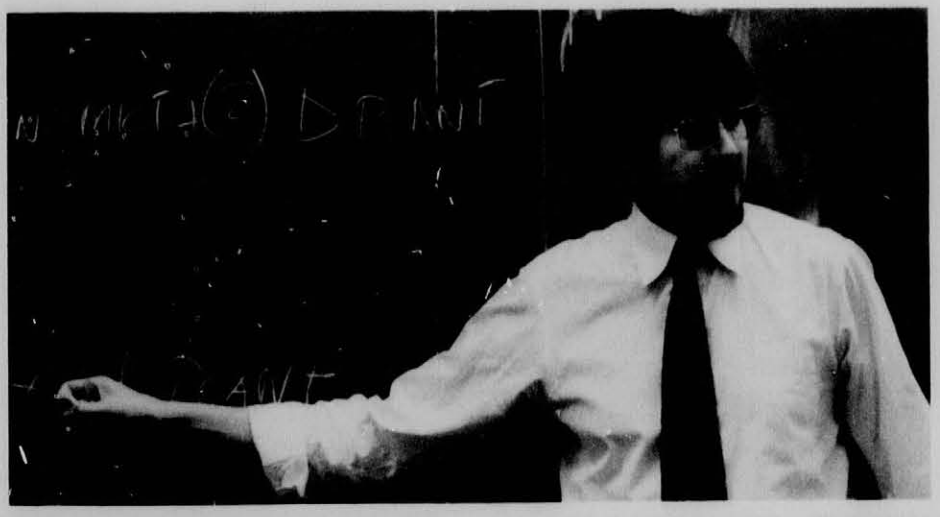
Bulletin 1983-84

Massachusetts Institute of Technology

Courses and Degree Programs Issue
1983-84









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August 1983

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The Institute reserves the right to make changes in the regulations and courses announced in this Bulletin.

The Massachusetts Institute of Technology admits students of any race, color, sex, religion, or national or ethnic origin to all rights, privileges, programs, and activities generally accorded or made available to students at the Institute. It does not discriminate against individuals on the basis of race, color, sex, sexual orientation, religion, handicap, age, or national or ethnic origin in administration of its educational policies, admissions policies, scholarship and loan programs, and other Institute administered programs and activities, but may favor US citizens or residents in admissions and financial aid.

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

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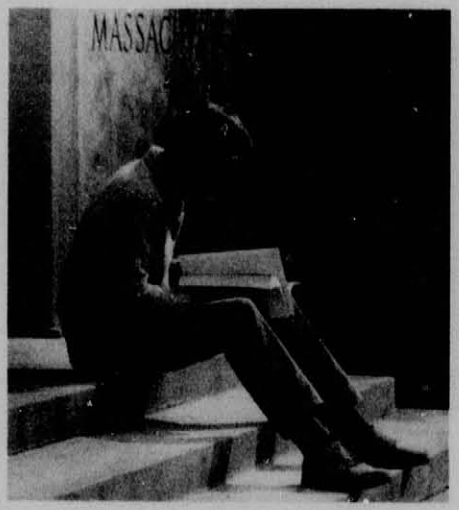
1
Civil Engineering 3D
2
Mechanical Engineering 16D
3
Materials Science and Engineering 26D
4
Architecture 35D
5
Chemistry 47D
6
Electrical Engineering and Computer Science 51D
7
Biology 66D
8
Physics 70D
9
Psychology 78D
10
Chemical Engineering 82D
11
Urban Studies and Planning 88D
12
Earth and Planetary Sciences 98D
13
Ocean Engineering 106D
14
Economics 113D
15
Management 120D
16
Aeronautics and Astronautics 135D
17
Political Science 145D
18
Mathematics 159D
19
Meteorology and Physical Oceanography 171D
20
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21
Humanities 179D
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Nuclear Engineering 210D
24
Linguistics and Philosophy 219D
CTS
Center for Transportation Studies 225D
HST
Health Sciences and Technology 226D
SEM
Undergraduate Seminar 230D
SPS
Special Studies 230D
STS
Science, Technology, and Society 231D
SWE
Engineering School-Wide Electives 236D
TPP
Technology and Policy 237D
AS
Aerospace Studies 238D
MS
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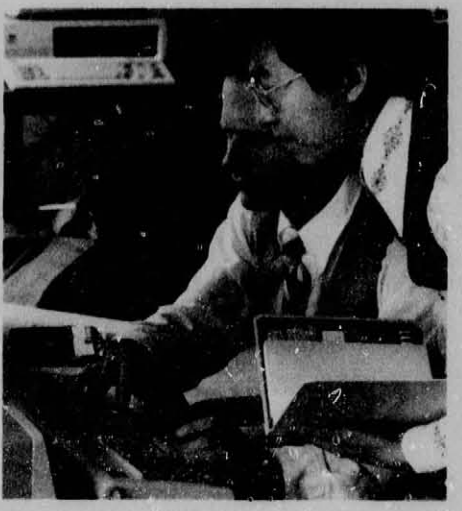
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MASSAC









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.

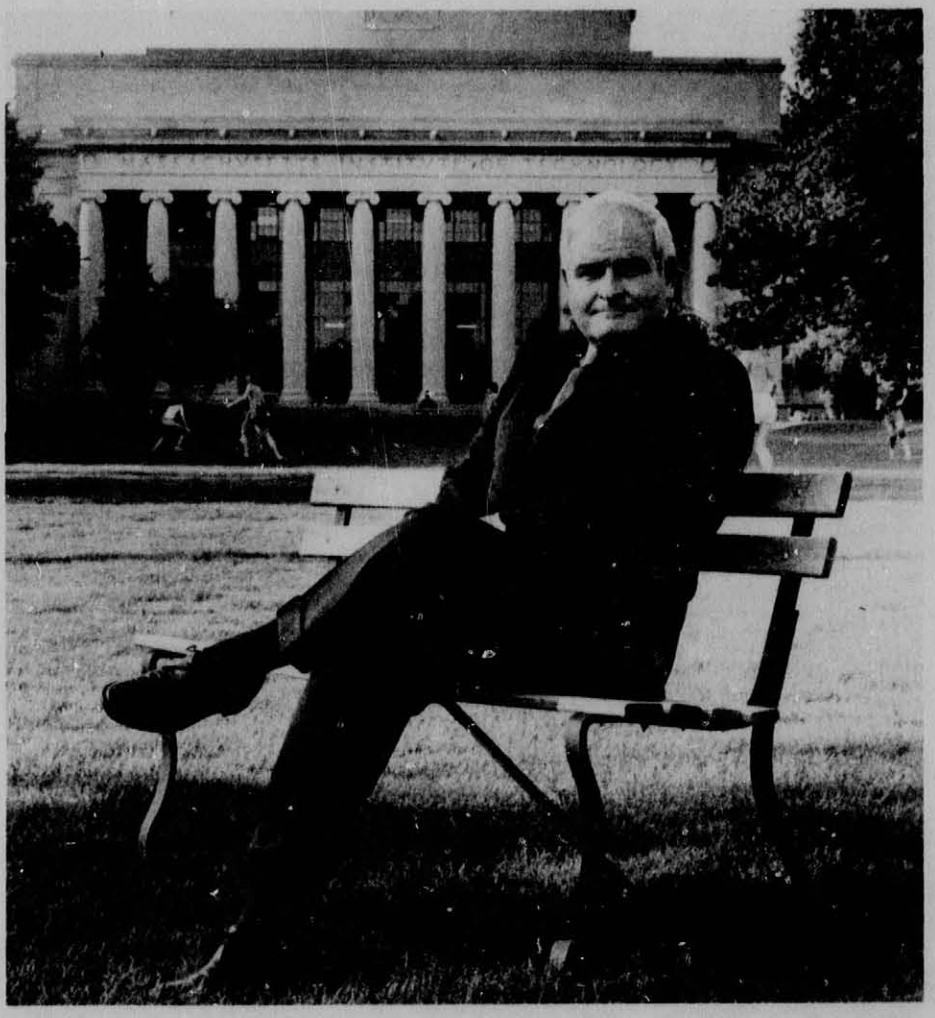
Scientific inquiry is, at once, a most natural and highly refined expression of the human mind and spirit. It is derived from native curiosity about the nature of our world and about the universe, and it results in speculations and concepts which help to give meaning and order to that world. Engineering 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 rest 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. . . .

