energy in crystals and gases; definition of temperature and the Boltzmann factor. Statistical characterization of thermal equilibrium; entropy. Entropy and heat; second law of thermodynamics. Open systems and free energy minimum principles. Vapor pressure and freezing points; chemical equilibrium; hemoglobin oxygenation.
Staff

HST 520J Artificial Internal Organs (A)

(Same subject as 10.58J)
Prereq.: Permission of Instructor
Year: G (2)
2-0-6

Theory and clinical application of artificial internal organs, particularly artificial kidneys and cardiopulmonary assistance devices. Review of pertinent engineering principles of mass transfer, fluid mechanics, and membrane transport. Problems posed by interaction of blood components and biomaterials. Design and performance of devices. Examples of artificial organ therapy for treatment of severe clinical disorders examined in detail to reveal limitations of the current state of the art. Previous exposure to mammalian physiology, calculus, and physical chemistry desirable. ***(Not offered 1981-82.)***
C. K. Colton, W. M. Zapol, E. G. Lowrie

HST 521J Biomedical Transport Phenomena (A)

(Same subject as 10.49J)
Prereq.: 10.301, 10.302
Year: G (2)
2-0-5

Application of principles of transport phenomena to analysis of selected physiological processes and design of artificial internal organs and extracorporeal devices. Review of pertinent physiological principles. Rheology of blood. Convective and diffusive mass transport in blood and tissues. Mass transport characteristics of biological and synthetic membrane processes. Clinical application of artificial internal organs, with emphasis on artificial kidneys and cardiopulmonary assist devices.
C. K. Colton, W. M. Deen

HST 530J Ultrasound: Physics, Biophysics and Technology (A)

(Same subject as 2.76J, 6.562J)
Prereq.: Permission of Instructor
Year: G (1)
4-1-7

Physics and technology of generation and detection of ultrasound. Transducers and arrays. Propagation and fields. Diagnostic, therapeutic, and processing applications in medicine and industry. State of the art of imaging and Doppler systems. Biophysics, biological effects, linear and nonlinear phenomena. Hazards and safety levels. (Alternate years. ***Not offered 1981-82.***)
P. P. Lele, F. R. Morgenthaler

HST 531J Non-Ionizing Radiations in Biomedical Sciences (A) (New)

(Same subject as 2.762J)
Prereq.: Permission of Instructor
Year: G (1)
4-1-7

Fundamental physics and biophysics; biological effects and mechanisms; hazards and safety levels of Laser, Microwaves, Ultrasound, and Ultraviolet. Special emphasis on current techniques and applications in medicine and biomedical research. (Alternate years. ***Offered 1981-82.***)
P. P. Lele, Staff

HST 541J Quantitative Physiology: Cells and Tissues (Revised Unit)

(Same subject as 2.791J, 6.021J)
Prereq.: 2.02 or 6.002 or 6.071; 8.02; 18.03
Year: U (1)
4-2-6

Principles of mass transport, energy transduction, and electrical and mechanical signal generation in animal cells. Structure of biological membranes. Transport through biological membranes: diffusion, osmosis, solute flow, ion flow, active transport. Mechanics of connective tissues (tendon, cartilage, blood vessels, and skin) and their analysis as fiber-reinforced composite materials. Electric properties of cells: equilibrium, resting, action, and junctional potentials. Electrical and chemical intercellular interactions. Mechanical properties of muscle. Conversion of electrical, chemical, and mechanical energy. Molecular basis of contraction. (Intended for juniors and seniors in engineering; others admitted by permission of instructor.)
T. F. Weiss, I. V. Yannas

HST 542J Quantitative Physiology: Organ Transport Systems

(Same subject as 2.792J, 6.022J)
Prereq.: 2.20, *HST 541J*, 2.791J, 6.013
Year: U (1)
3-2-7

Application of the principles of energy and mass flow to major organ systems of humans and other animals. Mechanisms of regulation and homeostasis. Anatomical, physiological, and pathophysiological features of the cardiovascular, respiratory, and renal systems. Clinical instrumentation and prosthetic devices. Emphasis on those systems, features, and devices that are most illuminated by the methods of physical sciences. (Intended for juniors and seniors in engineering: others admitted by permission of instructor. May be taken concurrently with HST 541J.)
B. B. Mikić, R. G. Mark, D. Kamm

HST 543J Quantitative Physiology: Sensory and Motor Systems

(Same subject as 2.793J, 6.023J, 16.351J)
Prereq.: 2.02 or 6.003 or 16.30; HST 541J
Year: U (2)
3-2-7

Studies of sensory and motor physiology with objectives of establishing quantitative models. Peripheral signal processing in eye, ear, and vestibular system. Physiology and psychophysics of audition, vision, orientation, and body stabilization. Organization of neuromuscular and proprioceptive systems at level of spinal cord reflex. Postural control and kinetics of movement. Supplemented by laboratory exercises. HST 541J recommended background.)
L. R. Young, R. W. Mann, L. S. Frishkopf

HST 544J Fields, Forces and Flows: Background for Physiology (A)

(Same subject as 6.561J)
Prereq.: 6.013, 6.021J
Year: G (1)
3-0-9

Conduction, diffusion and convection in electrolytes. Fields in heterogeneous media typical of physiological systems. Equilibrium double layers. Force-stress relations. Maxwell stress tensor and electrical forces in physiological systems. Fluid continua, stress-strain-rate relations and equations of motion for viscous, incompressible flow. Continuum mechanics of solids including equations of motion for elastic media and models useful in representing heterogeneous media. Case studies relevant to physiological systems, e.g., membrane/electrolyte, electrode/electrolyte interfaces; equilibrium configuration of muscle, connective tissue structures; flow through charged porous membranes; ECG; interaction of biomaterials with electric fields; examples from orthopedic research; electromechanical transduction including electrophoresis electroosmotic flows, electromechanical coupling in charged membranes, diffusion-reaction problems in biomaterials and tissues. (Appropriate background other than the listed prerequisites may be accepted by instructors.)
A. J. Grodzinsky

HST 550J Computers and Patient Care

(Same subject as 6.523J)
Prereq.: —
Year: G (2)
2-0-4

Seminar designed to give an overview of present and potential uses of computers in patient care applications. Typical topics: hospital administrative activities, automated medical histories, input of physician progress notes and orders, ambulatory medical record, patient monitoring, automated medical consultation and diagnosis, medical education and clinical simulations, data collection and analysis in clinical investigations. (Open to undergraduates.)
G. O. Barnett

HST 560J Biological and Medical Applications of Radiation and Radioisotopes I (A)

(Same subject as 22.55J)
Prereq.: 8.272 or 22.111
Year: G (1)
4-0-8

Principles of radiation production and interactions. Radiation dosimetry with emphasis on applications and health hazards. Shielding of beta, gamma, and neutron radiation from isotope and machine sources. Detection and spectroscopy of beta, gamma, and neutron radiation. Neutron activation analysis. Production of radioisotopes and radiopharmaceuticals. Principles of nuclear medicine. A comprehensive term paper and presentation required.
G. L. Brownell, Staff

HST 561J Principles of Medical Imaging (A)

(Same subject as 2.761J, 22.56J)
Prereq.: Permission of Instructor
Year: G (2)
4-0-8

Principles of medical imaging including X-ray, nuclear medicine, ultrasound, NMR, emission and transmission computed tomography and other modalities. Two-dimensional and three-dimensional imaging techniques and displays. Fundamentals of image formation, physiology of image perception, physics of radiation and ultrasound interaction and detection, and physics of NMR. Quantitation of images and reconstruction algorithms. Medical applications, biological hazards, and cost-benefit analysis of imaging modalities. A comprehensive term paper required.
G. L. Brownell, P. P. Lele, Staff

HST 562 Introduction to Physics of Diagnostic Radiology (A)

Prereq.: Permission of Instructor
Year: G (1)
2-0-4

For students in medical physics and radiological health. Covers the fundamentals of diagnostic radiology, including diagnostic criteria, such as abnormal size, position, motion, or structure, principles of specific studies, e.g. mammography and cardiac angiography, and the use of contrast media. Reviews principles of equipment employed, such as diagnostic X-ray sources, recording systems, film, screens and image intensifiers, and factors affecting image quality and patient exposure. (Half semester. Alternate years. ***Not offered 1981-82.***)
P. F. Judy

HST 564 Introduction to Physics of Radiation Therapy (A)

Prereq.: Permission of Instructor
Year: G (2)
2-0-4

For students in medical physics. Reviews tumors of different primary sites, including their histology and routes of spread. Various aspects of radiation therapy are discussed, including time-dose relationships, influence of oxygen and chemical agents, tumor localization, treatment planning and simulation. Also covered are treatment with external beams, radioactive isotopes, implants and intercavitary sources; dose calculations and machine design and specifications. (Half semester. Alternate years. ***Not offered 1981-82.***)
G. Svensson

HST 565 Physics of Diagnostic Radiology (A)

Prereq.: Permission of Instructor
Year: G (2)
3-3-6

Physical and mathematical aspects of image formation, including characteristics of diagnostic X-ray machines and recording systems, geometrical relationships, X-ray spectra, information limits, optical physiology and performance, special techniques such as magnification and cine radiography, and computed tomography. Radiation protection also is covered, with emphasis on patient dose. (Alternate years. ***Not offered 1981-82.***)
E. W. Webster

HST 566 Physics of Nuclear Medicine (A)

Prereq.: Permission of Instructor
Year: G (1)
2-3-7

Emphasis on the physical and chemical aspects of production, properties, and standardization of radionuclides and radiopharmaceuticals, including cyclotron production of short-lived isotopes. Also covers instrumentation (e.g. scanners, cameras, proportional counters, and the positron camera) and computer applications involving dynamic and regional function analysis, radionuclide tomography, and image processing. The measurement of calcium content of bone also is discussed. (Alternate years. ***Not offered 1981-82.***)
G. L. Brownell, R. E. Zimmerman

HST 567 Physics of Radiation Therapy (A)

Prereq.: Permission of Instructor
Year: G (2)
2-3-7

Deals with the mathematics of treatment planning for external beams, brachytherapy and radioactive nuclides, including computerized techniques. Also accurate and precise dosimetry measurements for photons, electrons, protons, and neutrons, including calibration and quality control of machines and sources. Selected studies of current clinical problems also presented. (Alternate years. ***Not offered 1981-82.***)
B. Bjarngard

HST 568J Radiation Biophysics (A) (New)

(Same subject as 22.57J)
Prereq.: 8.271 or 22.111
Year: G (1)
4-0-8

Effects of ionizing radiation, ultraviolet radiation, and heat on biological materials, cells and tissues of mammals. *In vivo* and *in vitro* mammalian systems examined in detail, and mathematical models for cell survival explored with particular emphasis on prediction. Microstructural damage to cell components such as membranes, organelles, enzymes, and DNA studied thoroughly. Radiation syndromes in man, mutagenesis, and carcinogenesis also investigated. Concludes with discussion on new directions for cancer therapy using heavy ion radiation.
A. C. Nelson

HST 570 Biomedical Instrumentation Electronics (New)

Prereq.: Permission of Instructor
Year: G (S)
6-6-6

Intended to introduce modern biomedical instrumentation electronics through a series of classroom exercises and major project in which each student progressively implements a computer-controlled instrument. Classroom material is focused on electronic circuit elements, networks, signal and system theory, on logic and digital design, and on elementary computer science. No background in electrical engineering or programming is assumed. Familiarity with calculus and differential equations helpful. In the laboratory, students, working in pairs, implement a specific diagnostic instrument.
S. K. Burns

HST 580J Medical Engineering Measurements (A except VI)

(Same subject as 6.564J)
Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Basic principles of medical measurements and transducers which form the basis of instrumentation, with emphasis on present and emerging techniques. Measurement topics include temperature, force, displacement, pressure, sound, flow, bioelectric potentials, chemical electrodes, non-invasive blood gas, optical transducers, biochemical assays, and microbiological determinations. General instrument concepts and sources of noise. Emphasis is on understanding the interaction of transducers with a biological system. Knowledge of elementary physics and circuit theory is assumed. Students in HST Medical Engineering and Medical Physics Program must take HST 581J concurrently.
J. C. Weaver

HST 581J Medical Engineering Measurements Laboratory (A except VI)

(Same subject as 6.565J)
Prereq.: *HST 580J*
Year: G (2)
0-4-2

Laboratory to accompany HST 580J Medical Engineering Measurements. Static and dynamic testing of biomedical transducers and instrumentation, first with artificial-physical inputs and then with biomedical inputs. Investigations into transduction principles and their practical application with emphasis on limitations and clinical constraints. Engineering design and clinical utilization aspects of transducers and instrumentation. Students in HST Medical Engineering and Medical Physics Program must take HST 580J concurrently.
E. D. Trautman

HST 582J Biomedical Signal Processing (A)

(Same subject as 16.356J)
Prereq.: HST 580J
Year: G (2)
3-3-6

Principles of processing and enhancing physiological information for use in medicine. Emphasis on understanding characteristics of present and experimental medical technology available to the physician. The areas of signal processing include: cardiology, radiology, neurophysiology, computer-aided diagnosis, etc. Basic principles and algorithms used in data processing concerning each system included. A general knowledge of control theory, computer hardware and software, and instrument transducers expected.
R. V. Kenyon

HST 590 Biomedical Engineering Seminar

Prereq.: —
Year: G (1, 2)
1-0-0

Weekly seminar describing recent research in biomedical engineering, medical physics, and related areas of interest to graduate students with backgrounds in the physical sciences and engineering. Speakers include faculty and research staff from MIT and other institutions in the Boston area, advanced graduate students, and occasional visitors. Registration is required each term of residence for all graduate students in the Medical Engineering and Medical Physics program, or receiving support from programs under the jurisdiction of the Interdepartmental Committee on Biomedical Engineering.
A. C. Nelson

HST 900 Topics in the Economics of Health Care (A)

Prereq.: Permission of Instructor
Year: G (J)
2-0-4

Introduction to some of the problems in the resource allocation of the health care sector. Brief introduction to economic theory. Topics: rising health costs, national health insurance, health indices, cost-benefit analysis and optimization, regulation and the structure of the industry (centralization vs. decentralization). Emphasis more on posing the important questions and examining different methods of analysis rather than arriving at definitive answers.
A. Detsky, Associates

HST 901J Health Economics

(Same subject as 14.21J)
Prereq.: 14.001
Year: U (2)
3-0-6

Application of theoretical and empirical tools of economics to problems of health and medical care delivery. Concentration in depth on selected problems such as: the welfare economics of "health" as a commodity; hospitals and the nonprofit sector; human capital and medical manpower; and innovation in medicine. (May be counted toward Humanities Requirement. ***Not offered 1981-82.***)
P. Temin

SEM Undergraduate Seminar

SEM 211 A Practicum in the Role of Education in Society

Prereq.: Permission of Instructor
Year: U (1, 2)
3-5-4

Relationship among education, social values, and social change studied. Ways of forming supportive learning relationships examined in depth. Students are required to spend five laboratory hours per week tutoring for the MIT-Wellesley Upward Bound Program at its Cambridge Rindge and Latin High School site. Resolution of problems such as social class conflicts, racial and sexual bias, and skills deficiencies is the focus of discussion. (Pass/Fail.)
L. Menand; Supervisor: J. Terry

SEM 212 A Reading Course in the Role of Education in Society

Prereq.: Permission of Instructor
Year: U (1, 2) HUM-D
3-0-9

Seminar designed for the student interested in intensively analyzing the effects of education on the individual and society as a whole. Seminar has two main intellectual goals: to develop students' critical awareness of the relationship between the values a society holds, both implicit and explicit, and the role formal education plays in the transmission or reproduction of these values; and to introduce students to the great debates in education and social organization theory. Basic assumptions about human nature, inequality, and social class differences are explored and discussed. (Graded.)
L. Menand; Supervisor: J. Terry

SEM 311 Undergraduate Teaching Seminar

Prereq.: —
Year: U (1)
Arr.

Teaching assistant program in the Experimental Study Group, providing opportunity to instruct MIT freshmen (under faculty supervision) in learning skills and facts relevant to mathematics, physics, chemistry, humanities, engineering, and computer science. Cooperation with MIT faculty members in leading seminars and discussion groups. Acceptance to the Program by decision of the MIT faculty member in charge of the particular area in the Experimental Study Group.
R. L. Halfman

SEM 312 Undergraduate Teaching Seminar

Prereq.: —
Year: U (2)
Arr.