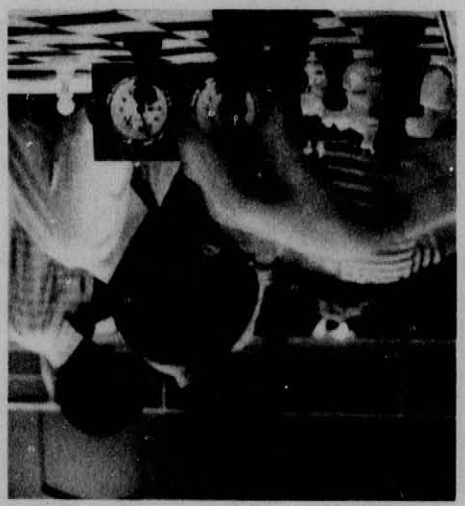
For over a century, MIT has been a place where exceptional people from all walks of life come together to work and to study. As such, MIT has a responsibility to itself and to the nation to be open — and to reach out — to the most talented and promising people, regardless of race or sex. . . . For the 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





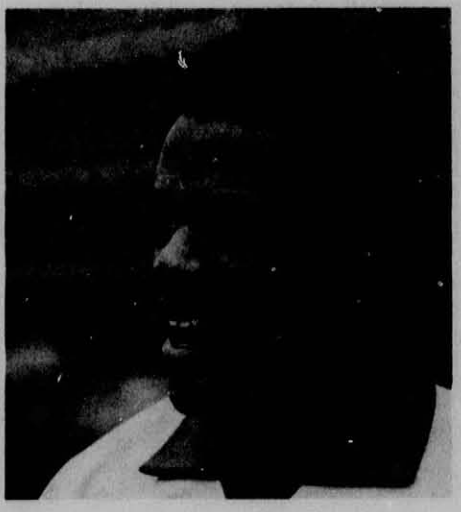


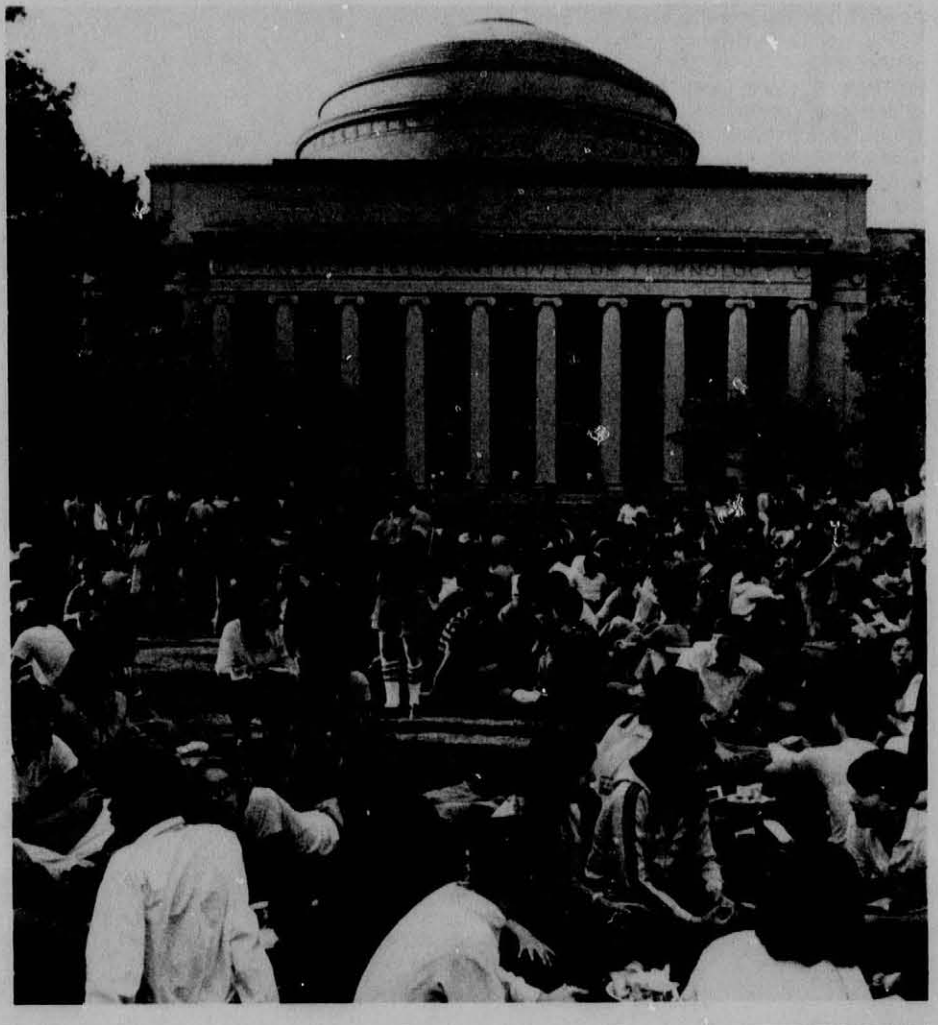


This is MIT









This is MIT

History and Purpose

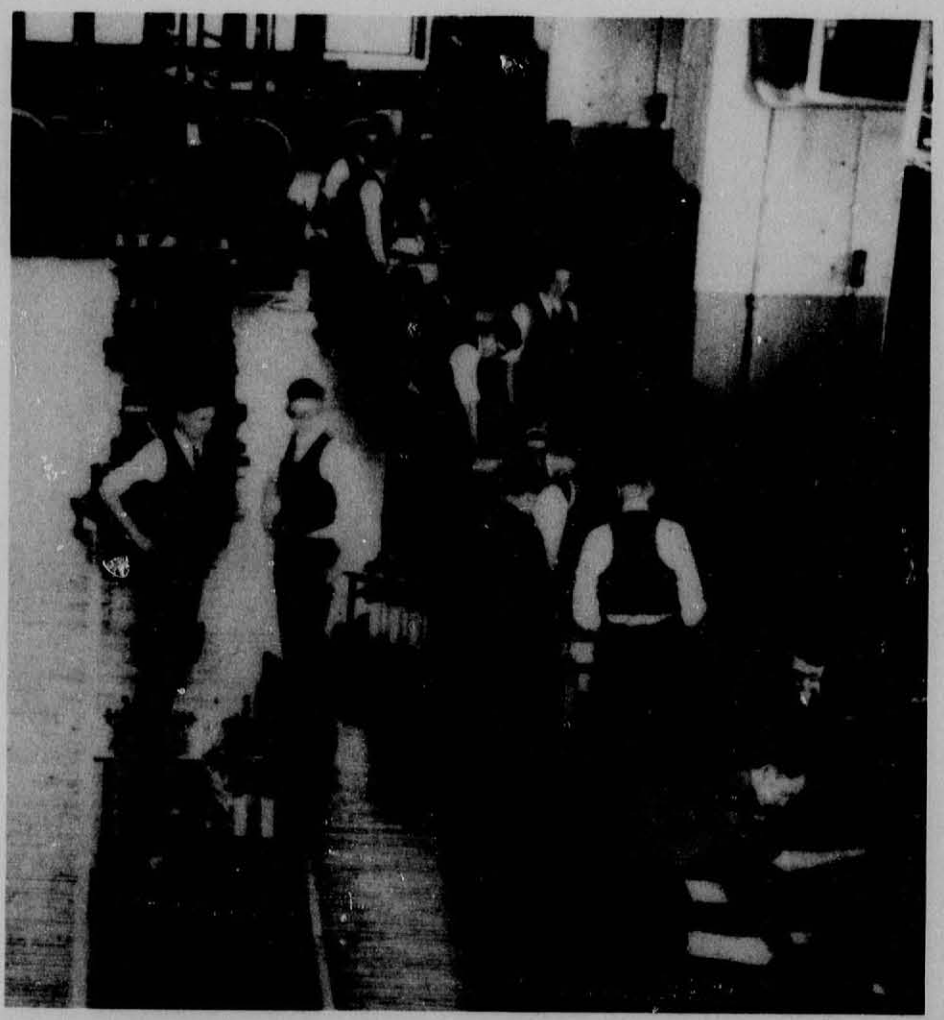
On February 20, 1865, four years after approval of its founding charter, the Massachusetts Institute of Technology opened its doors to admit the first class of 15 students. The event marked the culmination of an effort by William Barton Rogers, MIT's founder and first president, to create a new kind 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 22 academic departments, as well as many interdepartmental laboratories, centers, and divisions which extend beyond the traditional departmental boundaries.

MIT's total enrollment is approximately 9,500, almost evenly divided between undergraduate and graduate students. In 1982-83, MIT students came from all 50 states and the District of Columbia, Puerto Rico, the Virgin Islands, and 96 foreign countries. The proportion of international students at the Institute, about 20 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 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 Academic Program

The 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 22 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.





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.

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.

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 full week of September and ends before Christmas, and the spring term starts the first full week in February and ends in mid-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, and 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.

1983

August 1
Financial Registration Form due in Bursar's Office, Student Accounts, E19-215

August 12
Payment for first term due
Last day to petition for September Advanced Standing Exam and to return application card for Postponed Finals

August 31
Transfer Student Orientation begins

September 2
Freshman Orientation Week begins

September 5
Labor Day *(Holiday)*

September 6
Graduate Orientation Week begins

September 6, 7
Advanced Standing Exams and Postponed Finals

September 6-8
International Open House

September 12
Registration Day

September 13
First day of classes

September 16
Last day to petition for October Advanced Standing Exam

September 30
Application for advanced degrees in February due in Registrar's Office, E19-335. $20 fee after this date.

October 1
Advanced Standing Exams

October 10, 11
Columbus Day Vacation

October 14
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 17
Automatic withdrawal date for students not having completed six steps of registration

October 21
Deadline for students to turn in Freshman Evaluation Forms

October 26
Deadline for instructors to turn in Freshman Evaluation Forms

October 28
Last day to turn in Final Exam Conflict Report

November 11
Veterans Day *(Holiday)*

November 23
Last day to petition for December Advanced Standing Exam

November 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.

November 24, 25
Thanksgiving Vacation

December 5, 6
Second term registration material available in Building 10 Lobby

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

December 14
Last day of classes for subjects with final exam.

December 16
Last day of classes for subjects with no final exam.
Deadline for students to turn in Freshman Evaluation Forms

December 19-22
Final exam period

December 23
Registration material for second term due in Registrar's Office, E19-335. $10 fine for registration received after this date.

December 23-January 8
Christmas Vacation

1984

January 3
Financial Registration Form due in Bursar's Office, Student Accounts, E19-215

January 6
First term grade reports mailed

January 9
Deadline for instructors to turn in Freshman Evaluation Forms

January 9
First day of Independent Activities Period

January 10
Payment for second term due

January 13
Doctoral theses due for January

January 16
Martin Luther King, Jr.'s Birthday *(Observed)*

January 20
Theses, other than Doctors', due for January

January 20
Last day to go on or off February degree list

January 20
Last day to petition for February Advanced Standing Exam and to return application card for Postponed Finals

February 1
Last day of Independent Activities Period

February 2-5
Vacation

February 6
Registration Day

February 7
First day of classes

February 9
Grade reports for January period mailed

February 11
Advanced Standing Exams and Postponed Finals

February 20-21
Washington's Birthday Vacation

February 24
Application for advanced degrees in June due in Registrar's Office, E19-335. $20 fee after this date.

March 9
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 12
Automatic withdrawal date for students not having completed six steps of registration

March 23
Deadline for students to turn in Freshman Evaluation Forms

March 26-30
Spring Vacation

April 2
Deadline for instructors to turn in Freshman Evaluation Forms

April 13
Last day for changing thesis title. $20 fee after this date.

April 16, 17
Patriots' Day Vacation

April 20
Summer session registration material available in Registrar's Office, E19-335

April 27
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 27
Last day to petition for May Advanced Standing Exam and to turn in Conflict Report

May 4
Doctoral theses due for second term

May 4
Summer session registration material due, Registrar's Office, E19-335

May 7, 8
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 11
Theses, other than Doctors', due for second term

May 16
Last day of classes for subjects with final exam

May 18
Last day of classes for subjects with no final exam

May 18
Last day to go on or off degree list

May 21-23
Final exam period

May 24
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 28
Memorial Day *(Holiday)*

June 4
Commencement exercises

June 4
Second term grade reports mailed to home address

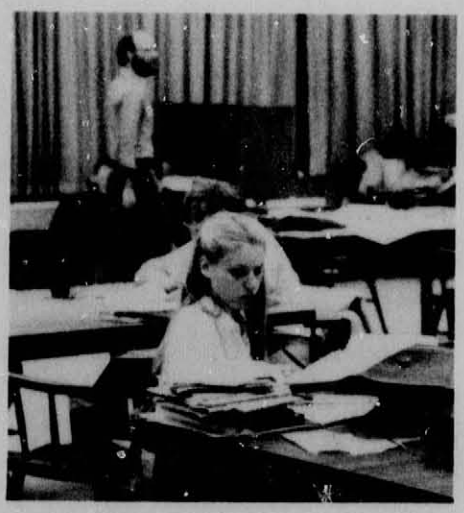
June 11-August 22
Summer Session

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.

MIT has unusual facilities for this research, 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 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 1.9 million volumes. More than 19,000 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, recordings, photographs, 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 libraries for each of the Institute's five Schools, 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, bibliographic guidance, complete microfilm and photocopying facilities, and retrieval from machine-readable databases. 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

Information processing for MIT's teaching and research programs utilizes the latest developments in computer technology, including a broad spectrum of processing power from personal machines to large multi-user access systems. IPS provides a full range of support services, including public terminals, documentation, education, user-consulting, and an extensive library of application and systems software. In addition, there are many local departmental and laboratory facilities which meet more specialized computing requirements, and many faculty and staff have access to personal computers. An increasing number of these computers is attached to networks which provide convenient communication between users and the distribution of computing resources.



MIT Press

The MIT Press, one of the country's largest university presses, publishes books and journals that enjoy worldwide circulation: professional, reference, and scholarly books; graduate and undergraduate texts; and books for general audiences. Books and journals published by the Press have won many awards, including the National Book Award, and a wide variety of citations for graphic and scholarly excellence.



The Council for the Arts at MIT

Student activities in the arts are supported through the Grants Program of MIT's Council for the Arts. The Grants Program, administered by a committee of alumni and friends of the Institute, offers direct financial support to individual students, faculty, and staff, and to MIT organizations and activities. Its purpose is to stimulate and support artistic activity at the Institute. Previous experience with the arts is not necessary; experimentation, interdisciplinary projects, and broad student participation are encouraged. Extracurricular projects are given priority over those directly related to an academic class, although research proposals are occasionally funded. Grant awards range from a few hundred to several thousand dollars.

The Council for the Arts also issues a calendar of arts events taking place at the Institute, a newsletter describing particular arts activities or individuals active in the MIT arts community, and a program of technical assistance. The latter includes a resource library with information on funding opportunities for artists, as well as staff assistance in proposal writing, publicity, funding opportunities, and program planning.

Founded in 1971, the Council is a self-supporting organization composed of 100 alumni and friends of the arts at the Institute.

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 perience.

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.



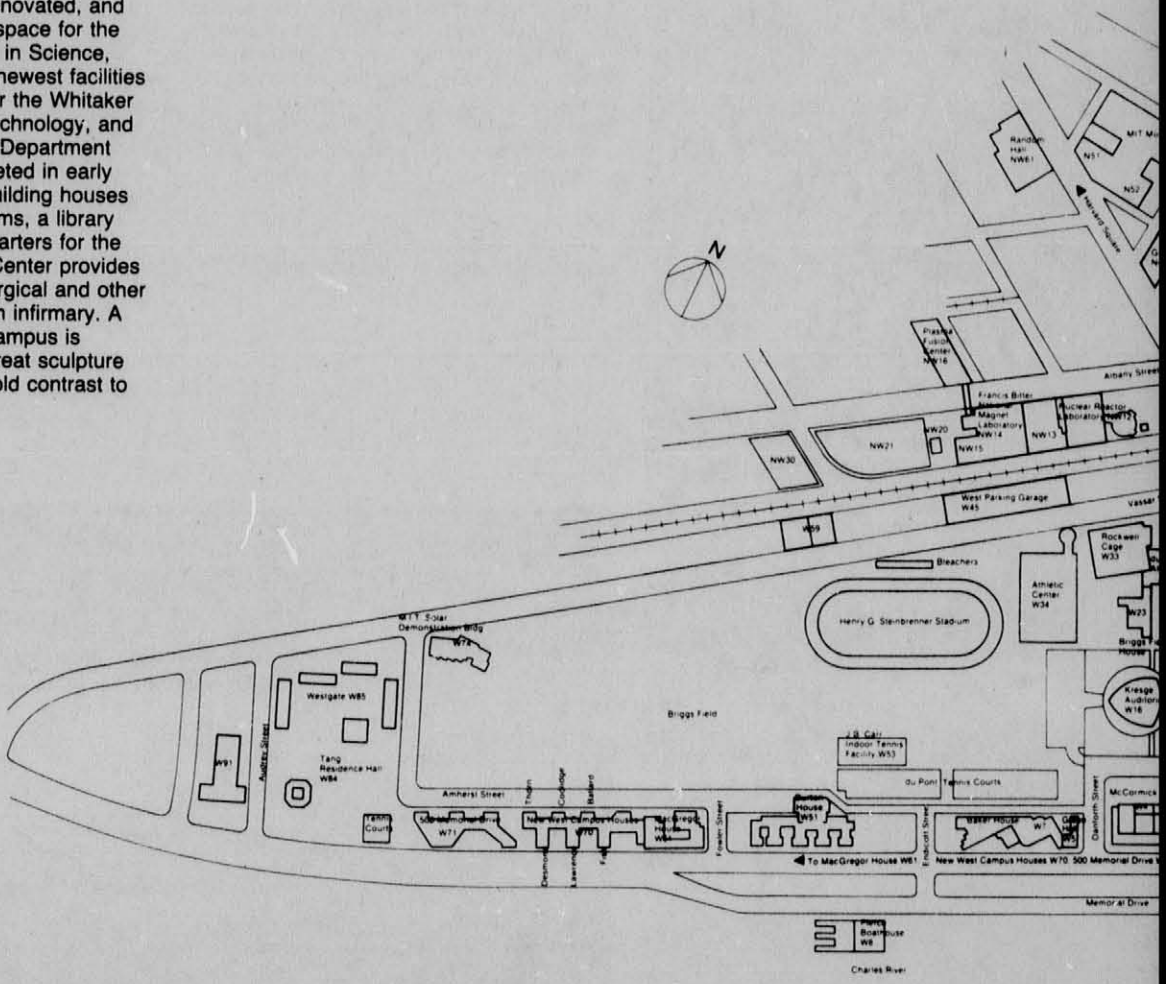
The Campus

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 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 house activities in management, economics, international studies, and political science. Adjacent to them is Eastgate, a 30-story apartment tower for married students. A building at 70 Memorial Drive was recently renovated, and contains classroom and office space for the Sloan School and the Program in Science, Technology, and Society. The newest facilities on campus are the buildings for the Whitaker College of Health Sciences, Technology, and Management, and the Medical Department Health Services Center, completed in early 1982. The Whitaker College Building houses research laboratories, classrooms, a library and reading room, and headquarters for the College. The Health Services Center provides facilities for medical, dental, surgical and other specialties, a pharmacy, and an infirmary. 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 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 Center for Space Research, the Sloan Laboratory, the Guggenheim Laboratory, and the Center for Advanced Engineering Study.