Continuation of SEM 311.
R. L. Halfman

Note also that a group of undergraduate electives is offered (normally for 6 units) through the Undergraduate Seminar Program. These seminars may involve small group discussion, laboratory work, or field trips, and each seminar is under the guidance of a faculty member. For detailed descriptions and subject numbers, consult the *Undergraduate Seminar Program* booklet, published twice yearly, available in the Undergraduate Seminar Program Office, Room 7-105.

SPS Special Studies

SPS 1 Special Summer Program (Project Interphase)

Prereq.: —
Year: U (S)
Arr.

Program intended to assist freshmen in developing and sharpening their knowledge and facility with those concepts, techniques, and skills, primarily mathematical and verbal, that are essential for a successful academic performance at MIT; to enable them to gradually develop individual styles, study habits and discipline that will lead smoothly into the first year's mode of operation, expectations, and quality and quantity of workload; and to introduce the students to MIT and its surrounding community under conditions somewhat moderated from those that characterize the fall and spring academic terms. Classes held in four academic areas: calculus, covering at least one-third of 18.01 and reviewing as needed pre-calculus topics from algebra, geometry, trigonometry, and analytic geometry; physics, introducing the concepts and applications of Newtonian mechanics, vectors, velocity and acceleration as taught in 8.01; humanities, consisting of classes chosen in accordance with students' interests and backgrounds from expository writing, study skills, and Institute resources; chemistry, placing emphasis on stereo-chemistry, Lewis electronic structures, resonances, and, as time permits, acid-base concepts. All students are required to enroll in calculus, physics, chemistry, and humanities classes. Credit will be arranged with an 18-unit maximum. (Enrollment by invitation of the Admissions Office and the Office of Minority Education.)
A. Davison

SPS 11 Experimental Study Group

Prereq.: —
Year: U (1)
Arr.

A self-directed study program for freshmen within a small individualized learning community. Staff includes faculty, instructors, and graduate students from the Departments of Physics, Mathematics, and Chemistry, and the School of Humanities and Social Science. Credit is available for General Institute Requirements.
R. L. Halfman

SPS 12 Experimental Study Group

Prereq.: —
Year: U (2)
Arr.

Continuation of SPS 11
R. L. Halfman

SPS 21 Experimental Study Group

Prereq.: SPS 12
Year: U (1)
Arr.

Continuation of SPS 12
R. L. Halfman

SPS 22 Experimental Study Group

Prereq.: SPS 21
Year: U (2)
Arr.

Continuation of SPS 21
R. L. Halfman

SPS 31 Concourse Program

Prereq.: —
Year: U (1)
Arr.

SPS 32 Concourse Program

Prereq.: —
Year: U (2)
Arr.

An integrative program for the freshman year. Staff includes faculty from the Schools of Science, Engineering, and Humanities and Social Science. Credits in Concourse fulfill the General Institute Requirements and are so recorded.
Staff

SRE Study and Research in Education

SRE UR Undergraduate Research in Education

Prereq.: —
Year: U (1, 2)
Arr.

Undergraduate participation in research on topics relating to education. (For further information contact Divisional Coordinator: Marion Wasserman.)
Staff

SRE 107J Human Development: Individual and Social Perspectives

(Same subject as 9.90J)
Prereq.: —
Year: U (2)
3-0-6

Psychological processes and structures examined from a developmental perspective. Evolution of individual personality and social awareness is treated first, followed by an overview of leading theories of cognitive growth. The perceptual, cognitive, and affectional systems operative in the human infant are given special attention; the organization of these immature systems is linked to the theoretical problem of the role of childhood experience in mature intellectual and emotional organization. (May be counted toward Humanities Requirement.)
D. N. Osherson

SRE 108J Introduction to Cognitive Science

(Same subject as 9.62J, 24.116J)
Prereq.: Permission of Instructor
Year: U (1)
3-0-9

Survey of major issues that occupy contemporary Cognitive Science. Topics: induction and inductive logics as psychological theories; formal learning theory in linguistics; Is English a finite state language?; deduction and deductive logics as psychological theories; concepts and conceptual composition; the problem of natural concepts; images and percepts. Emphasis on clear formulation of questions and theoretical criteria of adequacy. Examination of specific proposals in response to these questions. (May be counted toward Humanities Requirement.)
D. N. Osherson

SRE 110 Special Problems in Education

Prereq.: —
Year: U (1, 2)
Arr.

Opportunity for undergraduates to engage in research, study, or development of Special Topics in education under supervision of a staff member. (Divisional Coordinator: Marion Wasserman.)
Staff

SRE 112 Computer Projects in Science and Mathematics

Prereq.: —
Year: U (2)
0-6-0

Opportunity to explore principles of science and mathematics through open-ended computer projects. Projects involve only simple programming and lead to areas of science suitable for undergraduate research. 1) Simple computer-drawn geometric figures; computation theory, geometry, and number theory. 2) Qualitative geometry on curved surfaces; differential geometry, geodesics, curvature, Gauss-Bonnet theorem, general relativity. 3) Gravitational orbits and their perturbation, intuitive approach based on the geometry of phase-space. Real-time computer displays to develop heuristic astrogation. (Programming experience not required. Limited enrollment. Freshmen welcome.) ***(Not offered 1981-82.)***
H. Abelson, A. di Sessa

SRE 114 The Future of Education

Prereq.: —
Year: U (2)
3-0-9

Goal is to acquire a knowledge base and experience in research, discussion, and criticism relevant to informed planning for the future of education in a technologically developed society. Consists of three modules each of which focuses on an area relevant to education: 1) the computer presence, 2) developmental psychology, 3) the sociology of education. Each module taught by Seymour Papert in collaboration with a specialist in that area. Relevant readings embrace developmental psychology (Piaget and critics), educational philosophy and criticism (Neill, Illich, Kohl, Jencks), artificial intelligence (Simon, Minsky, Papert), personal computers (Kay, LOGO), technological trends. Classwork in addition to lectures and readings includes exercises in developing detailed designs of educational forms for 1990. ***(Not offered 1981-82.)***
S. A. Papert

SRE 202 Professional Education (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Managers, physicians, teachers, and other professionals are constantly engaged in building informal theories concerning many aspects of their work situations. Subject focuses on 1) processes involved in building such theories — often idiosyncratic — to guide professional action; 2) process of modifying them as experience deems appropriate; and 3) the possibility that very different kinds of theories for action might be more effective. Consequences of inquiries of this sort are important not only in the education of professionals but also as a source of general knowledge about the form and dynamics of acquiring and modifying theories for use in action. ***(Not offered 1981-82.)***
M. Rein, D. A. Schön

SRE 206 Case Studies in Institutional Learning (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Educational innovations may be prompted by concern for the adequacy of students' knowledge of particular subject matter; by concern for the psychological and social development of the young; or by the conviction that as social institutions schools have a role to play in the amelioration of social problems. In any case, the attempt to implement educational innovations requires attention to systematic features of the social context for which the innovation is proposed. A number of theories of organizational change examined with respect to the light they shed on this issue and tested against particular examples of educational innovation. Students develop case studies of instances of change in educational settings with which they are familiar.
B. S. Nelson

SRE 210 Special Topics in Education Research (A)

Prereq.: Permission of Instructor
Year: G (1, 2)
Arr.

Research and study of selected problems by small groups or individual students under staff supervision. (Divisional Coordinator: Marion Wasserman.)
Staff

SRE 211 Topics in Science and Mathematics (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Seminar discussing the description of, and educational strategies for, developing more *intuitive* and *learnable* representations of scientific knowledge. Themes are intuition, heuristics, cognitive and conceptual skills, procedurally framed knowledge. Several examples of intuitive formulations of math and physics examined. Students participate actively in "loud thinking" experiments and other methodologies for getting at the structure of informal knowledge.
H. Abelson, A. di Sessa

SRE 212 On the Nature of Mathematical Competence (A)

Prereq.: 18.001 or 18.01 or 18.012
Year: G (1)
3-0-9

Counting and measuring; the quantification of discrete and continuous magnitudes, arithmetic computation, semantic aspects of quantity and the problems of modeling, imagery and visual problem solving, and the interactions of mathematics, language, and culture. Emphasis given to the study of these issues in relation to the mathematical competence of school-age children although interested students are encouraged to pursue these and related issues with older students and adults. (Permission of instructor required. ***Not offered 1981-82.***)
J. L. Schwartz

SRE 215J Cognitive Aspects of Musical Development and Learning (A)

(Same subject as 21.953J)
Prereq.: Background in music theory, some familiarity with cognitive psychology
Year: G (1, 2)
3-6-3

Cognitive developmental processes related to musical understanding, including the interactions among perception, cognition, and representation. Comparisons made between "figural" and "formal" internal representations and their relations to languages for describing musical structure, e.g., in music theory and computational systems. The relation of cognitive development in music to cognitive development in other domains.
J. S. Bamberger

SRE 216 Seminar: The Role of Metaphor in Learning and Design (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Examples of the uses of metaphor in episodes of learning, invention, and design, as well as in concept formation. Testing of prevailing theories of metaphor against these examples. Working toward a deeper, more useful theory of metaphor in these several contexts.
J. S. Bamberger, D. A. Schön

SRE 220 Educational Technology (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Project Laboratory concentrating on the application of computer technology to education. Particular attention paid to reformulating topics in science and mathematics in such a way as to make them more accessible and closer to intuitive ways of thinking. Students work in project-centered groups. Possible projects include investigating physics through computer simulations, advanced computer interfaced "erector sets," and computer-animated films. ***(Not offered 1981-82.)***
H. Abelson, A. di Sessa

SRE 222 The Social Psychology of Schools (A)

Prereq.: Permission of Instructor
Year: G (1, 2)
3-0-9

Concentrates on the social psychology theory of the "self-fulfilling prophecy" or expectancy as it relates to the student's learning and performance in schools. Macrostructures such as social class, tracking, and labeling as well as microstructures such as teacher classroom behavior examined. We attempt to understand not just the effects of expectations, but how they are communicated. Readings, drawn primarily from the fields of social psychology, sociology, and urban anthropology, cover contemporary research in the area.
J. P. Terry

SRE 223 Readings in Organizational Learning (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Examination of whether organizations can or do learn. Issues include: Why is this metaphor appealing? What model of organizations does it imply? What is the connection between the individual and the organization which is implied? Between the individual, the organization, and the larger social context? What is the relevance of theories of individual learning?
B. S. Nelson

SRE 227 Special Topics in Education (A)

Prereq.: Permission of Instructor
Year: G (1)
Arr.

Special Topics in metaphor: transformational processes in learning, problem solving, and design.
J. S. Bamberger, D. A. Schön

SRE 228J Natural Concepts (A)

(Same subject as 9.630J)
Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Psychological theorizing requires an account of what concepts humans find natural, i.e., readily understandable and easily encoded in natural language. The problem of stating a non-question-begging distinction between natural and unnatural concepts occupies this subject. Several formal theories of conceptual naturalness are examined that attempt to link the distinction to independently motivated theories of simplicity, deductive validity, ontology, induction, and syntactic well-formedness. ***(Not offered 1981-82.)***
D. N. Osherson

SRE 229 Evaluating the Impact of Educational Programs (A)

Prereq.: Permission of Instructor
Year: G (1, 2)
3-0-9

Examination of the development and implementation of research designs and methodologies which participants will use in field settings to discover how various programs affect those involved. Topics explored: 1) the adequacy of various approaches for finding out what you want and need to know; 2) the politics and ethics of the assessment process; and

3) practical issues in implementing theory. Individuals may explore programs of their own choice or participate in ongoing projects of the instructor.
K. C. Cohen

SRE 230J Computer Cultures, Computation, and the Individual (A)

(Same subject as STS 421J)
Prereq.: Permission of Instructor
Year: G (2)
3-3-6

The computer presence as it affects the individual and contemporary culture. Subcultures of the computer world, computational theories of mind, computer metaphors in the culture, and relationships between people, machines and programming. Emphasis on ethnographic and individual case study approaches. Conducted as a research seminar requiring a supervised research project.
S. R. Turkle

SRE 231J Seminar in Cognitive Development (A)

(Same subject as 9.652J)
Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Critical survey of selected topics. Emphasis on one or more of the following: the growth of logic; the relation between conceptual change in the history of science and in the individual child; cognitive development from an information processing point of view. (Open only to graduate students or undergraduates who have completed 9.89 or its equivalent.)
S. Carey

SRE 232 The Intelligent Eye and the Intelligible Image (A)

Prereq.: Permission of Instructor
Year: G (1)
3-3-6

This seminar examines a variety of issues that center on the generation and use of images by both humans and machines. Topics: recognition of images and patterns, the problem of illusion, computer-generated images and visual representations of knowledge in natural and social sciences, television images and their generation and interpretation. Readings are largely in the areas of the psychology of perception, pattern recognition, television production, and computer graphics. Visual materials, with particular emphasis on alternative visual representations, are drawn from geography, topology, quantum mechanics, electrodynamics, molecular biology, biochemistry, fluid mechanics, as well as from broadcast television. Students are expected to undertake a project involving the generation of intelligible images. ***(Not offered 1981-82.)***
J. L. Schwartz

SRE 234J The Psychology of Reasoning (A)

(Same subject as 9.631J)
Prereq.: Permission of Instructor
Year: G (1)
3-0-9

Over the past 50 years a variety of logical formalisms has been developed to systematize the deductive validity and inductive strength of arguments. Often, such systems provide incompatible accounts of logical truth or probability. Treats logical systems as theories of human reasoning. General criteria of empirical adequacy are formulated and discussed and psychological data brought to bear on proposed logics.
D. N. Osherson

SRE 235 Turtle Geometry: Making Mathematics Learnable (A)

Prereq.: Permission of Instructor
Year: G (1)
3-0-9

How can the subject matter of a learning experience, as opposed to style of presentation, reflect insights and theories about the learning process? Turtle geometry is a computation-theoretical reconstruction of certain topics in geometry motivated by the idea that "learnability" and "intuitive grasp" can be favored by building on these non-traditional foundations. Seminar discusses it both in terms of its intrinsic mathematical structure and as a case study (in contrast to competing formalisms like Euclidean geometry) for the examination of psychological theories of learning and understanding mathematics. The subject lends itself to mini-research projects at a level suitable for students to carry out within the semester.
A. di Sessa

SRE 237 The Developmental Psychology of Scientific Thought (A)

Prereq.: Permission of Instructor
Year: G (2)
3-0-9

The interrelationship between conceptual frameworks and experimental procedures; commonalities and contrasts between children, adolescents, and adults; relationships between knowledge and development, understanding and invention, learning and teaching. Piagetian theory brought to bear on close observations of individuals as they try to make sense of the physical world. ***(Not offered 1981-82.)***
E. R. Duckworth

SRE 238J Mobility, Inequality, and Education in Modern Industrial Societies

(Same subject as STS 551J)
Prereq.: —
Year: G (1)
2-0-7

An examination of the interrelation between family, status, jobs, and income in modern industrial societies. Particular attention to higher education as a channel of social mobility. Who goes to college, and why? Who pays, who benefits? Functional differentiation in higher education: "Liberal Education" vs "Professional Training;" the structure of education in relation to the structure of occupations. Materials deal with the USA and the United Kingdom with lesser attention to continental Europe.
C. Kaysen

SRE 239 Research Seminar in Education (A)

Prereq.: Permission of Instructor
Year: G (1)
4-0-8

Intensive study of several modes of research in education, emphasizing topics covered in current DSRE research. Two modules, each including assigned readings and student projects. Topics for 1981 include: Studying Knowledge-in-Practice and Its Acquisition, and Using the Computer for Developing Intuitive Knowledge in a Domain.
W. T. Martin, D. A. Schön, J. S. Bamberger, A. di Sessa

SRE 240 Research Seminar in Education (A) (New)

Prereq.: SRE 239
Year: G (2)
4-0-8

Continuation of SRE 239. Intensive study of several modes of research in education, emphasizing topics covered in current DSRE research. Two modules, each including assigned readings and student projects. Topics for 1981-82 include: Educational Problem Identification, and Probable Impact of MIT Education: A Longitudinal Study. (Permission of instructor required.)
J. S. Bamberger, B. S. Nelson, B. R. Snyder

SRE 242 Project Lab in Microcomputer Software Design (New)

Prereq.: Permission of Instructor
Year: G (2)
2-5-5

In this subject students — in collaboration with interested faculty members in the appropriate departments — design, write, and debug microcomputer software for use in university-level physics and mathematics subjects. Successful software projects are those that allow users to augment their intuitions about the domain by unconstrained exploration. Emphasis on programs with graphic input and/or high resolution graphic output.
J. L. Schwartz

SRE 243 Introduction to Microcomputers in Education (A) (New)

Prereq.: —
Year: G (1)
3-0-9

A categorical framework for classifying educational uses of the computer; review of the present state of hardware and educational software; the application of the cognitive sciences to the design of games, tutorials, and simulations; the evolution of the roles of student and teacher and the likely organizational consequences of that evolution; educational uses of microcomputers outside of schools; the interaction of microcomputers with the developing communications technology.
J. L. Schwartz

SRE 244J Developing Musical Perception: Cognitive and Educational Implications (New)

(Same subject as 21.616J)
Prereq.: —
Year: U (2)
3-3-6

Investigates fundamental musical structures and helps students to develop their abilities to hear what gives music its coherence. Beginning with close analyses of relatively short musical compositions in various styles, students use these as models for their own experiments with pitch-time relations through the use of the LOGO computer music system. Consideration given to the underlying cognitive structures which inform and shape musical perception as well as the role of "languages of description" in this process. Broader implications of this approach for education in other domains considered. Students expected to keep a continuing log of their progress, to write several short reports derived from these logs, as well as one final paper to include the analysis of a short composition and the results of an experimental project motivated by this analysis. (May be counted toward Humanities Requirement. Limited to 10.)
J. S. Bamberger

SRE 245J Cognitive Processes (New)

(Same subject as 9.65J)
Prereq.: —
Year: U (1)
3-0-6

An introduction to human information processing and learning; topics include memory, problem solving, concept formation, complex perceptual processes, and related issues. (May be counted toward Humanities Requirement.)
M. C. Potter, S. Carey

STS Science, Technology, and Society

General Subjects

STS 100J Reading Seminar in Humanities, Science, and Technology I

(Same subject as 21.901J)
Prereq.: —
Year: U (1)
2-0-7

STS 101J Reading Seminar in Humanities, Science, and Technology II

(Same subject as 21.902J)
Prereq.: —
Year: U (2)
2-0-7

Reading and discussion of major primary and secondary works which illustrate or examine the interactions of science, technology, and society. Topic Term I: Classic Interpretations in the History of Ideas. Term 2: Ideas of Progress. (Primarily for students enrolled in XXI-A and XXI-B,1 Option 2; open to others by permission of instructor.)
Term 1: *A. C. Kibel*
Term 2: *K. R. Manning*

STS 110 Special Topics in Science, Technology, and Society

Prereq.: —
Year: U (1)
Arr.