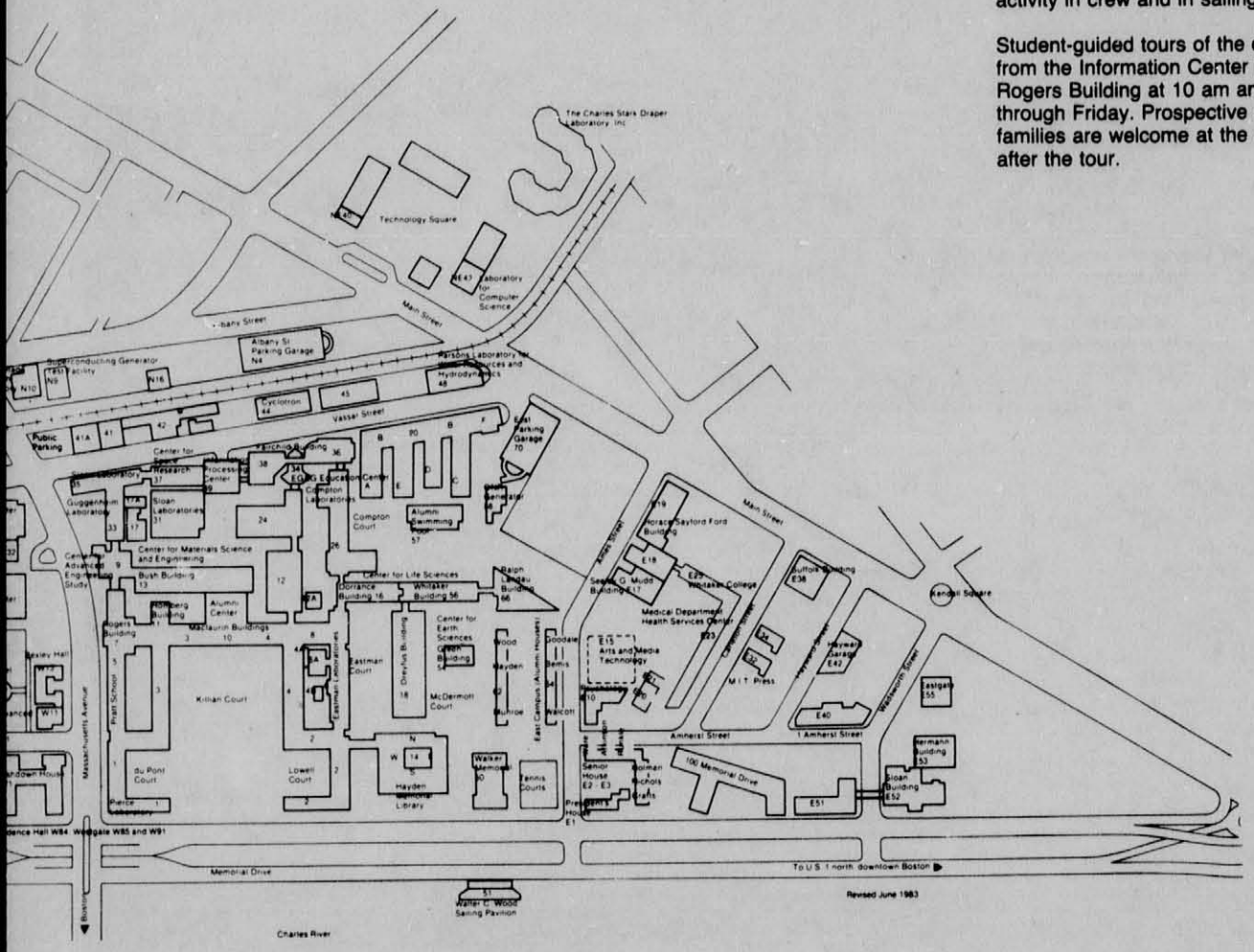
Across Massachusetts Avenue, on West Campus, is the Student Center (the Julius Adams Stratton building), which contains social rooms, cafeterias, offices for student activities, music rooms, a spacious library, and recreational and commercial facilities. The Student Center Plaza is bounded on the west 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 Athletics Center includes an ice rink and field house, and Rockwell Cage accommodates 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. Prospective students and their families are welcome at the Admissions Office after the tour.

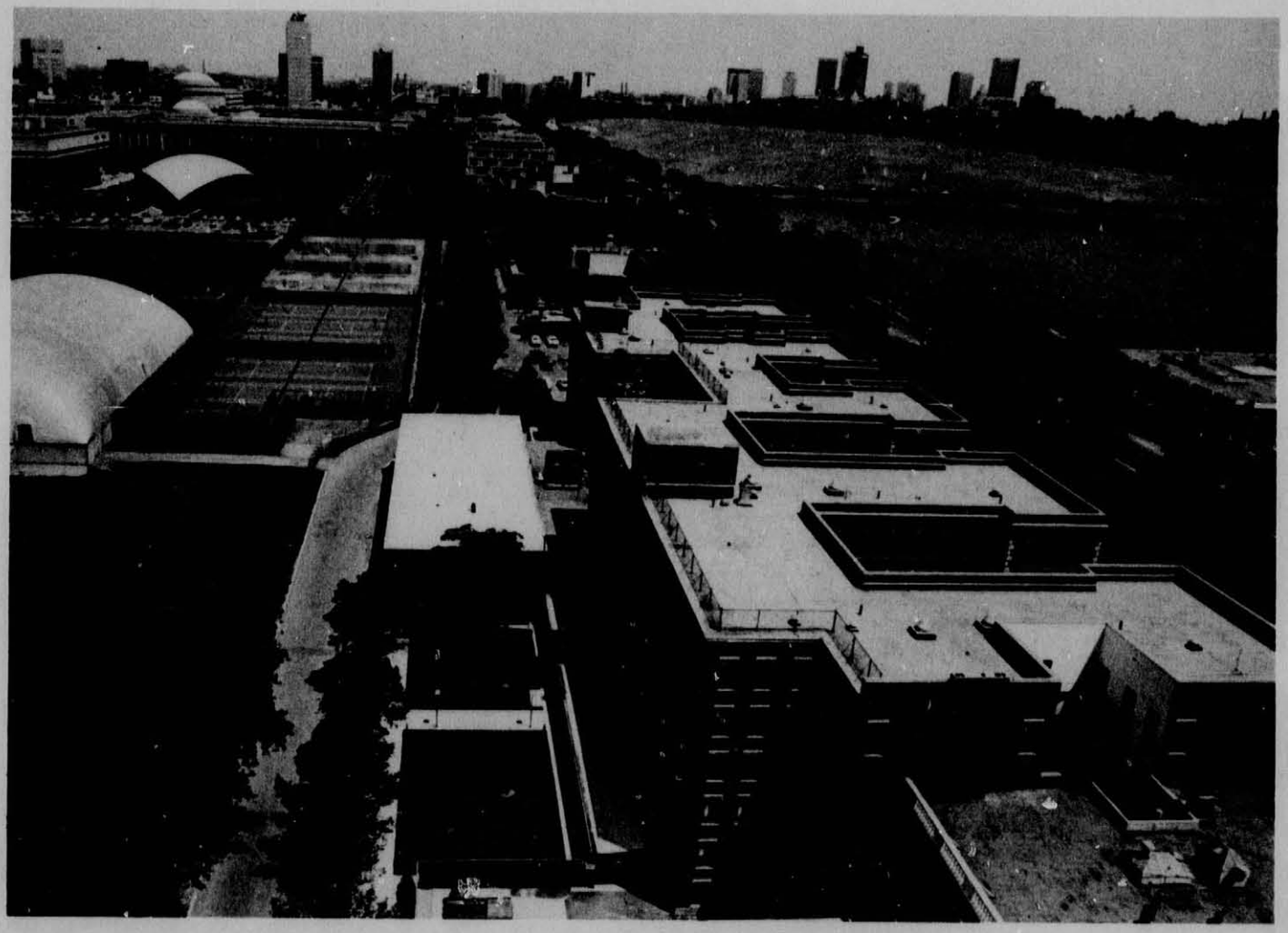


The Boston Environment

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 American Repertory Theatre.

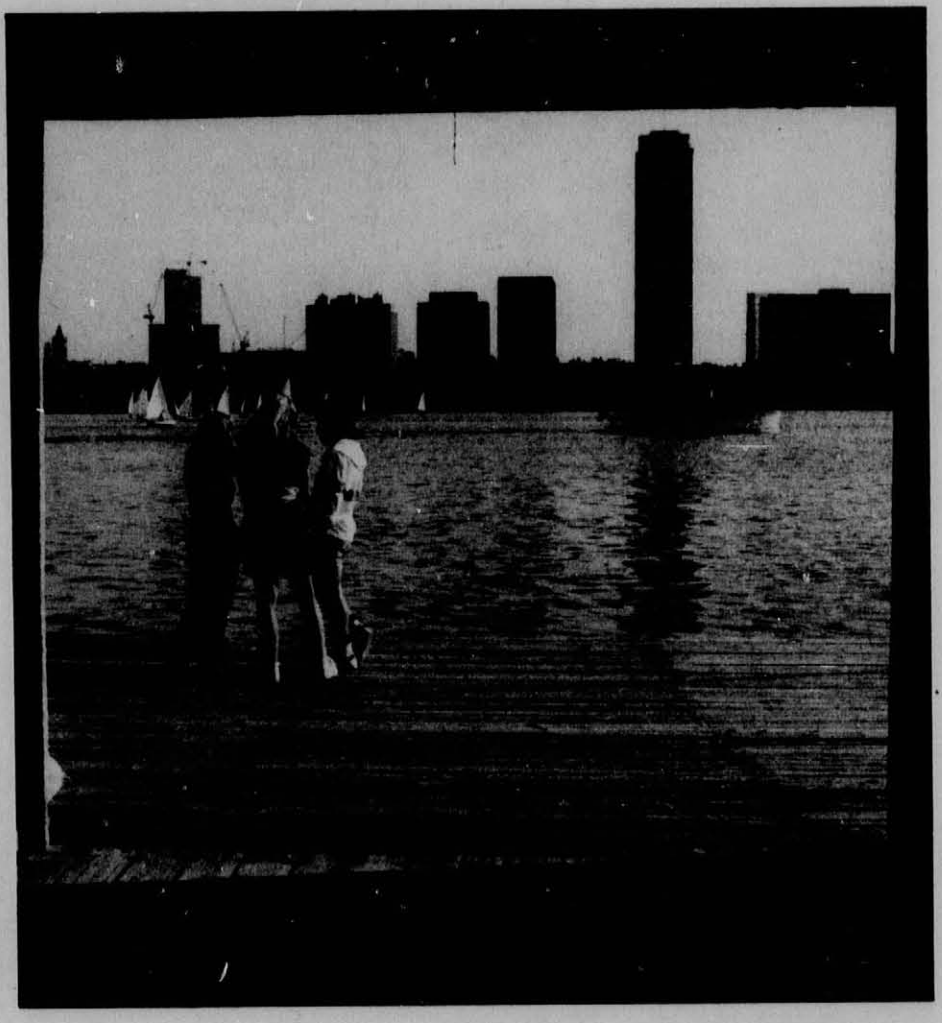
MIT is one of more than 50 schools located within the Boston area. Others include Harvard University, Radcliffe College, Boston University, Northeastern University, Boston College, Brandeis University, Tufts University, Simmons College, Wellesley College, and many specialized professional art and music 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, canoeing, kayaking, swimming, and camping.





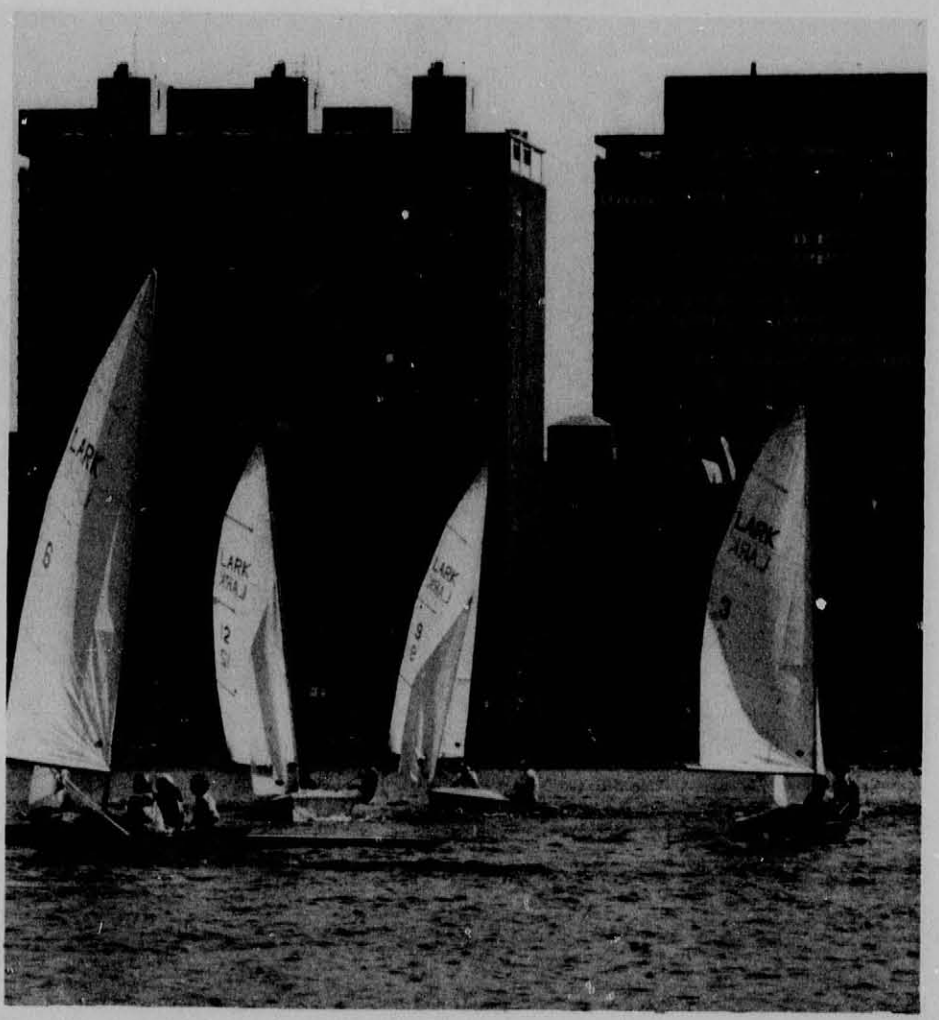











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Organization of the Institute

The Institute's board of trustees is known as the Corporation, over which the Chairman presides. Its members include 100 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 five 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 22 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., Ph.D.
			Architecture Studies	S.M.
			Visual Studies	S.M.
	Architecture (IV-B)	S.B.		
Department of Urban Studies and Planning	Planning (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	S.M.
			Electronic Materials	S.M.
			Materials Engineering	S.M.
			Materials Science	S.M.
			Metallurgy	S.M.
	Cooperative Course (III-B)	S.B.	Polymers	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 (XXI)	S.B.		
	Humanities and Engineering (XXI-E)	S.B.		
	Humanities and Science (XXI-S)	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.	Political Science and Public Policy (XVII-A)	S.M.
Department of Psychology	Cognitive Science (IX)	S.B.	Psychology (IX)	S.M., Ph.D.
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, Atmospheric, and Planetary Sciences	Earth and Planetary Sciences (XII)	S.B.	Earth, Atmospheric, and Planetary Sciences (XII)	Ph.D., Sc.D.
			Earth and Planetary Sciences	S.M.
			Meteorology	S.M.
			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.

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.
Harvard-MIT Division of Health Sciences and Technology			Health Sciences and Technology (HST)	Ph.D., Sc.D.
Whitaker College of Health Sciences, Technology, and Management			Health Policy and Management	Ph.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 Engineer (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 description of the Joint Programs with the Woods Hole Oceanographic Institution. This description follows the groups of department statements in the School of Science in Chapter VI of this catalogue.

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

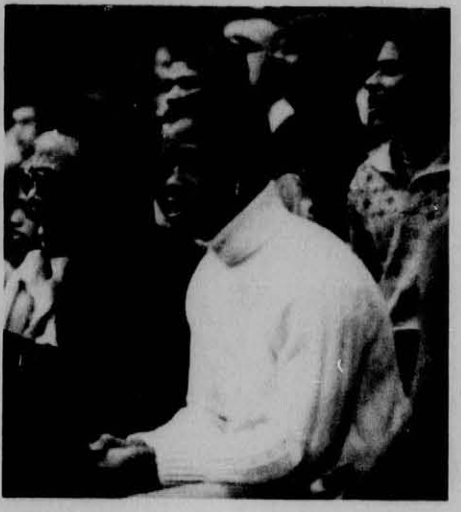
5
Several departments offer the S.M. in Transportation under interdepartmental supervision.

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





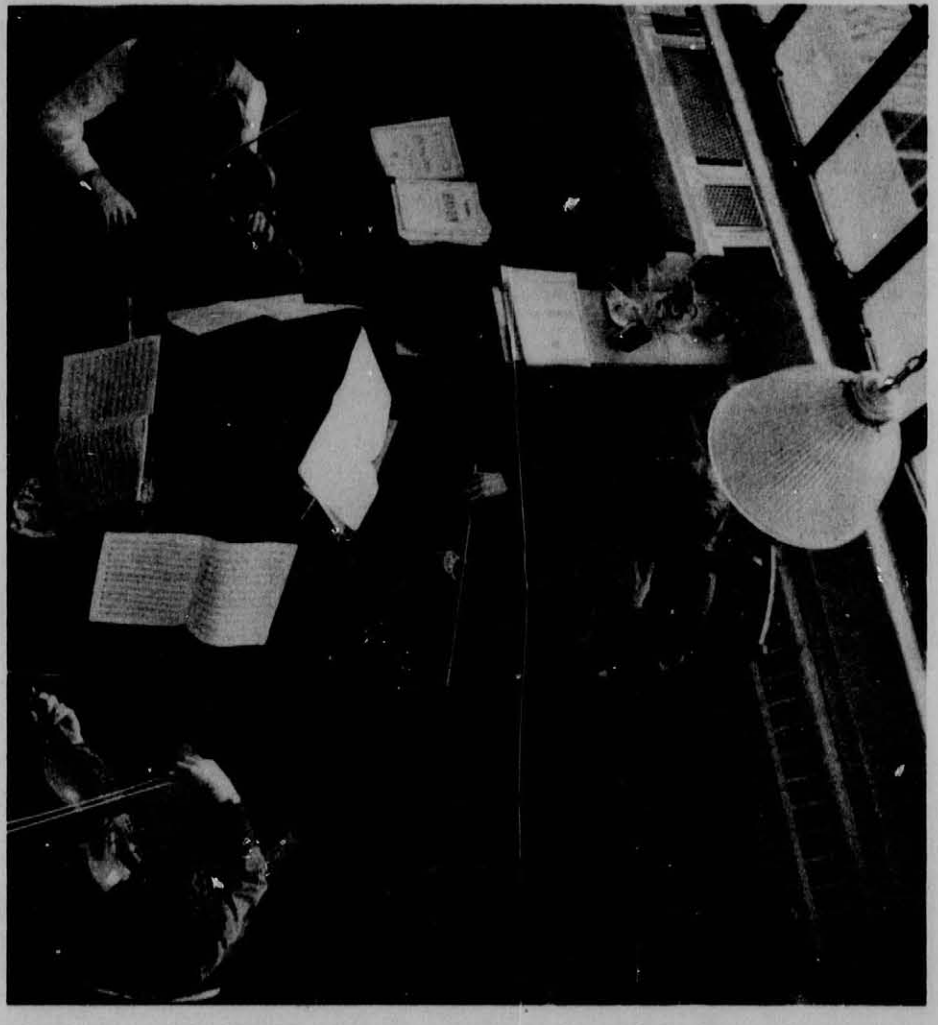

MIT



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 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 produces the major social events of the year.