STS 111 Special Topics in Science, Technology, and Society

Prereq.: —
Year: U (2)
Arr.

For students who wish to pursue special studies or projects with a member of the Program in Science, Technology, and Society. (Humanities credit for Special Topics subjects awarded only by individual petitions to the Committee on Curricula. Normal maximum is six units; to count towards Humanities Requirement, nine units are required. Exceptional nine unit projects occasionally approved.)
Staff

STS 120 Advanced Topics in Science, Technology, and Society

Prereq.: —
Year: G (1)
Arr.

STS 121 Advanced Topics in Science, Technology, and Society

Prereq.: —
Year: G (2)
Arr.

For students who wish to pursue special studies or projects at an advanced level with a member of the Program in Science, Technology, and Society.
Staff

History of Science

STS 200 The Scientific Revolution

Prereq.: —
Year: U (1) HUM-D
3-0-9

A treatment of the Scientific Revolution and its later consequences during the Enlightenment. Origins of scientific thought in the West, and the Medieval and Renaissance background in science and technology. Emergence of science as a new intellectual and social force in the late 16th and 17th centuries. Influence of Newtonianism on the development of physical and life sciences in the 18th century. Readings include the writings of major scientists such as Copernicus, Kepler, Galileo, and Newton, and philosophers such as Bacon, Descartes, and Leibniz, as well as secondary sources of general intellectual and social history of the periods.
K. R. Manning, I. Kaplan

STS 201 History of 19th- and 20th-Century Science

Prereq.: —
Year: U (2) HUM-D
3-0-9

Survey of the growth of the physical and biological sciences since the end of the Enlightenment. Emphasis on interactions between scientific thought and general intellectual history. An introduction to the history of scientific concepts and ideas which had great significance for the development of modern Western culture. Topics: evolution, electromagnetism and field theory, relativity and cosmology, quantum mechanics, genetics and molecular biology, ethology, sociobiology, and other biological approaches to the study of human behavior. Readings from works of such major figures as Darwin, Spencer, and Huxley; Mach, Einstein, and Bohr; Mayr, Watson, Lorenz, and Wilson. ***(Not offered 1981-82.)***
L. R. Graham, P. Buck

STS 205J Nature of Scientific Knowledge

(Same subject as 24.05J)
Prereq.: —
Year: U (1, 2) HUM-D
3-0-6

An introduction to fundamental philosophical problems concerning the nature of science and its development. How, for example, is scientific knowledge arrived at; in what circumstances are theories rejected and replaced; what criteria or values govern these processes; and what gives their outcome such reliability? Are facts, given once and for all, independent of theory, or does change of theory change what it is to be a fact? Do scientific theories describe an underlying reality, or do they merely provide an economical systematization of concrete experimental results?
Term 1: *P. G. Horwich*
Term 2: *T. S. Kuhn*

STS 206 Social and Political Implications of Science

Prereq.: —
Year: U (2)
2-0-7

Historical and contemporary studies of the interaction of science with social and political values. Examination of use of scientific theories and findings to support conclusions about the proper organization of society and politics. Discussion of ways in which conceptions of the natural world and people's place in it have been used to set guidelines, constraints, and limits on possibilities for social and political change. Emphasis on how scientists have viewed the relationship of their scientific work to moral and ethical issues. Topics: natural and social order in medieval thought; the Mechanical Philosophy and the English Revolution; evolution, sociobiology, and society; and cybernetics, computers, and political theory. ***(Not offered 1981-82.)***
L. R. Graham, P. Buck

STS 207J Scientific Knowledge, Social Values, and Politics (A)

(Same subject as 17.336J)
Prereq.: Permission of Instructor
Year: G (2)
2-0-10

Historical and contemporary studies of the changing role of scientific ideas and arguments in social and political discourse from antiquity to the present. Emphasis on the so-

cial and political implications that have been drawn from the natural sciences: how scientific concepts and theories have been employed to give meaning to social and political experience; ways in which conceptions of the natural world and people's place in it have served as models for the good society; uses of scientific modes of analysis to explain the values that shape human behavior. ***(Not offered 1981-82.)***
L. R. Graham, P. Buck

STS 210 American Science Since the 1930s

Prereq.: —
Year: U (2) HUM-D
3-0-6

History of science and technology in American context from the Great Depression of the 1930s through World War II, to the 1970s. Topics: patterns of funding, international links, government-industry-academic relations, public understanding, the rise of "big science," and response of the scientific community to new social responsibilities. Issues studied in relation to relevant social, economic, and political developments in the United States during the period.
C. Weiner

STS 211 Russian Science and Society

Prereq.: —
Year: U (2)
3-0-6

An introduction to the history of Russian and Soviet science, with special emphasis on the Soviet period. Topics: introduction of Western science to Russia, reception of Darwinism, influence of Marxism on Soviet scientific development, social and political context of Soviet science, role of dissidents in Soviet scientific life, and organizational and policy questions. Students encouraged to make a special study of some aspect of Russian or Soviet science or technology appropriate to their own interests. Required readings in English; supplementary readings in Russian also available. Graduate students encouraged to enroll. ***(Not offered 1981-82.)***
L. R. Graham

STS 212 Science and Society in Modern China

Prereq.: —
Year: U (1)
3-0-6

Examines social, cultural, and political aspects of the development of science in modern China. Sets China's experiences with modern science in the context of traditional Chinese conceptions of natural and social order, relations between philosophy and material technology, and connections between knowledge and political power. Relates the introduction of western science in the 19th and 20th centuries to the onset of China's continuing revolution and to western imperial expansion in east Asia. Against this background discusses the place of science in the People's Republic, with particular attention to the Cultural Revolution and its consequences. Topics: the role of American missionaries as transmitters of science and medicine in the 19th century; social Darwinism in China; the use of science as an ideology during the first Chinese revolution; and Maoist views of science, medicine, and technology. ***(Not offered 1981-82.)***
P. Buck, L. Trilling, R. M. Douglas

STS 220 History of Modern Mathematics

Prereq.: 18.02
Year: U (2)
3-0-9

Begins with development of algebra in the 16th century, outlines development of calculus as culminated in works of Newton and Leibniz in the 17th century. Traces applications of calculus in the 18th century by such mathematicians as Euler, Lagrange, and Laplace. In order to provide a synthesis of 18th-century traditions, discussions focus on attempts at rigorization of analysis by Cauchy, Bolzano, Dedekind, and Weierstrass in the 19th century. Rise of abstract algebra, emergence of complex analysis, and development of set theory are among topics treated in discussions of mathematics in the 19th century. References made to relevant 20th-century developments. (Some knowledge of concepts of algebra helpful.)
K. R. Manning

STS 221J Topics in the History of Physical Science

(Same subject as 24.270J)
Prereq.: —
Year: U (2)
3-0-9

By careful reading and analysis of selected scientific papers, the class attempts to reconstruct some significant episode in the evolution of physical science. Topic varies from year to year. ***(Not offered 1981-82.)***
T. S. Kuhn

STS 222J Historical Interpretation of Scientific Thought (A)

(Same subject as 24.854J)
Prereq.: Permission of Instructor
Year: G (2)
3-0-9

Close reading of selected primary sources in order to reconstruct a significant chapter in the development of scientific thought. Attention given not only to concepts, methods, and theories disclosed by the texts but, where possible, also to the experience of historical interpretation. ***(Not offered 1981-82.)***
T. S. Kuhn

STS 230 Emergence and Growth of New Research Fields: A Social History

Prereq.: —
Year: U (1)
3-0-6

Historical-sociological exploration of the interaction of individuals, ideas, institutions, and national environments in the formation and development of new research fields. How does a field come to be central within the scientific and engineering disciplines? What influences the priorities for allocation of resources — not only intellectual but also social (funds, facilities, fellowships, jobs) — for specific research fields? These processes explored in fields such as molecular biology; genetic engineering; nuclear, particle, and solid-state physics; nuclear engineering; and computer science. Lectures and discussions with participation by major contributors to the fields being studied. Optional student projects involving archival research and oral history interviews in their own field of interest.
C. Weiner

STS 240 The Work of the Scientist, and Its Sources

Prereq.: —
Year: U (2)
3-0-6

Case studies of major advances ("events") in the physical sciences. Analysis of an event in terms of: scientific content; public-scientific developments leading up to the event; prior trajectory of the scientist's own development; cultural and sociological setting; and the thematic presuppositions that often shape the scientist's and his or her antagonists' imagination. Cases range from Copernicus and Kepler to Einstein and Bohr. Biographies and works

in philosophy of science assigned in addition to the scientific papers themselves. Occasional guest lectures. Foreign language desirable but not necessary. (Limited to 25.)
G. Holton

STS 241 Biography in Science

Prereq.: —
Year: U (2)
3-0-9

An examination of biography as a literary genre to be employed in the history of science. The use of biography in different historical periods to illuminate aspects of the development of science. A critical analysis of autobiography, archival sources, and the oral tradition as materials in the construction of biographies of scientists. Published biographies of scientists constitute the major reading, but attention is given to unpublished biographical sources. Comparison drawn between biography as a literary form in the history of science and in other disciplines. ***(Not offered 1981-82.)***
K. R. Manning

History of Technology

STS 300 History of Technology in America I: 1787-1876

Prereq.: —
Year: U (1) HUM-D
3-0-6

A study of America's rural, agrarian, and artisanal "preindustrial society" from 1787 up to the Centennial Exhibition of 1876. Examines the emergence of industrial capitalism within this setting: the rise of the factory system and machine-based manufacture, and new forms of power, transport, and communication. Main theme is that technology is part of the larger society and consists of a range of possibilities which are chosen or rejected according to the dominant cultural, economic, political, and other social criteria of the time. The aim is to identify these possibilities as they presented themselves to contemporaries and to explain why developments took the direction they did, what factors — technical and nontechnical — proved decisive, and what the consequences were for society and for subsequent technological development.
M. R. Smith

STS 301 History of Technology in America II: 1876-the Present

Prereq.: —
Year: U (2) HUM-D
3-0-6

The second part of a two-term survey; has the same themes and aims as STS 300. Focus on the maturation of industrial capitalism after 1876 with the emergence of large industrial corporations, national and international markets, and the hallmarks of science-based industry: professional engineers, organized research, and significant institutional integration among schools, laboratories, and workshops. Major technological systems studied include: electric power; telecommunications; the internal combustion engine; chemicals and chemical processes; aviation; nuclear power; computers; and electronics. (May be taken independently of STS 300, but students are encouraged to take both.)
D. F. Noble

STS 310J Industrialization and Cultural Change in 19th-Century America

(Same subject as 21.433J)
Prereq.: —
Year: U (2)
3-0-6

A comparative study of 11 communities assessing the social dislocations and adjustments of an industrializing economy. The work ethic, craft customs, kinship ties, business attitudes, political ideologies, social institutions, and the growing speed and scale of mechanized production among the factors treated. Goal is to understand why some communities entered the industrial age more easily than others. Communities studied include: Wilmington, Delaware; Pullman, Illinois; Waltham-Lowell, Chicopee-Springfield, and Lynn, Massachusetts; Patterson-Newark, New Jersey; Troy and Oneida, New York; Philadelphia-Rockdale, Pennsylvania; Pawtucket, Rhode Island; and Harpers Ferry, Virginia. Members of the class submit thematic essays addressing various aspects of industrialization and culture change. ***(Not offered 1981-82.)***
M. R. Smith

STS 315J The Industrial Revolution: A Social and Cultural History

(Same subject as 21.371J)
Prereq.: —
Year: U (2)
3-0-6

An examination of the industrial revolution, 1750-1830, in terms of the context in which it occurred and its impact on society and culture. After a brief consideration of the industrial revolution itself, attention focused upon the intellectual, emotional, artistic, literary, and social effects, including the implications for demographic and class structure and for the family. Presentations, where possible, are made in terms of individuals such as A. Smith, Malthus, Rousseau, Owen, Carlyle, St. Simon, and Fourier.
B. Mazlish

STS 320 Arms, Power, and the Engineer

Prereq.: —
Year: U (1)
3-0-6

Examines cultural, social, and technical factors which underlie exercise of political power. Describes how consequences of technical progress and new world outlook which developed in the West after the Renaissance transformed selection, style, and goals of the power elite in England, France, China, and Japan, and how a more effective military technology affected views on war making and the reach of the state. Finally, examines role of the engineer and the scientist in the process of making decisions which involve "high" technology and its effects on national power and human welfare.
L. Trilling

Contemporary Issues in Science, Technology, and Society

STS 400 Science, Technology, and Society: Problems of Innovation

Prereq.: —
Year: U (1) HUM-D
3-0-9

The work of scientists and engineers generates problems whose solution requires more than scientific and engineering knowledge. These problems often involve basic conflicts about how scientific ideas and technical systems should interact with society and individuals. Examines such conflicts through exercises in making the kinds of choices presented to society by scientific and technological innovations. Historical and contemporary case studies used to show how opposing inferences

can be drawn from the same scientific and engineering data base; how choices involving facts and values are made in such situations; and what standards exist for debates in issues where technical, social, and political judgments interact. In 1981-82 the cases selected for study are: technology, production, and reproduction; medicine, the idea of progress, and the pastoral view of life; and the effort to attain a scientific understanding of human behavior.
K. Keniston, P. Buck, L. Marx, R. S. Morison

STS 401J Rationality, Risk, and Choice in Industrial Society

(Same subject as 17.305J)
Prereq.: —
Year: U (2) HUM-D
3-0-9

Survey of the environmental and health consequences of 20th-century technology, viewed from historical, ethical, legal, and scietific perspectives. Historical development of the concepts of risk and uncertainty; 19th- and early 20th-century precursors of current environmental controversies. Health effects of nuclear and fossil electricity generation. Toxicity of chemicals and food additives in general use. Value choices underlying social decisions to create modern technological systems; ethical limitations of cost-benefit analysis in valuing human life for public policy purposes. Justification for and limitations of formal adversary methods for dealing with rights in conflict.
J. Yellin

STS 402 Innovation and Society

Prereq.: —
Year: U (2) HUM-D
3-0-9

Focuses upon the complex interplay between major technological innovations and changing patterns of life in modern industrial society. In order to illuminate the origin and consequences of such innovations, considers the individual and social circumstances in which they are made: growth and dissemination of scientific knowledge; character of social, political and economic institutions; expectations and responses engendered by prevailing belief systems or ideologies. Three specific cases of technical change examined within this broad sociological and cultural context. The 1981-82 examples studied: the rise of national transportation systems as illustrated by the railroads; development and evolution of the automobile; and introduction of tape-controlled machine tools into the aircraft industry.
L. Trilling, M. R. Smith

STS 410 Ethical Issues in Science and Engineering

Prereq.: —
Year: U (1)
3-0-6

Seminar on the ethical problems faced by scientists and engineers in the course of their careers.What responsibilities do technical professionals have for the consequences of their work? What problems do they face in perceiving and carrying out their responsibilities? Case studies of on-the-job ethical dilemmas and of responses of scientists and engineers to issues in such fields as nuclear physics, nuclear energy, genetic engineering, chemical engineering, computer science, and biomedicine. Class explores issues such as conflicts of interest, whistleblowing and its consequences, the role of institutions and professional societies. Student projects in fields of their interest.
C. Weiner

STS 411J Legal, Ethical, and Scientific Issues in the Regulation of Dangerous Industries

(Same subject as 17.307J)
Prereq.: Permission of Instructor
Year: U (1)
3-0-9

Upperclass seminar dealing with the regulation of industrial activities in which the health and safety of the public are important considerations. Judicial review of environmental decisions made by Federal agencies. Litigation over air and water quality and nuclear power. The Constitutional basis of American administrative law: Congressional delegation of powers. The use of scientific and statistical methods by Federal agencies and courts. Consideration of whether procedural and scientific issues are separable in environmental controversies. Philosophical, economic, and ethical issues related to the valuation of human life.
J. Yellin

STS 412J Ethics and Technocrats

(Same subject as 1.12J)
Prereq.: —
Year: U (2)
4-0-8

Explores issues about ethics and social values central to the work of engineers, planners, systems analysts, economists, and other technical professionals. Primary objective is to assist the student in clarifying the ethical commitments of his or her own professional life. Examines several models of decision-making and problem-solving processes commonly employed in these professions. Analyzes how particular professions construct images of reality, implications of these images for what is considered to be appropriate professional work, and social value assumptions implicit in these images. Selected case studies from transportation, environmental engineering, urban planning, and other fields used to illustrate the issues.
M. L. Manheim

STS 413J Public Controversies on the Control of Technology

(Same subject as 8.206J)
Prereq.: —
Year: U (2)
2-0-7

Role of scientists and engineers in controlling the damaging side effects of technologies on which industrialized nations are now dependent. Presentations by professionals who have played major roles in such issues. Historical cases and contemporary problems studied through readings, discussions, lectures, and student reports. Topics: dangers of the nuclear arms race; environmental and health hazards; responsibilities of scientists and engineers as advisors and outside critics; means of involvement and opportunities for action.
C. Weiner, B. T. Feld, H. W. Kendall

STS 414J Regulation of Hazardous Materials (A)
(New)

(Same subject as 17.338J)
Prereq.: Permission of Instructor
Year: G (2)
3-0-6

Examination of statutory, organizational, procedural, and political bases for the regulation of hazardous materials in the US and how these various input variables influence regulatory outputs, such as standards and permits issued by regulatory agencies. Primary focus on how organizational structure, procedures, and politics interact with the acquisition and use of scientific and technical information and

with the use of various methodologies for risk assessment and cost-benefit analysis. Examples include the regulation of carcinogens, air pollutants, hazardous chemicals in the workplace, toxic wastes, and nuclear waste. Students examine the statutes underlying regulatory regimes, actual standards that agencies promulgate, and the analyses on which these are based. The issues and politics of current debate on regulatory reform examined. (Open to advanced undergraduates.)
T. R. I. Greenwood, J. Yellin

STS 420 Computers and People

Prereq.: —
Year: U (2)
3-3-6

The lives of most people in our society are touched by some use of computation. With mass marketing of the personal computer, hands-on, interactive relationships with machines seem destined to become part of the daily life of almost everybody. This subject studies many aspects of the increasingly ubiquitous computer presence in our society in the context of larger issues in the sociology of science. Three perspectives on computer impacts examined. *Computer impact on large social processes:* privacy, electronic money and mail, computer crime, political control, ethical responsibility of computer science professionals. *Computer impact on the individual:* the psychology of computer programming, computer hobbyists and the home computer, computers and the educational experience. *Computer impact on sciences of mind and images of humanity:* the AI controversy, impacts on psychology, literature, and popular culture. Projects include field work studies at MIT and elsewhere to document and analyze different computer "subcultures."
S. R. Turkle

STS 421J Computer Cultures, Computation, and the Individual (A)

(Same subject as SRE 230J)
Prereq.: Permission of Instructor
Year: G (2)
3-3-6

The computer presence as it affects the individual and contemporary culture. Subcultures of the computer world, computational theories of mind, computer metaphors in the culture, and relationships between people, machines and programming. Emphasis on ethnographic and individual case study approaches. Conducted as a research seminar requiring a supervised research project.
S. R. Turkle

STS 425 Technology and the Individual

Prereq.: —
Year: U (2)
3-0-6

How do interactions with technologies and technological systems affect individuals? How do people use technologies for purposes not anticipated by their inventors? Examines the non-instrumental or unintended human effects and uses of technologies through four case studies: e.g., computers and intensive users, television and viewers, engineering systems and engineering students, "automated" tools and workers. These cases used to examine critically theories of "technological man," "technological society," and "the effects of technology."
K. Keniston, S. R. Turkle

STS 430 Engineering Design in Social Context

Prereq.: —
Year: U (2)
3-0-6

Examines issues about social values that arise in engineering design. Who influences and what constrains the design process? What is the engineer's role in that process? What are the social implications of design alternatives? Beginning with a study of the design of photovoltaic solar energy systems, the class considers design as an aspect of modern social history, the limits of scientific knowledge in decision making about design, and ethics in the design process. As a context for discussing these issues the class compares ideas about design in other fields — the arts, architecture, city planning, and political theory. Special attention given to social criteria beyond those of cost-effectiveness. Subject materials parallel Mechanical and Civil Engineering design subjects 2.73 and 1.412J.
L. L. Bucciarelli

Science, Technology, and the Organization of Industrial Society

STS 501 The Automobile: Mass Production and Mass Consumption

Prereq.: —
Year: U (1) HUM-D
3-0-6

Rise and decline of the automobile industry. Examines the 19th-century origins of mass production and mass consumption. The auto industry as the epitome of the American economic miracle. Workers in the high-wage economy. Influence of machine technology on culture. The long decline of the auto-industrial age, and its crisis in the 1970s. Concerned with the changing political and economic role of a dominant national industry. Emphasis on European reactions to and variations on American industry. Readings include works of classical political economists, writings of auto industry pioneers such as Henry Ford and Alfred Sloan, studies of consumption and mass travel, recent reports on automotive technology and organization.
E. G. Rothschild, C. F. Sabel

STS 502 The Profession of Engineering: Past, Present, and Future (New)

Prereq.: —
Year: U (2) HUM-D
3-0-6

The evolution, contemporary role, and dilemmas of engineering as a profession. Part I examines the development of engineering from its pre-industrial beginnings through its 19th-century professionalization to its role in modern industrial societies. Part II analyzes the societal position, education, and careers of contemporary engineers. Part III looks at four dilemmas confronted by today's engineers in the course of their work.
K. Keniston

STS 510J The Rise of the Modern State (A)

(Same subject as 17.154J)
Prereq.: Permission of Instructor
Year: G (1)
3-0-9

The theory of the state. Focuses on three stages in the development of the modern state: political absolutism, the property-contract state, and the corporate-welfare state. In each section close attention given to key texts in political theory and to their relationship to the corresponding historical period.
C. F. Sabel, J. Cohen

STS 511 Capitalism and Its Critics

Prereq.: —
Year: U (2) HUM-D
3-0-6

The social context and consequences of industrialization and the development of the market economy. The virtues and shortcomings of the market economy as seen by its exponents and critics, examined in the light of its historical development. Early and late industrializing societies compared. Interrelations of market capitalism, technological change, and political evolution.
C. Kaysen, P. Buck

STS 520 Technology as a Social Process

Prereq.: —
Year: U (1)
3-0-6

Focuses on the problem of technological determinism, the tendency to ascribe to "technology" a dominant causative role in human affairs. Explores content and historical origins of both the idea of technological determinism and the recent critique of that idea, viewing each in terms of the rise, maturation, and disintegration of liberal ideological hegemony in capitalist society. Major part of the subject is spent examining technology as a social process in itself. First, an historical exploration of the institutions in America which have fostered technological development and, second, an in-depth examination of two case studies (sewer systems and automated production machinery). Aims to shed light on the cultural, ideological, political, sociological, economic, and psychological determinants of technological development. Having explored the ideology of technological determinism and examined the actual realities of technology as a social process, students begin to identify actual constraints imposed by our technologies and to explore the possibilities for social change.
D. F. Noble

STS 521 Technology and Labor in Industrial America: Another Look at Progress (New)

Prereq.: —
Year: U (2)
3-0-6

Social implications of the industrial labor process in the US as it has been transformed over the last century by changes in the technology of production. Shifts in methods of production (e.g., from craft- to machine-based, from batch to continuous process, and most recently, from mechanical and organizational to cybernetic control) in key industries such as mining, steel, auto, metal-working, textile, tobacco, chemical, and farming and their social ramifications. All discussion grounded in concrete reality of production experienced by various participants in the labor process.
D. F. Noble

STS 530 Growth and Structure of Urban Environments

Prereq.: Permission of Instructor
Year: U (2)
3-0-6

Upperclass seminar on historical and theoretical perspectives on urban structure and growth, as affected by technological change. Topics: population distribution, patterns of racial and income segregation in housing, transport availability; their relations to places of work. Analysis of historical and contemporary descriptions of urban communities. Comparisons of narrative literature and of current census data with the results of abstract models. Limited attention to related topics in urban economics. ***(Not offered 1981-82.)***
J. Yellin

STS 540 The Political Economy of Food

Prereq.: —
Year: U (1)
3-0-6

Looks at the world food economy, and the role that the United States as the dominant exporting country plays in it. Emphasis on changes in diet patterns; impacts of technical change on agricultural productivity and income distribution in developing countries, and how they are affected by policy decisions in the US and other advanced countries; changes in food technology; food aid; political changes. Students expected to undertake independent research into some aspect of the world food economy. Readings include works of economic and social history, government documents, anthropological and political studies, trade statistics, surveys of food consumption.
E. G. Rothschild, L. J. Taylor

STS 551J Mobility, Inequality, and Education in Modern Industrial Societies

(Same subject as SRE 238J)
Prereq.: —
Year: G (1)
2-0-7

An examination of the interrelation between family, status, jobs, and income in modern industrial societies. Particular attention to higher education as a channel of social mobility. Who goes to college, and why? Who pays, who benefits? Functional differentiation in higher education: "Liberal Education" vs "Professional Training;" the structure of education in relation to the structure of occupations. Materials deal with the USA and the United Kingdom, with lesser attention to continental Europe. ***(Not offered 1981-82.)***
C. Kaysen

STS 560 Arms Races in Industrial Society (New)

Prereq.: —
Year: U (1)
2-2-5

Studies the influence of technology in arms races and the consequences for the dynamics of industrial society. Examination of the interplay between political and technical processes. Particular emphasis on the relationship of scientists, the military, and government since the Second World War; and on the employment of engineers and scientists in military industries. Considers possible strategies for ending the arms race. Students work in small groups on research projects, and write papers based on their research.
J. B. Wiesner, E. G. Rothschild

Cultural Dimensions of Science and Technology

STS 600 Technological Society and Its Critics

Prereq.: —
Year: U (1) HUM-D
3-0-6

Emergence of urban industrial society has provoked strong critical reaction in the name of a "natural," simple, and reverential way of life. This alternative vision is examined chiefly as revealed in the dissident movements of the last 20 years in the US (e.g., the antiwar protest, environmentalism, the "counterculture"). An earlier version of this reaction in the 1840s, as exemplified by Thoreau's *Walden*, examined. Focuses on the usefulness of the pastoral ideal as a critique of (or possible alternative to) a complex society characterized by high technology.
K. Keniston, L. Marx

STS 601J Literature, Ideology, and National Experience in the United States

(Same subject as 21.103J)
Prereq.: —
Year: U (2) HUM-D
3-0-6

Study of the interplay among imaginative literature, the prevailing belief systems (or ideology), and collective experience in what is now the United States, with emphasis upon the critical reading of literature within an historical context. Traces the emergence of a conflict between the idea of America as an embodiment of the progress of civilization and the mastery of nature on the one hand, and of the recovery of natural (or pastoral) harmony, in-

nocence, and happiness on the other. The bearing of this conflict — both as cause and effect — upon the emergence of a science-based technological society is at issue. Readings chiefly drawn from classic American writers of the 19th century, but works from earlier and later periods as well as pertinent extra-literary materials included. Writers include: F. Scott Fitzgerald, Franklin, Jefferson, Emerson, Tocqueville, Thoreau, Whitman, Hawthorne, Melville, F. J. Turner, and D. H. Lawrence. ***(Not offered 1981-82.)***
L. Marx

STS 602 The Machine: Metaphor, Fact and Theory

Prereq.: —
Year: U (2) HUM-D
3-0-6

Centrality of the machine as a fact, a metaphor, and a subject of theoretical discourse is a gauge of the impact of technological change upon Anglo-American culture during the last two centuries. The class addresses the reasons for this preoccupation, and ways in which the existence of machine power has been treated by representative writers, and their perception of its promise and its dangers during these distinct phases of industrialization. Particular attention given to the place of the machine metaphor in theories of technological society and the theorists' conceptions of "the machine" as a vehicle of alienation or liberation. Readings include the work of Adam Smith, Thomas Carlyle, Karl Marx, Charles Dickens, Thorstein Veblen, Frank Norris, Lewis Mumford, Jacques Ellul, and Norman Mailer.
L. Marx, M. R. Smith

STS 611J Writing: Technology and Society

(Same subject as 21.761J)
Prereq.: —
Year: U (1) HUM-D
3-0-6

Examination of different "voices" used to consider issues of technological and social concern. Students write frequently and choose among a variety of non-fiction forms: Historical writing, social analysis, political criticism, policy reports. Instruction in expressing ideas clearly and in organizing a thesis-length work. Reading and writing on four case studies drawn from 1) the history of industrial societies; 2) the cultural study of technology and science; 3) industry studies, and 4) policy issues. ***(Not offered 1981-82.)***
E. G. Rothschild, K. Keniston, K. R. Manning, J. Paradis

STS 625J American Television: A Cultural History

(Same subject as 21.032J)
Prereq.: One subject in Literature or Science, Technology, and Society
Year: U (2)
3-0-6

Television's evolution as a system of storytelling and myth-making, studied from anthropological, literary and cinematic perspectives. Centers on prime-time commercial broadcasting but also examines the medium's technological and economic history as well as the theoretical perspectives from which scholars and policy makers have perceived our television system. Much required viewing as well as readings in media theory and cultural interpretation. (Cambridge Humanities Seminar subject given at MIT.)
D. Thorburn

TPP

Technology and Policy

TPP 11J Project Proseminar in Technology and Policy I (A)

(Same subject as 2.981J)
Prereq.: Permission of Instructor
Year: G (1)
4-0-8

TPP 12J Project Proseminar in Technology and Policy II (A)

(Same subject as 2.982J)
Prereq.: TPP 11J
Year: G (2)
4-0-8

Designed to develop the students' ability to analyze problems involving the interaction of technology with economic and social considerations. Exercises in problem formulation, design, analysis, and evaluation of alternative policies and hardware configurations. Problems of institutional change. Case studies, individual and group projects drawn from fields such as: energy, transportation, communications, health care, automation. Emphasis on written, oral, and graphic communication of results. Integral to the projects is directed reading and written or oral critique with respect to value implications and historical context. This effort, consisting of approximately one-third of the total proseminar, is guided by associated faculty in the School of Humanities and Social Science and explicitly designed to ensure that the student experience a perspective outside that of technology itself. (Restricted to graduate students in Technology and Policy; others admitted by permission of instructor.)
M. A. Sirbu, T. B. Sheridan, D. F. Noble

TPP 13J Engineering Policy Thesis Seminar (A)

(Same subject as 1.980J, 16.783J)
Prereq.: Thesis Registration
Year: G (1, 2)
2-0-1

Weekly seminar designed to assist students in formulating research topics, designing their investigation, executing the analysis, and writing the thesis itself. It thus also serves as preparation for general examinations. Students required to present their work for general discussion by faculty, research staff, and their colleagues.
R. de Neufville, A. R. Odoni, Staff

TPP 21 Engineering Systems Analysis (A) (New)

Prereq.: Permission of Instructor
Year: G (1)
3-0-6

Synthesis of analytic procedures for identification and selection of optimal systems. Review of economic framework for analysis. Systematic survey of theory and applications of mathematical optimization to engineering problems. Evaluation procedures for single and multi-attributed problems covering utility theory and decision analysis in addition to standard procedures. Application of this material to real problems in planning and design stressed throughout term. (Open to qualified undergraduates. Knowledge of probability, microeconomics, and computer systems at an undergraduate level required.) This subject is an Engineering School-Wide Elective.
R. de Neufville, J. P. Clark

TPP 22J The Policy-Making Process (A)

(Same subject as 17.220J)
Prereq.: Permission of Instructor
Year: G (2)
3-0-9

An overview of the ways in which public policy evolves, with special emphasis on the interactions of politics and policy analysis. Examines the ways in which cultural, economic, and technological factors have combined with politics and analysis to shape welfare, regulatory, and economic promotional programs in the US and other industrialized democracies. Also considers recent literature on the roles of formal policy analysis in the political process.
A. A. Altshuler

TPP 32J Law, Technology, and Public Policy

(Same subject as 3.576J)
Prereq.: Permission of Instructor
Year: G (2)
3-0-6

In-depth examination of the relationship between technology and the legal system. Five major areas discussed: 1) responses of the legal system to new social problems created by new or existing technology (including regulation); 2) responses of technology to legal action; 3) changes in legal theory and practice (including the burden and standards of proof with regard to technological issues, and ways in which technology has changed the treatment of evidence in the courts); 4) responses of the political system to increasing technology (including forums for the interaction of legal and technological issues such as the science court); and 5) equity/market changes brought about by the law/technology interaction (including discussion of differences between the processes involved in "market" or "economic" regulation from those designed to ameliorate the adverse consequences of technology, and the law as a resolver of equity and distributional problems raised by changing technology).
N. A. Ashford, G. R. Heaton, Jr.