The International Students' Council represents the interests of international 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 Non-Resident 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 800 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.

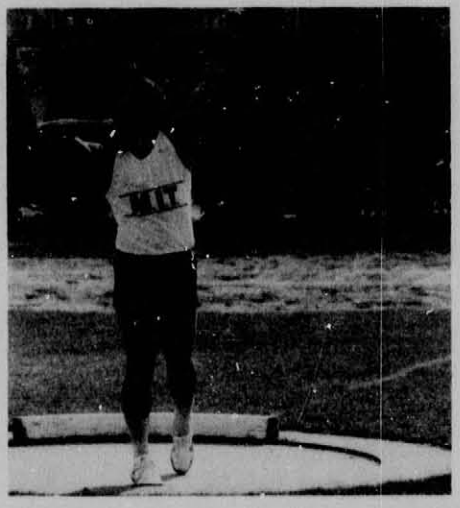
MIT sponsors varsity sports for men in baseball, basketball, crew (heavyweight and lightweight), cross country, fencing, golf, gymnastics, indoor and outdoor track, lacrosse, pistol, rifle, sailing, skiing, soccer, squash, swimming, tennis, water polo, and wrestling. In addition, there are women's varsity 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. Club varsity sports include football and men's ice hockey.

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 1,150 teams with an estimated 11,000 participants, including duplications reflected by those students who competed on more than one team.



There are intramural programs in backgammon, badminton, basketball, billiards, bowling, chess, cross country, cycling, fencing, football, frisbee, hockey, sailing, soccer, softball (fast and slow pitch), squash, swimming, tennis, track (indoor and outdoor), volleyball, water polo, weightlifting, and wrestling.

Club sports include badminton, fencing, figure skating, women's ice hockey, 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 Athletics 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 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.

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.

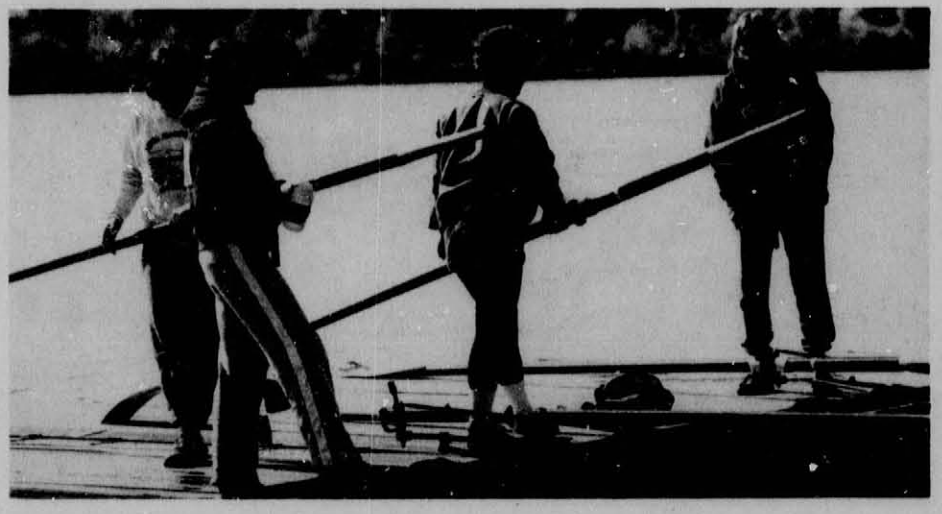
In accordance with the Chapel's interdenominational status, the Institute has not appointed an Institute Chaplain or Dean of the Chapel. MIT considers that one of its responsibilities is to maintain an atmosphere of religious freedom for all and to provide opportunity for the exercise of all spiritual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

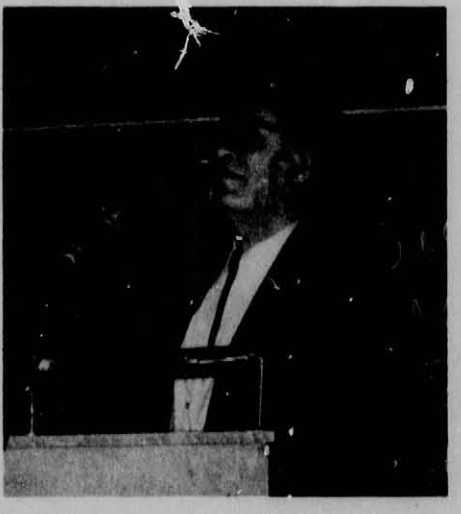
Technology Community Association

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.

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. Nationality groups also present movies, as does the Student Center Committee.





Student Publications

Student publications at MIT include *The Tech,* a student newspaper published twice each week; *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 and organizational 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 Music Society, Festival Jazz Ensemble, Concert Jazz Band, Gospel Choir, and Early Music 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

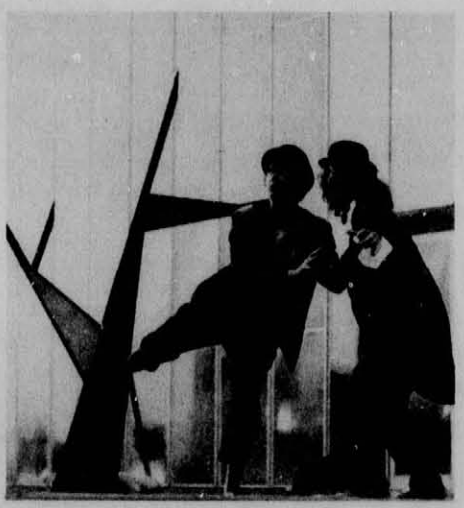
A variety of theatrical performances is presented on the campus by both student organizations and professional groups.

Dramashop is the student drama group which functions under the supervision of the Director of the Drama Program and his or her 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. For further information on the Drama Program, see the description under the Department of Humanities.

The Musical Theatre Guild presents two major and two smaller-scale musical productions each year. All manager, director, designer, orchestra, cast, and technical positions are filled when possible by MIT students. *Tech Show,* an original student-written musical, is usually produced in the spring term.

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, composed of MIT and Wellesley students and a professional director, presents two main productions each year and maintains an extensive repertory of scenes. The Ensemble tours its fall production throughout the Northeast. During the school year, the group performs at Boston-area high schools and institutions. The Ensemble also conducts an apprentice program that offers training in Shakespearean acting.



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 noncurricular educational activities. The Hayden Galleries show 10 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 particularly noted for outdoor sculpture and contemporary works of art on paper.

Educational activities include an undergraduate seminar, "Issues in Contemporary Art"; lectures; symposia; and an extensive publications program in conjunction with Hayden Galleries exhibitions.

The Hart Nautical Collections, a branch of the MIT Museum, maintain 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.

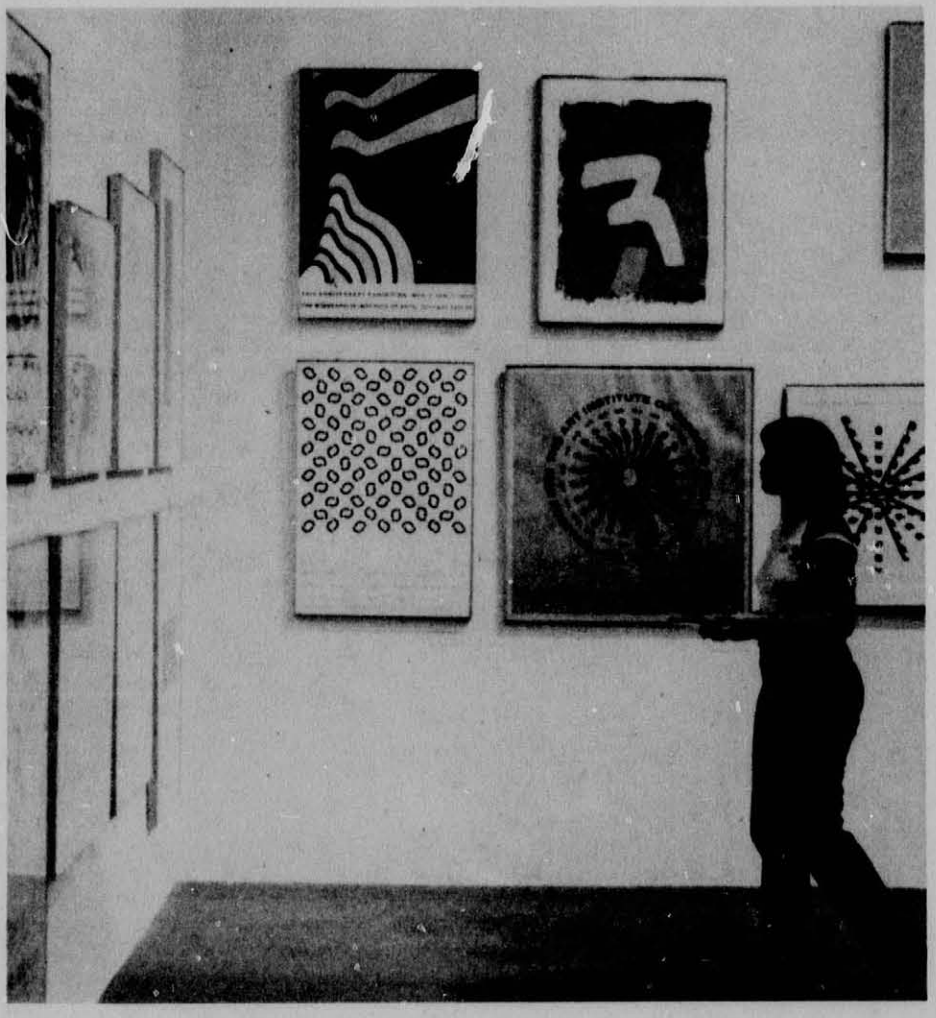
Exhibitions in the Margaret Hutchinson Compton Gallery illustrate the Institute's programs and fields of inquiry. Exhibitions this past year included a perspective on William Barton Rogers 1804-1882; A Bunch of Electricals: An MIT Electrical Engineering Retrospective; and Math in 3-D: Geometric Sculptures by Morton C. Bradley, Jr.