TPP 33J Environmental Law: Pollution Control (A)

(Same subject as 1.811J)
Prereq.: Permission of Instructor
Year: G (1)
3-0-6

Review and analysis of common law, legislation, and regulation of air and water pollution. Emphasis on use of legal mechanisms and alternative approaches for controlling environmental pollution. Economic consequences of pollution control discussed. The Clean Air Act, Clean Water Act, and National Environmental Policy Act analyzed regarding the goals of pollution control, economic consequences, and the role of the courts. Both classical pollutants and highly toxic industrial chemicals discussed.
N. A. Ashford, G. R. Heaton, Jr.

TPP 34J Regulation of Health and the Environment: Selected Topics

(Same subject as 1.812J)
Prereq.: 1.811, 3.575J, 10.805J
Year: G (2)
3-0-6

Topics related to environmental and safety regulation selected from the following: the Toxic Substances Control Act, occupational safety and health, noise, pesticides, food additives, pharmaceuticals, hazardous and solid waste, land use and control, fish and wildlife, endangered species. Health and economic consequences of environmental policy discussed. Focuses on policy design and evaluation in the environmental and safety area. (Recommended: other law-related subjects, or permission of instructor.)
N. A. Ashford, G. R. Heaton, Jr.

TPP 35J Technology, Law and the Working Environment

(Same subject as 10.805J)
Prereq.: Permission of Instructor
Year: G (1)
3-0-6

Addresses the relationship between technology-related problems and the law applicable to the work environment. National Labor Relations Act, Occupational Safety and Health Act of 1970, Toxic Substances Control Act, and state workers' compensation examined. Suits by workers in the courts discussed. Problems related to occupational health and safety, collective bargaining as a mechanism for altering technology in the workplace, job alienation, productivity, and the organization of work addressed. (Prior courses or experience in the environmental, public health, or law-related areas.)
N. A. Ashford

TPP 41J Evaluation of Public Programs (A)

(Same subject as 11.523J)
Prereq.: 11.521 or 11.983
Year: G (2)
2-0-7

Evaluations characterized and compared as to methodology, scale and scope, sponsorship, audience, and feasibility. Experimental design and related statistical issues are considered. Political, social, economic, and institutional contexts of evaluation are analyzed. Several evaluations drawn from health, housing, and criminal justice are examined as case studies.
R. C. Larson

TPP 43J Logistical and Transportation Planning Methods (A) (New)

(Same subject as 1.203J, 6.281J, 11.526J, 13.665J, 15.078J, 16.76J)
Prereq.: 6.431, 15.075
Year: G (1)
3-0-6

Quantitative techniques of operations research with emphasis on applications in transportation systems analysis (urban, air, ocean, highway, pick up, and delivery systems) and in the planning and design of logistically oriented urban service systems (e.g., fire and police departments, emergency medical services, emergency repair services). Unified study of functions of random variables, geometrical probability, multi-server queueing theory, spatial location theory, network analysis and graph theory, and relevant methods of simulation. Discussion of implementation difficulties. Examples of applications: design of ambulance systems having both specialized and general-purpose vehicles; emergency response to oil spills; estimation of energy consumption by commuters in a metropolitan area; design of dial-a-ride transportation systems; controlling randomness in mass transit systems; evaluation of technologies for vehicle location, routing, and control.
A. I. Barnett, R. C. Larson, A. R. Odoni, H. N. Psaraftis

AS Aerospace Studies[1]

AS 11 The Air Force Today

Prereq.: —
Year: U (1)
1-0-1

Examines the role of the US Air Force in the contemporary world. Topics include background, mission, and organization of Air Force and functions of US Strategic forces. Also, emphasis is placed on development of written communicative skills.
Staff

AS 111 Leadership Laboratory

Prereq.: —
Year: U (1)
0-1-0

Introduction to the customs, traditions, and courtesies of the Air Force through seminars, guest speakers, and a field trip to an Air Force base.
Staff

AS 12 The Air Force Today

Prereq.: —
Year: U (2)
1-0-1

Continues study of the contemporary Air Force by examining general purpose forces, aerospace support forces, and the total force structure.
Staff

AS 121 Leadership Laboratory

Prereq.: AS 111
Year: U (2)
0-1-0

Continues AS 111 with emphasis on the role and responsibilities of an Air Force junior officer.
Staff

AS 21 The Development of Air Power

Prereq.: —
Year: U (1)
1-0-1

History of the development of air power from balloon experiments up through World War II. Emphasis is placed on the interaction among technology, doctrine, and historical events. Student participation and presentations are encouraged to enhance verbal communicative skills.
F. K. Arzt, Jr.

AS 211 Leadership Laboratory

Prereq.: AS 121
Year: U (1)
0-1-0

Emphasizes development of techniques used to direct and inform. Students are assigned leadership and management positions in the AS 111 programs described above.
Staff

AS 22 The Development of Air Power

Prereq.: —
Year: U (2)
1-0-1

History of air power since 1946, with emphasis on the US Air Force. Includes the role of air forces in conflicts, and the effect of space-age technology on air power. Also an examination of the employment of US air power in peaceful ways. Students are required to research and present a short speech on a topic of historical significance.
F. K. Arzt, Jr.

AS 221 Leadership Laboratory

Prereq.: AS 211
Year: U (2)
0-1-0

Continues AS 211. Adds a special program in preparation for Field Training.
Staff

AS 31 Management and Leadership

Prereq.: —
Year: U (1)
3-0-3

The study of management and leadership from the point of view of the Air Force junior officer. The individual motivational and behavioral processes, leadership, communication, and group dynamics are covered to provide a foundation for the development of the junior officer's professional skills as an Air Force officer.
L. G. McCoy

AS 311 Leadership Laboratory

Prereq.: AS 221
Year: U (1)
0-1-0

Supervisory practice and exercise of leadership functions in controlling and directing activities of the cadet corps. Development of leadership potential in a practical, supervised training laboratory.
Staff

AS 32 Management and Leadership

Prereq.: AS 31
Year: U (2)
3-0-3

Continues AS 31 with special emphasis on the basic managerial processes involving decision making, utilization of analytical aids in planning, organizing, and controlling in a changing environment. Organizational and personal values, management of forces in change, organizational power, politics, and managerial strategy and tactics are discussed within the context of the military organization. Actual Air Force cases are used to enhance the learning and communication processes.
L. G. McCoy

AS 321 Leadership Laboratory

Prereq.: AS 311
Year: U (2)
0-1-0

Continues AS 311 emphasis on supervisory and leadership skills. Emphasis on advantages of an Air Force career.
Staff

[1]Aerospace Studies subjects are not for MIT credit.

AS 41 The Military in American Society

Prereq.: —
Year: U (1)
3-0-3

Study of the military's role as an institution in a democratic society. Topics: civil-military interaction and the military as a profession. Emphasis on developing communicative skills through student presentations.
Staff

AS 411 Leadership Laboratory

Prereq.: AS 321
Year: U (1)
0-1-0

Exercise of management functions in planning, supervising, and directing cadet corps activities. Acquire proficiency in military leadership skills.
Staff

AS 42 US National Security

Prereq.: AS 41
Year: U (2)
3-0-3

Study of the role of the military in maintaining the security of the United States. Examines the international environment, the background of defense policy, strategy and forms of conflict. Addresses specific issues including weapons acquisition, arms control, nuclear deterrence, and the national military decision-making process.
Staff

AS 421 Leadership Laboratory

Prereq.: AS 411
Year: U (2)
0-1-0

Continues AS 411. Includes preparation for professional duties.
Staff

MS Military Science[1]

MS 11 Civil-Military Relations

Prereq.: —
Year: U (1, 2)
2-0-1

Covers American civil-military relations since the birth of the Republic. Emphasis on major issues developed over the last 200 years: civil control of the military, cost of the defense effort, and social makeup of both the officer corps and the enlisted ranks. Students lead discussion groups and write a short paper on one of the topics discussd.
R. C. Oertel

MS 111 Introduction to ROTC and the Army

Prereq.: —
Year: U (1)
0-1-0

Begins with a look at the origins, history, and role of the ROTC Program. A discussion follows on customs, courtesy, and traditions of the Army; the Army pay and rank systems; the organization of Army units, with emphasis on the company, platoon, and squad; and small unit tactics and combined arms concepts.
T. D. Bortner

MS 121 Land Navigation

Prereq.: —
Year: U (2)
0-1-0

Students acquire the ability to determine point locations accurate to within 10 meters, and learn the fundamentals of direction and distance determination both on a map and on the ground. Familiarizes students with the fundamentals of terrain analysis to include the ability to construct accurate terrain profiles. Familiarizes students with the techniques used in interpretation of aerial photographs, to include determination of scale and direction, and identification of objects on the ground.
T. D. Bortner

MS 21 Leadership and Ethics

Prereq.: MS 11
Year: U (1, 2)
2-0-1

Introduction to military leadership and management. Various leadership theories discussed, and an "Integrated Leadership Model" developed. Using this model, the class investigates: the individual — his or her needs, goals, attitudes, and behavior; the group — its goals, structures, roles, and norms; and the leader — his or her style, behavior, needs, and goals. Topics such as professional ethics, interpersonal communications, motivation, management, counseling, race relations, and drug and alcohol abuse discussed. Case studies are used to enhance classroom effort.
R. C. Oertel

MS 211 Instructional Methodology

Prereq.: MS 111
Year: U (1)
0-1-0

Designed to provide the student with theoretical and practical experience in preparing and presenting effective oral presentations. Investigates the psychology and principles of learning, speech techniques, integration of audio-visual media, programmed instruction techniques, test and examination construction, and classroom management techniques. Every student required to deliver two oral presentations, each of which is recorded on videotape, critiqued and evaluated by other members of the seminar, and then played back to the student. For second presentation, students required to develop an acceptable lesson plan as part of that presentation.
R. C. Oertel

MS 221 Branches of the Army

Prereq.: MS 111
Year: U (2)
0-1-0

Acquaints students with the career branches of the Army, to include their functions, initial entry positions, and the career patterns associated with each branch. Each career branch studied in sufficient detail to provide a basic understanding. However, more depth obtained in the form of guest lecturers from those branches in which students express a strong interest. Addressed from the point of view of the individual officer's management of his or her own career; the Army's Officer Personnel Management System is introduced.
R. C. Oertel

MS 31 Military Management

Prereq.: MS 21
Year: U (1, 2)
2-0-1

Concerned with the integrated management of Army units and activities with emphasis on the small unit commander as the team coordinator and leader. Current Army organizational structure reviewed, and future trends discussed. The commander and the staff examined in detail, with emphasis on the various formal and informal methods used to acquire information, anticipate and forecast requirements, make decisions, implement those decisions, and supervise and evaluate the results. Nature and role of combat support activities discussed with emphasis on the integration of fire support, air defense, engineering, intelligence and security, and signal communications assets into the overall scheme of operations. Administration and logistical support of military units covered, with emphasis on those areas most critical to the unit commander in the field.
D. L. Johnson

MS 311 Small Unit Tactics I

Prereq.: MS 221
Year: U (1)
0-1-0

Addresses the leadership of small units conducting conventional combat operations. Elements of terrain analysis and application to *offensive, defensive,* and *retrograde* operations discussed along with weather considerations and their impact on combat operations. Current organization and hardware associated with small tactical combined arms formations reviewed.
D. L. Johnson

[1]Military Science subjects are not for MIT credit.

MS 321 Small Unit Tactics II

Prereq.: MS 311
Year: U (2)
0-1-0

Continuation of MS 311. Examines in detail current tactical doctrine and its interpretation and application to situations requiring accomplishment of missions on the modern battlefield. Troop leading procedure emphasized along with the planning, preparation, and conduct of both combat patrols and reconnaissance patrols. Also includes an orientation on the ROTC Advanced Camp.
D. L. Johnson

MS 41 Military Law and Administration

Prereq.: MS 31
Year: U (1, 2)
2-0-1

Provides the Military Science student with an introduction to the United States Military Justice System. Develops historical and legal basis, as well as modern practical application of Military Justice. Prepares student for a leadership position which inherently involves administration of discipline and justice. Also, students discuss some practical aspects of small unit administration.
J. S. Kark

MS 411 Advanced Leadership Practicum I

Prereq.: MS 321
Year: U (1)
0-1-0

Incorporates all previous Military Science instruction and field experience. Students work as staff officers and unit commanders and are tasked to plan, organize, and execute two field training exercises for the entire cadet corps at MIT. Real problems solved through independent research, group discussion, and face-to-face coordination with Army training support agencies at Fort Devens, Massachusetts, and Army National Guard and Reserve units in the local area. Emphasis placed on problem identification and use of appropriate decision-making methods and techniques.
W. P. Roe

MS 421 Advanced Leadership Practicum II

Prereq.: MS 411
Year: U (2)
0-1-0

A continuation of MS 411.
W. P. Roe

NS Naval Science[1]

NS 11 Introduction to Naval Science

Prereq.: —
Year: U (1)
2-0-1

General introduction to seapower and the naval service, covering an overview of the organization and historical develoment of the US Navy and its tactics and equipment. Covers the basic tenets of naval courtesy and customs, discipline, leadership, and ship construction, as well as the major challenges facing today's Naval officer.
Staff

NS 12 Naval Ships Systems I[2]

Prereq.: —
Year: U (2)
3-0-3

Lecture series on technological fundamentals of applied and planned Naval Ships Systems from an engineering viewpoint. Topics: stability, propulsion, ship control and compartmentation.
T. S. Charis

NS 21 Naval Ships System II[2]

Prereq.: 18.02, 8.01
Year: U (1)
2-2-2

Basic system modeling techniques and state variable representations. Examples taken from systems found on naval ships and aircraft. Laser fundamentals, applications, side-looking radar, and radar holography discussed. Selected readings on naval weapons and fire control systems.
T. S. Charis

NS 22 Seapower and Maritime Affairs

Prereq.: —
Year: U (2)
2-0-2

Exploration of the general concept and history of seapower (including the merchant marine and oceanographic research), the role of various warfare components of the Navy in supporting the Navy's mission, implementation of seapower as an instrument of national policy, and a comparative study of US and Soviet naval strategies.
Staff

NS 31 Navigation and Naval Operations I

Prereq.: —
Year: U (1)
3-0-3

Comprehesive study of tactical and planning considerations relative to employment of naval forces, including communications, tactical formations and dispositions, relative motion, maneuvering board, and nautical rules of the road.
Staff

NS 32 Navigation and Naval Operations II[2]

Prereq.: —
Year: U (2)
2-2-4

Comprehensive study of the theory, principles, and procedures of piloting and celestial navigation, including mathematics of navigation, practical work involving navigational instruments, sight reduction by *pro forma* and computerized methods, charts, publications, and voyage planning.
Staff

NS 33 Modern Warfare

Prereq.: —
Year: U (1)
2-0-2

Study of warfare as an instrument of political action throughout modern history. Interrelationship with other components of statecraft stressed, as is the influence of economic, psychological, moral, political, and technological fators on strategic thought. Great leaders and military organizations of history examined to discover the ingredients of their successes.
Staff

NS 34 Marine Corps Doctrine and Tactics (New)

Prereq.: —
Year: U (2)
2-0-2

Overview of general military subjects and concentration on Marine Corps small unit tactics and leadership in preparation for Marine 1st Class cruise, "Bulldog." Covers the basic tenets of land navigation, the M16 rifle, offensive combat operations and orders, and leadership at the fire team and squad level. Stresses the development of individual leadership skills and self-confidence. Practical exercises in land navigation and tactics conducted at local military training areas.
Staff

NS 41 Leadership and Management I

Prereq.: —
Year: U (1)
2-0-2

In-depth, participative subject in leadership and management practices in the Navy, and the concepts and theories that underlie them, examined within the context of American social and industrial organizations and practices. Emphasis on management and leadership functions, particularly control, direction, interaction, motivation, and decision making.
M. J. Wojdyla

NS 42 Leadership and Management II

Prereq.: —
Year: U (2)
2-0-2

Gives the student a basic background in the duties and responsibilities of a junior division and watch officer; strong emphasis on the junior officer's responsibilities in the area of training, counseling, and career development. Student familiarized with equal opportunity programs, the exemption program, and drug/alcohol rehabilitation programs. Principles of leadership reinforced through leadership case studies.
M. J. Wojdyla

1
Naval Science subjects are not for MIT credit with the exception of NS 51J.

2
This subject is normally conducted in conjunction with an MIT accredited seminar. Any technical aspects of the subject matter of interest only to midshipmen are covered in separate NROTC sessions and field trips.

NS 43 Amphibious Warfare

Prereq.: —
Year: U (2)
2-0-2

Historical and tactical analysis of amphibious warfare. Seeks to define the concept, explore its doctrinal origins, and trace its evolution as an element of naval policy during the 20th century. Case study approach used to provide the prospective Marine Corps Officer with the fundamentals of amphibious tactics.
Staff

NS 51J Water, Air, and Interface Vehicles

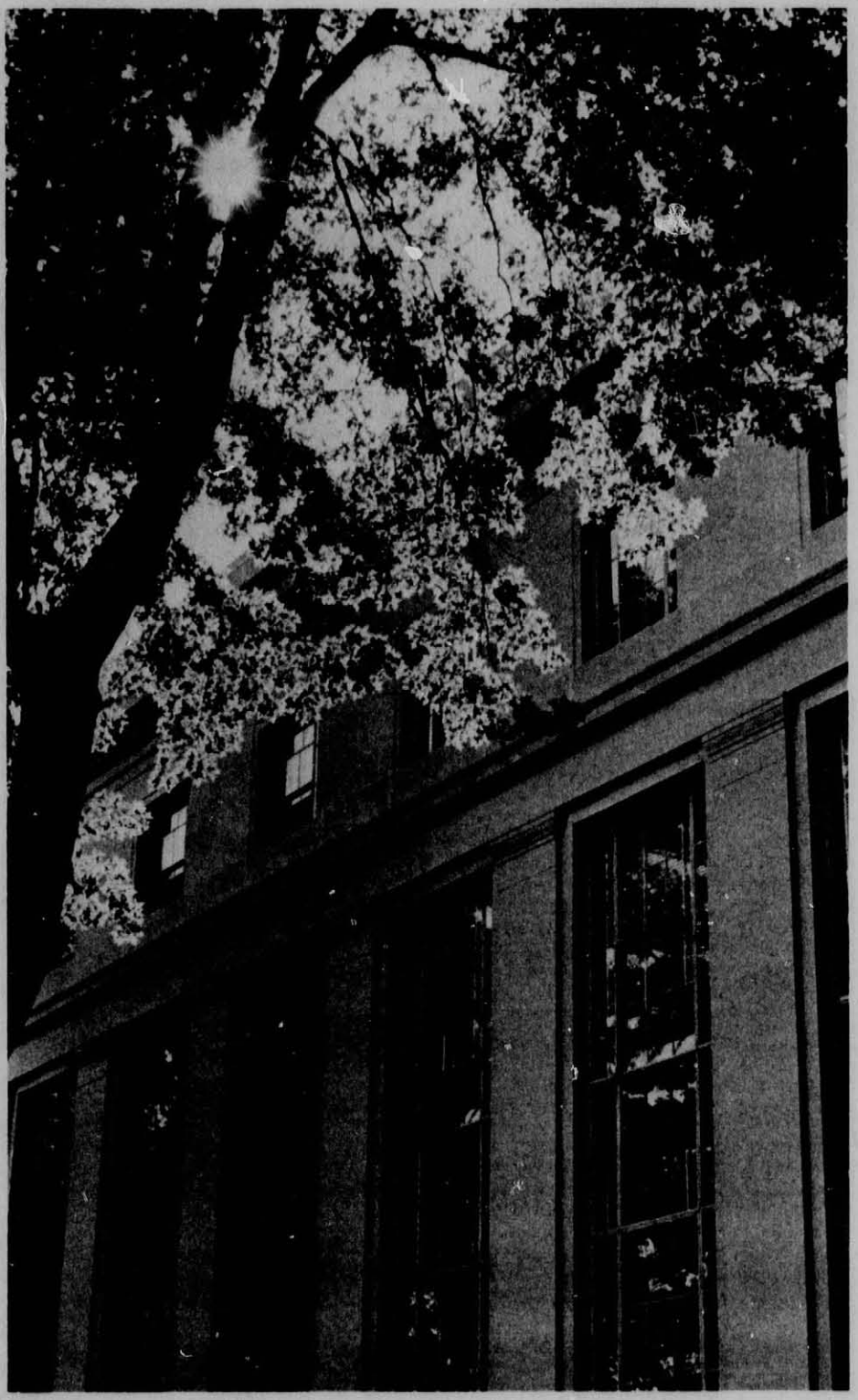
(Same subject as 13.013J)
Prereq.: —
Year: U (2) SD
3-0-9

The competitive position of diverse water, air, and interface vehicles in the world today determined from basic engineering principles. Development of the concepts of buoyancy, hydrodynamic lift, hydrodynamic drag, propulsor thrust, and scaling laws as applied to surface ships, deep submersibles, dirigibles, airplanes, hydrofoil craft, planing craft, and air-cushion vehicles. Comparison of performance criteria among these different vehicle types as well as evaluation of the effect of vehicle size, speed, and fluid density on these performance criteria.
J. H. Sweeney, M. A. Abkowitz





VIII MIT Corporation, Academic Officers, Administration, and Committees



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Former President and General
Manager
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Cabot Corporation

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Technology

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1
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2
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Varsity Golf Coach

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Personnel Officer

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Personnel Officer

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Personnel Officer

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Personnel Officer

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(On leave)

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Family Day Care Developer

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Head, Fusion Systems Division

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Associate Dean, Program Development

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Assistant to the Dean

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Comparative Pathologist

Christian E. Newcomer, D.V.M.
Clinical Veterinarian

(To be appointed)
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Manager, Animal Facilities

Christine A. Anderson, B.S.
Medical Technologist

Joel I. Ackerman, M.S.
Microbiologist

Carolyn A. Wish, B.S.
Medical Technologist

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Melvin Herbert Rodman, M.D.
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Medical Director
Head of Department

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Edward Strong Rendall, M.D.
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Physician

Samuel Wolf Stein, M.D.
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Physician

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Psychiatrist-in-Chief

Joseph Hyman Brenner, M.D.
Associate Psychiatrist-in-Chief

Peter Borie Jenney, M.D.
Associate Psychiatrist-in-Chief

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Professor of Psychiatry

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Frederic Garfield Worden, M.D.
Professor of Psychiatry

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Deborah Anne Leone, R.N., M.S.
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Supervisor of Nurses, MIT Infirmary

Janet Virginia Beyer, R.N.P.
Supervisor of Nurses,
Ambulatory and Off-Hours Services

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Barbara B. Merrifield, R.N., M.S.
Nurse Midwife

Katherine Evelyn Mulligan, R.N., B.S.
Dermatology Assistant

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Orthopedic Assistant

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Jean I. Prahl, R.N.
Arthur St. Andre, R.N.
Lorraine G. Toher, R.N.P.
Marcia Cecilia West, R.N.P.

Physician Assistants

Joyce Bishop, R.N., P.A.
George M. Taylor, P.A., B.S.

Nurse Practitioners

Eileen Catherine Cecca, R.N.P.
Janice Marie McDonough, R.N.P.
Katherine M. McDonough, R.N.P.
Colleen Ryan, R.N.P.
Mary Zook, R.N.P.

Infirmary

Inpatient Nurses

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Joyce M. Biller, R.N.
Anita L. Darveau, R.N.
Lois K. High, R.N.
Joyann Kay, R.N., B.S.
Patrick S. Lamin, R.N.
Carolyn M. Leonard, R.N.
Elizabeth Gay Matteson, R.N.
Robert Russell, R.N.
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Associate Director for Administration

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Constance A. Bean, M.S.
Coordinator for Health Information and Education

Iris Mae Goldberg, M.P.H.
Assistant Coordinator for Health Information and Education

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F. Judith Klayman, M.S.
Health Planner

Norma Loomis, A.S.
Provider/Third Party Liaison Officer

Martha Loss, B.A.
Manager, Medical Records and Data Processing

Gioia M. Morongell, M.Ed.
Enrollment Services Manager

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Finance and MIT Health Plans

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Manager, Ambulatory Support Services

Sally Zinno, M.P.A.
Operations Manager

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William Franklin, M.D.

Audiologist

Linda Ronis-Kass, M.A.

Dentists

George Christman, D.M.D.
Richard Doff, D.M.D.
Joel Leonard Dunsky, D.D.S.
Fe Banzon Pastorfide, D.M.D.

Oral Surgeon

Edward B. Seldin, M.D., D.D.S.

Dermatologists

Maisi E. Tam, M.D.
Robert Frederick Tilley, M.D.

Neurosurgeon

Marx Bowens, M.D.

Neurologists

Linda Y. Buchwald, M.D.
Camille B. Draskoczy, M.D.
Thomas H. Glick, M.D.
Edward Ray Wolpow, M.D.

Nutritionists

Barbara Vereena Cholakos, B.S.
Mary Lou P. Every, B.S.

Obstetricians-Gynecologists

Laurent Delli-Bovi, M.D.
Charles Fletcher Eades, M.D.
Fruma Winer Ginsburgh, M.D.
Toni Beth Walzer, M.D.

Ophthalmologists

Jacob Rice, M.D.
Michael Selig Wiedman, M.D.

Optometrists

Anthony Albert Cavallerano, O.D.
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Ronald H. Geiger, M.D.
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Robert Chase Runyon, M.D.
Elliot L. Thrasher II, M.D.

Otolaryngologists

John E. McKeigue, M.D.
Howard Smith, M.D.

Consultants in Pathology

Gregory Gauvin, M.D.
James P. Nolan, M.D.
Karl Harvey Sorger, M.D.
Joel Umlas, M.D.

Pharmacist

David E. Bailey, M.S.

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Bruce J. Biller, M.D.
Melvin H. Chalfen, M.D.
Edward Carlton Dyer, M.D.
Richard Charles Gardner, M.D.
Joseph Gerstein, M.D.
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Charles J. Hatem, M.D.
H. Walter Jones, M.D.
Paul Alan Kantrowitz, M.D.
John Michael Moses, M.D.
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Noemi Martha Pedraza, M.D.
Cheryl Lynne Birchette-Pierce, M.D.
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Willard Samuel Putnam, M.D.
William Atkinson Ruth, M.D.
Diane Joan Schweitzer, M.D.
Elaine Li Shiang, M.D.
Leonard Wolsky, M.D.

Psychiatrists

John Henry Brandt, M.D.
Eric S. Chivian, M.D.
Rochelle Rame Friedman, M.D.
Alfred Jan Koumans, M.D.
Geoffrey Erdmann Linburn, M.D.
Chester Middlebrook Pierce, M.D.
David Arthur Reisen, M.D.
Wade Rockwood, M.D.
Margaret Strousse Ross, M.D.
Albert Samaraweera, M.D.
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Psychologists

Lois Eichler, Ph.D.
Lora Heims Tessman, Ph.D.
Gerald E. Zuriff, Ph.D.

Clinical Sociologist

Charlotte Green Schwartz, Ph.D.

Radiologists

Paul L. Dratch, M.D.
Stanley C. Foster, M.D.
Gerard F. Kenny, M.D.
Charles Spencer Langston, M.D.
Earl David Nordberg, M.D.
Richard Schatzki, M.D.
Stefan Conrad Schatzki, M.D.
Michael Shortsleeve, M.D.

Social Workers

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Myra Aileen Rodriques, M.S.S.

Surgeon

Sheldon Carl Binder, M.D.

Urologists

John Stockton Daly, M.D.
George Reservitz, M.D.

Sanitary Consultant

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Environmental Medical Service

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Acting Head of Environmental Medical Service

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Richard Fink, B.S.
Assistant Biohazards Assessment Officer

Frederick L. Schaefer, B.S.
Assistant Biohazards Assessment Officer

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Associate Industrial Hygiene Officer

Joseph Edward Leahy, B.S.
Industrial Hygiene Engineer

Stephen Kenneth Piccolo, B.B.A.
Industrial Hygiene Engineer

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Reactor Radiation Protection Officer

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Radiation Protection Officer

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Paul Black, M.S.
Assistant Radiation Protection Officer

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Assistant Radiation Protection Officer

James Leo Jones, M.S.
Assistant Radiation Protection Officer

Gerald L. Fallon, M.S.
Assistant Radiation Protection Officer
Linear Accelerator

Constantine Maletskos, Ph.D.
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Frederick James Viles, Jr., S.M.
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Real Estate Property Manager

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Real Estate Officer

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Treasurer Emeritus-Financial Consultant

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Vice President for Financial Operations

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Assistant Comptroller

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Assistant Comptroller

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Staff Accountant

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Staff Accountant

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Staff Accountant

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Charles Joseph Ward, B.A.
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Candy Brower, B.A.
Assistant Auditor

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Assistant Auditor

Francis Thomas Conroy, B.S.B.A.
Assistant Auditor

James Henry Dreyer, B.S.B.A.
Assistant Auditor

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Assistant Auditor

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Assistant Auditor

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Assistant Director

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Assistant Director

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Assistant Contract Administrator

Rosanne Kumins, B.A.
Assistant Director

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Assistant Director

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Administrative Assistant

Martha L. Newton, B.A.
Assistant Contract Administrator

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Jack Henry Frailey, AER.E.
Director of Student Financial Services

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Bursar

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Associate Bursar

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Assistant Bursar

Ann S. McCormick
Assistant Bursar

Richard E. Davidson, M.A.
Assistant Bursar

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Maureen Catherine DeCourcey
Assistant to the Bursar

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Assistant to the Bursar

Paul L. Bergonzi
Assistant to the Bursar

Joanne C. Barrett, B.S.
Assistant to the Bursar

Maurice L. Linton
Assistant to the Bursar

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Director of Student Financial Aid

James Samuel Jones, A.M.
Associate Director of Student Financial Aid

Dorothy Elizabeth Bowe
Associate Director of Student Financial Aid

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Associate Director of Student Financial Aid

Frederick Douglas Massie, A.M.
Associate Director of Student Financial Aid

Lois B. Levine
Assistant Director of Student Financial Aid

Lucy M. Van der Wiel, B.A.
Assistant Director of Student Financial Aid
Director of Student Employment

Yvonne L. Gittens, B.A., M.Ed.
Assistant Director of Student Financial Aid

Jane D. Smith, A.B.
Assistant Director of Student Financial Aid

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Director

Anne Hartung Whealan, B.S., M.B.A.
Assistant Director of Finance

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Assistant Director of Finance

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Budget Director

Robert Michael Dankese, B.S.
Associate Budget Director

William Joseph Coady, B.S.B.A., B.S.A.
Budget Officer

James Lewis Maclary
Budget Officer

Doreen Morris, B.A.
Budget Officer

William Robert Dickson, S.B.
Vice President for Operations

Howard Francis Miller, A.B., M.S.
Executive Assistant to the Vice President for Operations