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 2,650 single men and women live in the ten 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. The opening of a new undergraduate residence in 1981 now allows for the housing of transfer and readmitted students.

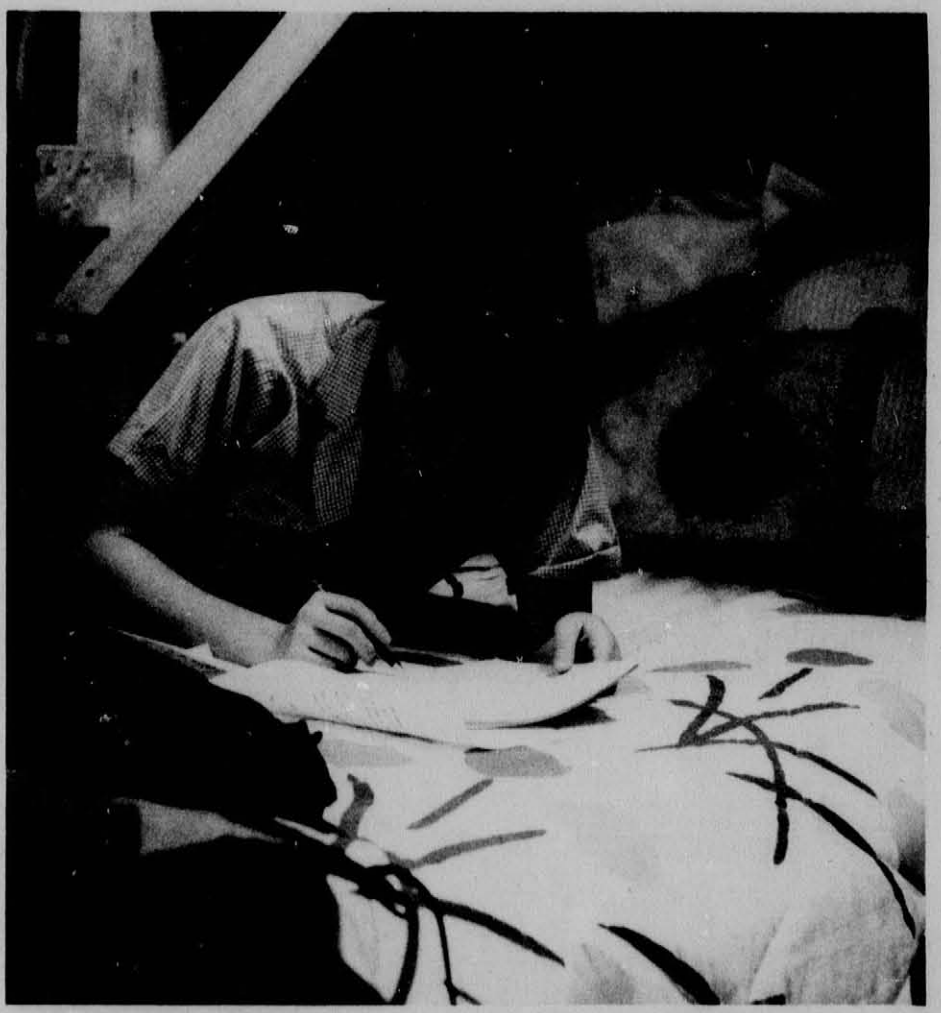
The central purpose of the residential system is to provide an environment conducive to personal development as well as academic achievement. The Institute relies greatly on the initiative and responsibility of both individual students and student government organizations in the residences.

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 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, Bemis, and Walcott

French House

German House

Frank S. MacGregor House

Stanley McCormick Hall

New West Campus Houses — Ballard, Laurence, Coolidge, Desmond, Fisk, and Thorn

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 1983-84, the average rents for the houses range from $855 to $1,155 per term.

A student cancelling a room assignment after the stated deadline of July 8 will be charged a cancellation fee. 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 1983-84

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 1983 all students living in houses which have dining rooms (Baker House, MacGregor House, McCormick Hall, and 500 Memorial Drive), will be required to take the following meal plan: freshmen "360" plan, sophomores "310" plan, juniors "260" plan, and seniors "210" plan. All four plans are with Basic or Seconds as a minimum. There will be no meal requirement in East Campus and Senior House due to the construction of new kitchens.

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	$862	$1,019
460 Plan	735	863
410 Plan	671	785
360 Plan	608	708
310 Plan	544	629
260 Plan	480	552
210 Plan	416	474
160 Plan	353	397
Charge Plan	200	—



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.

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.

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, Building E18-301, 77 Massachusetts Avenue, 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, (617) 253-4051. 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, Tang Hall, and Green 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 $1,966 per person for the academic year, depending on the type of room.

Ida Flansburgh Green Hall

Opened this past spring after a substantial renovation, Green Hall accommodates 46 single graduate women in 31 single and eight double rooms. Situated in the former Infirmary, the completely refurbished dormitory is centrally located on Memorial Drive within five minutes walking distance of athletic, Student Center, and main campus buildings.

Rooms are furnished with a bed, desk, chair, lamp, and dresser, and average $1,962 per person for the academic year. Rooms in Green Hall are rented for the full academic year beginning September 1 and include all utilities except private telephone.

An MIT faculty member resides in the Hall and assists student leaders in planning social and orientation activities. Community cooking facilities are available on each floor, or residents may purchase meals on a charge plan or a la carte in nearby McCormick Hall.

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 $193 to $235 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 all graduate 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. Apartment rents range from $318 to $536 per month and include all utilities except telephone.

Married student housing is managed by the MIT Housing 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 larger 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/Student Assistance Services offers counseling services to all students, whether the situation is academic or personal or both. The office has special responsibilities for international students, women, minorities, and handicapped students. 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 can be helpful as well.

Several offices specialize in particular areas. They include the Student Financial Aid Office, which includes student employment, the Religious Counselors, and the Career Services and Preprofessional Advising Office. The Campus Police are 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. The psychiatrists, psychologists, and social workers from the Medical Department are considered by many students 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 at the Health Services Center (Building E23) without further charge except for pre-entry physicals, obstetrical care, routine eye examinations, contact lens service, hearing aid evaluations, ear piercing, dental care, missed appointments, contraceptive devices, prescription drugs, 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 by paying the $300 Health Service fee for coverage from September 1, 1983 through August 31, 1984.

The MIT Medical Department is a multi-specialty 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, gastroenterology, pathology, radiology, psychiatry, and social work services. The Department provides a pharmacy and 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 major goal of the Department is to provide high-quality, accessible medical care; students are encouraged to identify a primary physician who coordinates their health care.

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. The form, which is completed by the student and his or her personal physician, is returned to the Chief, Student Health Programs. This form consists of historical information, immunization record, physical examination, and specified laboratory studies. In addition, freedom from active tuberculosis as evidenced 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 Inpatient Service 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 Inpatient Service, 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 Health Services Center 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 Inpatient Service. The cost of hospitalization and outside medical care for serious illness or injury is extremely high; in Boston-area hospitals it exceeds $500 per day. For this reason, it is extremely important that students maintain adequate health insurance for themselves and family members. All regular students will be enrolled automatically in the MIT hospital insurance program and billed for each semester. 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 are eligible to purchase the MIT hospital and accident insurance, but are not enrolled automatically.

Annual Rates (September 1, 1983-August 31, 1984)

	MIT Medical Department	Hospital & Accident Insurance
Student	included in tuition	$216
Spouse	$300 or fee for service	$582
Child(ren)	fee for service	$192

Office of Career Services and Preprofessional Advising

The Office of Career Services and Preprofessional Advising 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 400 companies, government agencies, and graduate schools make recruiting visits to the 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 $2.50 to $3.00 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, nonprofit corporation which operates a variety of programs on campus for children who are at least two years and nine months old.