Campus Patrol

James Olivieri, B.S.
Chief

William Michael Lyons
Captain

Endicott House

Aimee Pierson, B.A.
Manager

Graphic Arts and Audio-Visual Services

James William Coleman
Director

Vernon Albert Raine
Assistant Director

Albert Kenneth Paone
Assistant Director

Francis G. Cook
Manager, Audio-Visual Services

Glenn Thomas Curtis, B.S.
Manager, Institute Printing and Copying

Housing and Food Services

Harmon Eugene Brammer, B.B.A.
Director

George Ellis Hartwell, B.S.
Associate Director

Salvatore Lauricella
Manager, Vending Services and Special Functions

Samuel Edward Leonard, Jr., B.S.B.A.
General Manager, Food Services

Howard Franklin McCullough, Jr., B.A.
Manager, Student Center Food Services

John Thornton McNeill
Operations Manager, Food Services

Robert Edgar Shaw
Assistant Director, Housing Operations Manager

John Woodbury
Assistant Director, Housing

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Thomas Edward Donnelly
Property Accountant

Earl Clifton Fuller
Property Administrator

Carol Laura Kane
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Senior Applications Programmer

Judith Ann Lugus, B.S.
Senior Application Analyst

John Terence Meehan, B.S.
Assistant Director

Laxmi Janardhanmohan Rao, B.E., M.B.A.
Senior Applications Programmer

Rita Lenore Russell. S.B.
Data Base Manager

Robert David Taylor, S.B.
Property Manager

Physical Plant

Paul Frank Barrett, B.S.
Director of the Physical Plant

Thomas Elwell Shepherd, Jr., S.B.
Associate Director of the Physical Plant

Bernard Slaton Awtrey, Jr., B.S., B.Arch.
Project Architect

Dennis Baron
Technical Manager, Telecommunications

Morton Berlan, B.A., M.B.A., J.D.
Superintendent for Administrative Services

John Charles Berlinguet, Jr., S.B.
Manager, Building Maintenance

Paul Murray Blanchard
Manager of Electrical Services

Robert Bernard Cavanaugh, B.A., M.Ed.
Assistant to the Director for Space Administration

William Hobart Combs, S.B.
Staff Superintendent

Fay Donna DeAvignon, B.Arch.
Architect-Building Programming and Design

Richard Francis DeWolfe
Facilities Coordinator
Northwest Campus

John Joseph Foley
Special Assistant, Support Services

Haig Garo Gechijian, S.B.
Manager of Engineering

Herman Gilman, B.S.
Mechanical Engineer

Harry Maurice Gloss, B.S., M.S.
Mechanical Engineer

Ralph Hoyle Griswold, S.B.
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Corporation Auditing, Advisory, and Visiting Committees

Auditing Committee 1980-81

George P. Gardner, Jr.
Chairman

Paul Hotte
Frank R. Milliken
Harold J. Muckley
Robert C. Sprague

Joint Advisory Committee on Institute-Wide Affairs 1980-81*

Gregory Smith
Chairman

Harl P. Aldrich, Jr.
Ex officio

Sharon H. Lee
Ex officio

Charles R. Markham
Ex officio

Sheila E. Widnall
Ex officio

Claude W. Brenner (1981)
Vincent S. Castellano (1981)
Anthony P. French (1981)
Jean E. Jackson (1981)
Paul A. Lagace (1981)
Guy T. Petrillo (1981)
Reynold C. Verret (1981)
Judith Bostock (1982)
Fernando J. Corbato (1982)
Emily V. Wade (1982)
Andrew J. Washburn (1982)
Edward H. Bowman (1983)
Paulette Coleman (1983)

Martha L. Bertrand
Secretary

*Note: One additional graduate student to be elected

Visiting Committees, 1980-81[1]

Department of Aeronautics and Astronautics

Semon E. Knudsen
Chairman

Holt Ashley*
Arden L. Bement, Jr.**
Seymour M. Bogdonoff**
Claude W. Brenner
Joseph S. Dunning**
Daniel J. Fink**
Joseph G. Gavin, Jr.*
Crawford H. Greenewalt
Brian G.R. Hughes
Robert G. Loewy**
Angus N. MacDonald**
Kenneth H. Olsen
Eberhardt Rechtin**
Herman A. Rediess*
James P. Reilly*
Russell L. Schweickart**
M.E. Shank*
Dorothy M. Simon**
George S. Trimble**
Holden W. Withington*

School of Architecture and Planning

Norman B. Leventhal
Chairman

William Alonso**
Bruce N. Anderson*
Denise Scott Brown**
Paulette Coleman
Catherine Donaher*
Earl R. Flansburgh*
S. James Goldstein
Reginald W. Griffith**
Frank T. Keefe**
Spiro K. Kostof**
John O. Merrill, Jr.*
Raymond D. Nasher**
Barbara Novak**
Rai Y. Okamoto*
Richard E. Oldenburg**
Paul Parks**
I.M. Pei
Frances Fox Piven**
George Rickey**
Paul P. Shepherd*
Gregory Smith
George M. White**

Arts

Gregory Smith
Chairman

Leo M. Beckwith*
Paul Caponigro**
Joseph E. Dietzgen*
Luis A. Ferré
Kitty Carlisle Hart**
Ada Louise Huxtable**
Donald M. Kendall**
James R. Killian, Jr.
Alan M. Kriegsman**
Henry Loomis**
Angus N. MacDonald*
Gjon Mili*
I.M. Pei
Charles E. Reed**
Beverly Sills**
Paul Tishman*
Jerome B. Wiesner

Athletics

Irénée du Pont, Jr.
Chairman

Merrily D. Baker**
William R. Brody*
Harold Brown*
Ernest U. Buckman**
Henrietta J. Dane*
Russell DeYoung
Thomas P. Gerrity, Jr.*
Jerome H. Holland**
Robert J. Kane**
Roseanna H. Means*
Mary Jean Mulvaney**
Clint W. Murchison, Jr.
Richard M. Nichols**
John F. Pearson*
Joseph H. Ruetz**
George M. Steinbrenner, III**
Philip F. Wagley**
David R. Wilson
Katrina M. Wootton**

Department of Biology

David R. Clare
Chairman

Bruce M. Alberts**
Joseph F. Alibrandi*
Alan W. Burg*
Gerald Fink**
Leroy E. Hood**
Martha M. Howe*
Nathan O. Kaplan**
Ellen B. Koerber*
M. Daniel Lane*
June R. Scott*
Thomas E. Smith**
Charles A. Thomas
P. Roy Vagelos**
Jonathan R. Warner*
Emily L. Wick

[1] Names without notations indicate nominees by the Corporation
*Nominees by the Alumni Association
**Nominees by the President

Center for International Studies

Louis W. Cabot
Chairman

Yaichi Ayukawa
William S. Brewster*
Louis Coen*
Norishige Hasegawa**
Paul Hotte
Edward R. Jayne II*
Allan J. MacEachen**
Jacques G. Maisonrouge**
Jerry McAfee
Wylie S. Robson*
Herbert M. Shayne**
Arthur L. Singer, Jr.**
Stephen Stamas**

Department of Chemical Engineering

John C. Haas
Chairman

Neal R. Amundson**
John S. Bonner**
P.L. Thibaut Brian*
W. Kenneth Davis*
Herbert H. Dow*
Elisabeth M. Drake**
C.A. Eckert*
Raymond C. Foster, Jr.*
Maurice F. Granville
Robert C. Gunness
J. Kenneth Jamieson
George M. Keller*
Ralph Landau
Edward A. Mason*
Jerry McAfee
Arthur B. Metzner**
Robert L. Mitchell**
Robert J. Richardson**
William R. Schowalter**
L.E. Scriven**
Richard F. Tucker**

Department of Chemistry

Paul M. Cook
Chairman

Leonard M. Baker*
John I. Brauman*
Ellen R. Bressel*
Thomas Winston Cole, Jr.**
Marshall Fixman*
Harry Gray**
E.R. Kane
William A. Klemperer*
Harden M. McConnell**
Alan Schriesheim**
David A. Shepard
Howard E. Simmons*
Christine S. Sloane*
Emily L. Wick

Department of Civil Engineering

Harold J. Muckley
Chairman

Harl P. Aldrich, Jr.
Louis Berger*
Richard A. Carpenter**
W. Kenneth Davis**
Ralph E. Fadum**
Arthur Z. Gray**
Thomas J. Lamphier*
Julian C. Madison**
Charles E. McGinnis**
Denman K. McNear
William H. Mills
Joseph Penzien**
Hunter Rouse**
Paula J. Stone*
Richard L. Terrell
C. Vincent Vappi*

Earth Sciences

Frank R. Milliken
Chairman

Albert W. Bally**
Iris Y. Borg**
Francis P. Bretherton**
Jon F. Claerbout*
Allan V. Cox**
Robert W. Decker*
Norman E. Gaut*
Maurice F. Granville
Cecil H. Green
Myrl C. Henderschott**
W. Barclay Kamb**
Breene M. Kerr
Charles G. Koch
Walter H. Munk**
Norman A. Phillips**
Jean Riboud
Ferris Webster*
Robert M. White*

Department of Economics

Joseph J. Snyder
Chairman

Karen W. Arenson*
Virgilio Barco**
Lloyd D. Brace
Hollis B. Chenery**
Richard N. Cooper**
Thomas F. Creamer*
George F. deMenil*
Otto Eckstein**
William S. Edgerly**
Walter W. Heller**
Glenn C. Lowry*
E. Kirkbride Miller**
Barbara W. Newell
Ellmore C. Patterson
John S. Reed
Albert E. Rees**
Michael Roemer*
Robert V. Roosa**
George P. Shultz*
Joseph E. Stiglitz*

Department of Electrical Engineering and Computer Science

William J. Weisz
Chairman

C. Gordon Bell*
Manuel Blum*
Arthur M. Bueche**
Dennis Buss**
Bob O. Evans**
John M. Fluke**
Joseph S. Gaziano**
Ulrich Haier**
Arthur Hauspurg**
C. Lester Hogan**
Paul Hotte
Cuthbert C. Hurd**
Joseph F. Keithley**
David I. Kosowsky**
Jane W.S. Liu*
Frank R. Milliken
Robert N. Noyce*
Howard L. Richardson
Lawrence G. Roberts*
Raymond S. Stata*
William R. Sutherland*
William R. Thurston**
Howard Vollum**

Department of Humanities

Claude W. Brenner
Chairman

G. Elaine Beane*
Donald F. Carpenter
Alfred D. Chandler, Jr.**
Joel Colton**
Robert C. Cowen*
Robert Freeman**
Kenneth J. Germeshausen
Arnold S. Judson*
Steven Marcus**
Thomas H. Maugh II*
Joe F. Moore
Cecily C. Selby**
Gregory Smith
Edward T. Thompson*
Frank S. Wyle**

Libraries

S. James Goldstein
Chairman

Edward L. Brady*
Allan L. Bralove*
Walter Burke**
Charles D. Churchwell**
Thomas F. Creamer**
Richard DeGennaro**
Connie R. Dunlap**
Y.T. Feng**
John C. Haas
Patrick J. McGovern*
Kenneth H. Olsen
Glenora E. Rossell**
Linda G. Sprague*
John D. Stanitz*
Robert D. Stueart**
Arthur E. Vershbow**
Jeptha H. Wade**

Department of Linguistics and Philosophy

Gregory Smith
Chairman

Paul Benacerraf**
Dennis Flanagan**
Osamu Fujimura**
Thomas R. Horton**
Ray S. Jackendoff**
Edward S. Klima**
Ruth B. Marcus**
Edwin A. Martin, Jr.*
F. Richard Meyer, III
Barbara H. Partee*
David A. Shepard
Warren D. Siemens*
Joseph E. Slater**
Julius A. Stratton
Jerome B. Wiesner
Stewart W. Wilson*
Harry Woolf**

1
Names without notations indicate nominees by the Corporation
*Nominees by the Alumni Association
**Nominees by the President

Alfred P. Sloan School of Management

T. A. Wilson
Chairman

Edward E. Barr*
Willard C. Butcher**
Eugene A. Cafiero**
Vincent S. Castellano
Colby H. Chandler
W. Van Alan Clark, Jr.
William S. Edgerly*
W.H. Krome George
Winston R. Hindle, Jr.*
Wayne J. Holman, Jr.*
Fred Kayne**
William J. McConie, Jr.**
Denman K. McNear
George W. Morgenthaler*
Clint W. Murchison, Jr.
Gerard F.M. Pelisson*
Donald E. Procknow*
John S. Reed
Charles A. Sanders**
Richard L. Terrell
Martha R. Wallace**
William J. Weisz

Department of Materials Science and Engineering

Colby H. Chandler
Chairman

D.M. Alstadt**
Alfred E. Brown**
Louis W. Cabot
Carolyne Clay*
Thomas R. Clevenger, Jr.*
Irénée du Pont, Jr.
James R. Johnson**
Lisa C. Klein*
Anthony D. Kurtz*
Robert A. Laudise*
William R. Prindle**
Richard E. Schubert**
Richard P. Simmons**
Charles H. Smith, Jr.**
Phillip H. Smith**
Morris A. Steinberg*
John B. Wachtman**
David R. Wilson

Department of Mathematics

Herman R. Branson
Chairman

William Browder**
Vincent S. Castellano
Shirley A. Jackson
Joseph B. Keller**
James K. Knowles*
Joseph J. Kohn*
Martin D. Kruskal**
Cathieen Morawetz**
G. Daniel Mostow**
Virginia T. Norwood*
Elizabeth J. O'Neil*
Kenneth E. Ralston*
Linda P. Rothschild*
Jacob T. Schwartz**
John W. Tukey**

Department of Mechanical Engineering

F. Richard Meyer, III
Chairman

Walter L. Abel**
W. Gerald Austen
W. Dale Compton**
Ralph E. Cross**
Alexander V. D'Arbeloff*
S. William Gouse, Jr.*
William J. Harris, Jr.**
Edward J. Hayes*
Wallace A. McGahan*
Robert G. McGregor**
Stanley M. Proctor
Karl N. Reid*
William J. Smith**
Philippe Villers**
Joseph D. Zimmerman*

Medical Department

W. Gerald Austen
Chairman

Roland F. Beers, Jr.*
Richard I. Bergman*
Christopher J. Davis*
Joseph L. Dorsey**
Frances M. Dyro*
Kenneth C. Edelin**
Harvey Fineberg**
Henry L. Foster**
Robert J. Glaser**
James A. Hester, Jr.*
Margaret E. Mahoney**
Christian J. Matthew*
Henry C. Meadow**
John I. Sandson**
Gregory Smith
Warren E.C. Wacker**
Emily V. Wade

Department of Nuclear Engineering

Edward O. Vetter
Chairman

Betsy Ancker-Johnson**
Keith Boyer*
Robert A. Charpie**
Floyd L. Culler**
George Ferguson**
Angelo Giambusso*
Kenneth J. Germeshausen
Edwin E. Kintner*
N. Barrie McLeod*
Lawrence T. Papay*
Thomas H. Pigford*
Cecily C. Selby**
Robert C. Sprague
Francis M. Staszesky**
Laurence Storch**
Mason Willrich**

Department of Nutrition and Food Science

Ralph Landau
Chairman

Maynard A. Amerine**
Charles M. Apt*
Yaichi Ayukawa
Charles J. Bates*
William O. Beers**
John J. Burns**
John W.A. Buyers*
Walter A. Compton**
William C. Cooper*
John T. Dorrance, Jr.**
Arthur E. Humphrey*
Morris A. Lipton**
Richard I. Mateles*
William H. Mills
Emil M. Mrak**
William B. Murphy
Cornelius W. Pettinga**
Glenn S. Pound**
J. Paul Sticht
Harold Thorkilsen*

Department of Ocean Engineering

Emily V. Wade
Chairman

Victor K. Atkins*
Albert M. Bradley*
Clarence R. Bryan**
Dayton H. Clewell*
Paul M. Cook
Rebecca A. Donnellan**
Phillip Eisenberg**
David H. Frantz, Jr.*
George P. Gardner, Jr.
R.L. Geer*
Oivind H. Lorentzen, Jr.**
Dimitri A. Manthos*
Harold J. Muckley
Evelyn F. Murphy**
Erling D. Naess**
John J. Wilson

Department of Physics

David S. Saxon
Chairman

Herman R. Branson
Solomon J. Buchsbaum*
J. Fred Bucy**
Sidney D. Drell**
George B. Field*
Elsa M. Garmire*
Cecil H. Green
Janet B. Guernsey*
Shirley A. Jackson
Russell G. Meyerand, Jr.**
George Pake**
Emanuel R. Piore**
Charles E. Reed**
Burton Richter*
Julius A. Stratton
Albert D. Wheelon*
Harry Woolf**

Department of Political Science

Howard L. Richardson
Chairman

Clark C. Abt*
Gabriel A. Almond**
Gregory Anrig
W. Van Alan Clark, Jr.
Paulette Coleman
Philip R. Jonsson**
Vernon E. Jordan, Jr.**
James A. Moody
Levitt J. Pope*
Wesley W. Posvar**
Robert A. Scalapino**
Enid C.B. Schoettle*
Richard H. Solomon*
Michael L. Telson*
Aaron B. Wildavsky**
Marvin Zonis*

1Names without notations indicate nominees by the Corporation
*Nominees by the Alumni Association
**Nominees by the President

Department of Psychology

Barbara W. Newell
Chairman

Margaret J. Charlton**
David G. Cogan**
Stephen L. Foote*
Marvin C. Grossman*
Ward J. Haas*
Patricia W. Hewitt**
Dorothea Jameson Hurvich**
Leo M. Hurvich**
Kenneth A. Klivington**
Christiana M. Leonard*
Alvin M. Liberman**
James A. Moody
Werner Reichardt**
Robert B. Semple
Catherine M. Spencer**
Martin J. Steinbach**
J. Paul Sticht
Mary F. Wagley**

Sponsored Research

Robert B. Semple
Chairman

Marvin A. Asnes**
Jordan J. Baruch**
Herbert D. Benington*
Robert C. Bowie**
Joseph A. Boyd**
Lewis M. Branscomb**
Arthur M. Bueche**
Albert E. Cookson**
Thomas M. Ferrill, Jr.*
John N. Hanson**
Arthur Hauspurg**
S. Allen Heininger*
David R. Israel*
David I. Kosowsky*
Richard W. Lyman**
William P. Murphy**
William C. Norris**
David S. Saxon
Edward O. Vetter

Student Affairs

D. Reid Weedon, Jr.
Chairman

Herman R. Branson
Kenneth C. Browning*
Vincent S. Castellano
James A. Champy*
Carola Eisenberg**
Edmund W. Gordon**
Brian G.R. Hughes
Herant Katchadourian**
Charles E. Kolb, Jr.*
Lynn Mahony*
Joe F. Moore
Luther T. Prince**
Stanley M. Proctor
Gregory Smith
Emily L. Wick

Whitaker College of Health Sciences, Technology, and Management

George W. Thorn
Chairman

Joseph F. Alibrandi*
Richard I. Bergman*
Eugene Braunwald**
Joseph D. Brenner**
William Budinger**
Robert H. Ebert**
Alain C. Enthoven*
Cyrus Levinthal**
Alan S. Michaels*
R. Anderson Pew**
Edward J. Poitras**
Edward M. Purcell**
Jeffrey K. Raines*
Ora M. Rosen**
Berta Scharrer**
John Sterner*
J. Paul Sticht
John F. Taplin*
Helen F. Whitaker

[1]Names without notations indicate nominees by the Corporation
*Nominees by the Alumni Association
**Nominees by the President

Standing Committees of the Faculty, 1981-82

Academic Performance

Judson R. Baron (1982)
(Chairman)

Dean for Student Affairs*
Registrar*
Medical Director*
Director of Student Financial Aid*
Head, Undergraduate Academic Support Office*

Marcus Karel (1982)
Alan J. Grodzinsky (1983)
William W. Kaufmann (1983)
Sallie W. Chisholm (1984)
Ann F. Friedlaender (1984)
Vernon M. Ingram**

E. Jane Dickson
Staff to the Committee

Curricula

Barry Zevin (1983)
(Chairman)

Registrar*
Head, Undergraduate Academic Support Office*
Associate Provost*

Francis Noblesse (1983)
Barbara Underwood (1983)
Kenneth R. Manning (1984)
William H. Orme-Johnson (1984)
Robert R. Tenney (1984)
Arthur C. Smith**

Ronald P. Smith
Executive Officer

Discipline

Louis D. Braida (1982)
(Chairman)

Dean for Student Affairs*

Margaret L. A. MacVicar** (1982)
Wit Busza (1983)
Chryssostomos Chryssostomidis (1983)
Annamaria Torriani-Gorini (1984)
Thomas F. Weiss (1984)

Educational Policy

Felix M. H. Villars (1983)
(Chairman)

Harvey M. Sapolsky (1983)
(Deputy Chairman)

Provost*
Associate Provost*
Vice President*

Glenn A. Berchtold (1982)
Wilbur B. Davenport (1982)
Anthony P. French (1982)
Vernon M. Ingram (1982)
Cynthia G. Wolff (1982)
Lotte L. Bailyn (1983)
Sylvain Bromberger (1983)
Joseph Ferreira, Jr. (1983)
Rae Goodell (1983)
Margaret L. A. MacVicar (1983)
Arthur C. Smith (1983)
J. Kim Vandiver (1983)

David S. Wiley
Secretary

Faculty-Administration

Faculty:
Edgar H. Schein (1982)
(Chairman)

Amedeo R. Odoni (1982)
James Paradis (1983)
Margaret H. Weiler (1983)
Robert M. Fogelson (1984)
Steven R. Lerman (1984)

Administration: †
Robert A. Alberty
Harold J. Hanham
Constantine B. Simonides
Kenneth A. Smith

Graduate School Policy

Dean of the Graduate School
(Chairman)*

Associate Deans of the Graduate School*
Dean for Student Affairs*
Director of Admissions*
Associate Chairman of the Faculty*
Registrar*

Members for 1982:

Hayward R. Alker, Jr.
Nesmith C. Ankeny
Glenn A. Berchtold
Edward H. Bowman
Sylvain Bromberger
A. Douglas Carmichael
Carl Allin Cornell
Ernest G. Cravalho
David J. Epstein
Leon B. Groisser
Gary Hack
Allan F. Henry
Steven Kleiman
George F. Koster
Mary Lou Pardue
Regis M. N. Pelloux
Gordon H. Pettengill
Raymond T. Pierrehumbert (Fall 1981)
Mary C. Potter
Ronald G. Prinn (Spring 1981)
Warren M. Rohsenow
Jerome Rothenberg
Anthony J. Sinskey
Harold Y. Wachman
Glenn C. Williams

Industrial Liaison

Thomas J. Allen, Jr. (1982)
(Chairman)

Daniel M. Holland (1982)
János M. Beér (1983)
Richard D. Robinson (1983)
Paul Penfield, Jr. (1984)
Julian Szekely (1984)

Library System

William M. Siebert (1984)
(Chairman)

Provost*
Director of Information Processing Services*
Director of Libraries*
Two Library staff members

Stephen H. Crandall (1982)
Gary Hack (1983)
Sean C. Solomon (1984)
Joanne Yates (1984)

Nominations†

Mary C. Potter (1983)
(Chairman)

Albert R. Meyer (1982)
Woodie C. Flowers (1983)
Rainer Weiss (1983)
Henry D. Jacoby (1984)
Campbell L. Searle (1984)

Outside Professional Activities

Gordon M. Kaufman (1983)
(Chairman)

John B. Vander Sande (1982)
Herman N. Eisen (1983)
Robert M. Fano (1984)
Tunney F. Lee (1984)

Student Affairs

M. Nafi Toksöz (1983)
(Chairman)

Dean for Student Affairs*

Merton J. Kahne (1982)
Arthur P. Mattuck (1982)
William G. Thilly (1982)
Jeanne S. Bamberger (1983)
Ronald M. Latanision (1983)
Charles E. Holt III (1984)
Judah Schwartz (1984)
Campbell L. Searle (1984)
Rae Goodell**

Undergraduate Admissions and Financial Aid

Frederick J. McGarry (1983)
(Chairman)

Director of Admissions*
Director of Student Financial Aid*
Head, Undergraduate Academic Support Office*

John J. Donovan (1982)
Hale Von Dorn Bradt (1982)
Travis R. Merritt (1983)
Keith Stolzenbach (1984)
Jane Betts (1984)
Harvey M. Sapolsky**

1
The dates to the right indicate the years in which the terms of appointment expire.
*Ex officio
**Appointed from the Committee on Educational Policy
†Presidential appointment

Councils

Academic Council

President (Chairman)
Provost (Vice Chairman and Chairman, Educational Programs Subgroup)
Vice President (Secretary)
Associate Provosts
Vice President and Dean of the Graduate School
Vice President for Financial Operations
Vice President for Operations
Vice President for Research
Vice President, Resource Development
Dean of the School of Architecture and Planning
Dean of the School of Engineering
Dean of the School of Humanities and Social Science
Dean of the Sloan School of Management
Dean of the School of Science
Dean for Student Affairs
Chairman of the Faculty
Director of Libraries

Faculty Council

President (Chairman)
Provost (Vice Chairman)
Vice President (Secretary)
Chairman of the Corporation
Members of the Academic Council
Heads of Departments
Secretary of the Institute
Associate Chairman of the Faculty
Secretary of the Faculty
Director of the Center for Advanced Engineering Study
Director of the Center for Advanced Visual Studies
Director of the Center for Cancer Research
Director of the Center for Computational Research in Science and Economics
Director of the Center for International Studies
Director of the Center for Materials Science and Engineering
Director of the Center for Policy Alternatives
Director of the Center for Space Research
Director of the Center for Transportation Studies
Director of the Division for Study and Research in Education
Director of the Energy Laboratory
Director of the Francis Bitter National Magnet Laboratory
Director of the Harvard-MIT Division of Health Sciences and Technology
Director of the Laboratory of Architecture and Planning
Director of the Laboratory for Computer Science
Director of the Laboratory for Information and Decision Systems
Director of the Laboratory for Nuclear Science
Director of the Lincoln Laboratory
Director of the Nuclear Reactor Laboratory
Director of the Operations Research Center
Director of the Plasma Fusion Center
Director of the Program in Science, Technology, and Society
Director of the Research Laboratory of Electronics
Director of the Sea Grant Program
Director of the George Russell Harrison Spectroscopy Laboratory
Director of the Whitaker College of Health Sciences, Technology, and Management
Director of Admissions
Director of Athletics
Comptroller
Director of Computing and Telecommunications Resources
Director of the Division of Comparative Medicine
Director of Finance
Director, Industrial Liaison
Director of Information Processing Services
Director of the MIT Press
Medical Director
Director of the Office of Sponsored Programs
Director of the Office of Student Financial Services
Registrar
Director of Resource Development
Director of the Summer Session
Associate Dean of the School of Architecture and Planning
Associate Dean of the School of Engineering
Associate Dean for Educational Programs, School of Engineering
Associate Dean of the School of Humanities and Social Science
Associate Dean of the Sloan School of Management
Associate Heads, Electrical Engineering and Computer Science
Representative of the Office of ROTC Programs
Executive Vice President, Alumni Association
Special Assistants to the President
Special Assistant to the Provost

Administrative Council

President (Chairman)
Provost (Vice Chairman)
Vice President (Secretary)
Vice President for Operations
Director of Admissions
Director of Athletics
Director of Career Planning and Placement
Comptroller
Director of Finance
Director of Finance and Administration, Sloan School
Director of Graphic Arts and Audio-Visual Services
Director of Housing and Food Services
Director, Industrial Liaison
Director of Information Processing Services
Director of Lincoln Laboratory
Director of the MIT Press
Medical Director
Director of the News Office
Director of the Office of Facilities Management Systems
Director of the Office of Minority Education
Director of the Office of Sponsored Programs
Director of Personnel
Director of Physical Plant
Director of Planning
Director of Purchasing and Stores
Registrar
Director of Resource Development
Director of the Safety Office
Director of the Office of Student Financial Services
Director of the Summer Session
Associate Chairman of the Faculty
Associate Dean of the School of Engineering
Associate Dean, Program Development, Graduate School
Associate Dean of the School of Humanities and Social Science
Associate Dean for Student Affairs
Associate Director, Industrial Liaison Program
Associate Director of Libraries
Associate Director for Administration, Medical Department
Assistant Dean for Administration, School of Engineering
Assistant Treasurer
Chief, Campus Patrol
Manager, Campus Information Services
Executive Vice President of the Alumni Association
Special Assistants to the President
Special Assistant to the President for Urban Relations
Special Assistant to the Provost
Assistant Equal Opportunity Officer

Engineering Council

Gerald Loomis Wilson, Sc.D.
Dean, School of Engineering

Kent Forrest Hansen, Sc.D.
Associate Dean, School of Engineering

James Wah Mar, Sc.D.
Head, Department of Aeronautics and Astronautics

James Wei, Sc.D.
Head, Department of Chemical Engineering

Joseph Martin Sussman, Ph.D.
Head, Department of Civil Engineering

Joel Moses, Ph.D.
Head, Department of Electrical Engineering and Computer Science

Peter Elias, Ph.D.
Acting Associate Head for Computer Science and Engineering
Department of Electrical Engineering and Computer Science

Richard Brooks Adler, Sc.D.
Associate Head for Electrical Science and Engineering
Department of Electrical Engineering and Computer Science

Walter Shepherd Owen, Ph.D.
Head, Department of Materials Science and Engineering

Herbert Heath Richardson, Sc.D.
Head, Department of Mechanical Engineering

Neil Emmanuel Todreas, Ph.D.
Head, Department of Nuclear Engineering

Ira Dyer, Ph.D.
Head, Department of Ocean Engineering

Myron Tribus, Ph.D.
Director, Center for Advanced Engineering Study

J. Herbert Hollomon, Sc.D.
Director, Center for Policy Alternatives

Daniel Roos, Ph.D.
Director, Center for Transportation Studies

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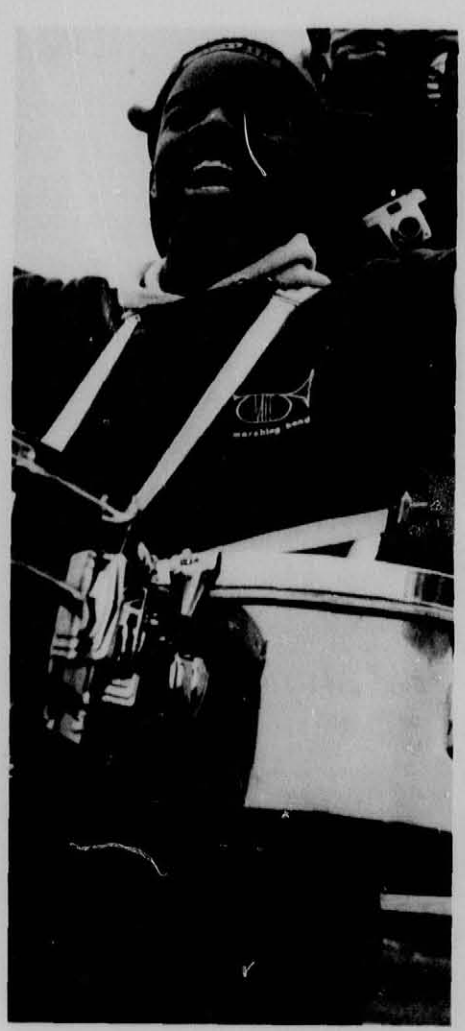







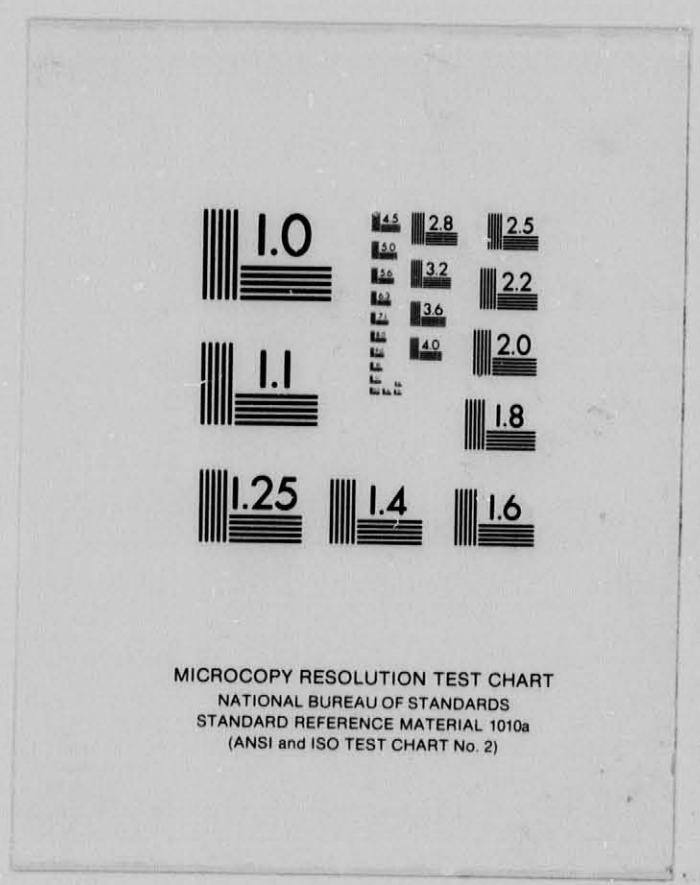

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