The Half-day Program 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 half-day classrooms, one in Eastgate and one in Westgate. Fees for the 1983-84 school year are $1,862 for five mornings; $1,117 for three mornings; and $745 for two mornings.

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 1983-84 is $4,625. For children who need Kindergarten plus full day care, the Kindergarten-Extended Day program is available at Eastgate. The program operates from September until mid-June. The hours are 8 am to 5:30 pm, Monday through Friday. The comprehensive fee for 1983-84 is $4,200.

The Child Care Office maintains information about child care 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 the Child Care Office, Room 4-144, MIT, Cambridge, Massachusetts 02139, (617) 253-1592, or TCC, 60 Wadsworth St., Cambridge, Massachusetts, 02142, 253-5907.

Rules and Regulations

Conduct, Discipline, and Grievance Procedures

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 these 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.

Privacy of Student Records

Institute Policy on Harassment

Harassment of any kind is unacceptable at MIT and is in conflict with the policies and interests of the Institute. Moreover, many forms of harassment have been recognized by the US Equal Opportunity Commission and the courts as violations of the civil rights laws.

Harassment is defined as verbal or physical conduct which has the intent or effect of unreasonably interfering with an individual's or group's educational and/or work performance at MIT, or creating an intimidating, hostile, or offensive educational and work environment on or off campus. Harassment on the basis of race, color, sex, religion, national origin, or sexual orientation includes harassment of an individual in terms of a stereotyped group characteristic, or because of that person's identification with a particular group. With reference to sexual harassment, the definition also includes unwelcomed sexual advances and requests for sexual favors which might be perceived as explicitly or implicitly affecting educational or employment decisions concerning an individual.

Any member of the MIT community who believes that he or she has been harassed is encouraged to raise the issue, or lodge a complaint, in accordance with the established grievance procedures outlined above.

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.

The Family Educational Rights and Privacy Act of 1974 (sometimes called "the Buckley Amendment") 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 Police, 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 specific 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, they 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 of Faculty and Staff

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.

Administration of Institute Policy

Questions concerning this 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 Police. 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 Police.

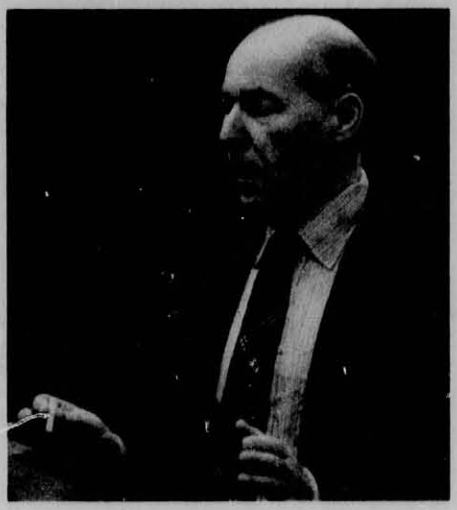
Parking facilities at MIT are limited. In general, the Institute cannot provide parking for resident students. With the approval of the Dean for Student Affairs, a limited number of spaces is available for assignment to students with physical handicaps requiring use of an automobile and to a few other undergraduates. Recent regulations issued by the US Environmental Protection Agency require a continual reduction of the total number of available parking spaces. Parking is prohibited and towing in effect on Memorial Drive in front of MIT between the hours of 7 and 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.















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. A student may also 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; 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 subjects in 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 (listed later in this chapter), 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, one of three sequences in physics, and from a designated list of subjects in the humanities, arts, and social sciences. Students have five options from which to choose to satisfy the first phase of the Writing Requirement.

A typical program for the first year includes 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. All subjects taken by freshmen are graded on a pass/fail basis. 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.

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.

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.

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 approach is not only to achieve competence in the separate disciplines but to examine 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 1983-84 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.

ESG (Experimental Study Group)

ESG is a small academic community at MIT which offers a comprehensive alternative program in the core subjects for freshmen and sophomores. Students enrolling in ESG can study mathematics, physics, chemistry, humanities, and social science subjects through a combination of tutorials, seminars, study groups, and independent study projects. In contrast to the set structure of the regular curriculum, ESG's flexibility allows students to go at their own pace whenever possible, to choose their own topics of concentration within the course material, and to organize their schedules as they wish. Although ESG can be a full-time activity for freshmen, students usually take one or two courses in the regular curriculum which are not offered in ESG. Every freshman is guaranteed at least 50 units of credit each term, including specific credit for subjects completed and free elective credit for work done that is not covered under a particular subject number.

In addition to offering a solid academic program for freshmen and sophomores, ESG also provides a place where students and staff can study and socialize together. Each year approximately 45 freshmen, 25 sophomores, 10 staff members, and 20 upperclass tutors (who have been in ESG as freshmen) participate in ESG. Staff members are drawn from MIT's Departments of Mathematics, Chemistry, Physics, and from the School of Humanities and Social Science. Interaction between community members is facilitated not only through seminars, study groups, and tutorials, but also through community activities such as weekly luncheons and weekend trips. In such an atmosphere, students and staff members are encouraged to explore and develop their own academic and nonacademic interests.

More information may be found in the *Freshman Handbook* or by writing to ESG, 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 receive formal 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 is designed to meet a variety of objectives; among them are 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.

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 motivation for the lifelong learning necessary for 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.

Electives

Any subject offered by the Institute is open to first-year students, provided they 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 some part 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 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 on field trips, or engage in "hands-on" research. Many topics are interdisciplinary in nature.

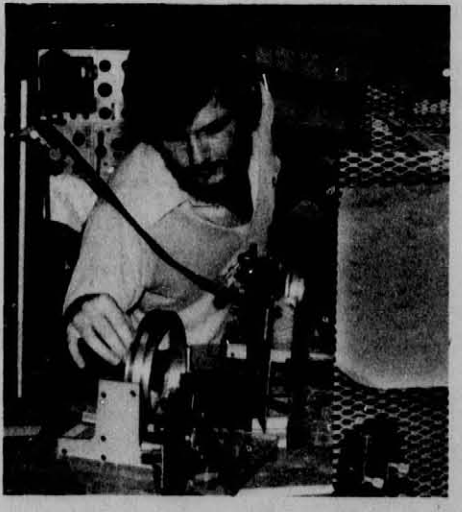
Most seminars carry six units of pass/fail credit and the class size is generally restricted to a small group. Titles and descriptions of seminars to be offered in the upcoming term are published in the Undergraduate Seminar Program booklet, published twice yearly. Copies of the current booklet are available in the Undergraduate Academic Support Office, Room 7-104.

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 *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. 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 for advice, consolation, or congratulations.



Preprofessional Advising and Education

Within the Office of Career Services (Room 12-170), the Preprofessional Advising programs serve students who are interested in pursuing professional postgraduate education, particularly in the fields of medicine, law, and psychology. 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.

Premedical Education

In recent years increasing numbers of students have entered medical school upon graduation from MIT. Each year nearly 10 percent of the senior class as well as a number of alumni and graduate students go on to medical study. Students in nearly every Course of study are represented among the applicants. Since there is no specific premedical department 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, medical research, or student counseling, provides guidance and information to students interested in medical careers. The Office of Preprofessional Advising and Education, Room 12-170, (617) 253-4737, maintains Medical College Admissions Test application forms, school catalogues, *A Pre-Medical Handbook for MIT Students,* and other information pertinent to medical study. Students interested in medicine are encouraged to make an appointment in the Preprofessional Office by the second term of their sophomore year. Students interested in medicine are assigned to a premedical advisor at that time.

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 and make contact with the Preprofessional Office during their junior or senior year.

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 admissions 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 of this catalogue for a further discussion of opportunities and programs in this area.

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. Students are encouraged to contact the faculty in the Education Department at Wellesley.



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 Office of Career Services and Preprofessional Advising, Room 12-170, (617) 253-4733. The Office of Career Services can provide a great deal of assistance and information as a student plans for study at another college or university. 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

This program provides the opportunity to spend from one semester to one year at another academic institution for the pursuit of work generally not available at MIT. A student on such an approved program maintains, without payment of MIT tuition, official MIT registration as "undergraduate studying away," with student aid status and dormitory priority. Approval for Domestic Year Away status 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 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 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, 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. Cross-registration is normally limited to upperclassmen who must be regularly enrolled at MIT and paying full tuition for the term in question. 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 Humanities Undergraduate Office.

Wellesley-MIT Exchange Program

The Wellesley-MIT Exchange Program was established in 1968 to expand the educational opportunities for students of each institution. 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 the section.

A small, liberal arts college for women located on a 500-acre woodland campus 12 miles west of Boston, Wellesley College 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 or bicycling around the vast expanse of trees and grass, or swimming or sailing at the lake, the experience at Wellesley can 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, students need at least one hour between their Wellesley and MIT classes. Cross-registered students have priority in boarding, but others with MIT or Wellesley identification cards may use the bus on a space-available basis.

Classes at Wellesley vary in length from two 70-minute periods each week for many courses in the humanities and social sciences to three, four, or five scheduled periods a week in certain courses for foreign languages, art, music, and the sciences.

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.

Unless otherwise stated in the Wellesley *Bulletin* a semester course receives one Wellesley unit of credit, which equals 12 (3-0-9) MIT units.

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 by the MIT drop-date deadline.

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 Wellesley courses listed in the HASS Distribution section 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.

Religion 108: Introduction to Asian Religions, a Wellesley subject designated as a HASS Humanities subject, will be taught on the MIT campus second semester.

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 Humanities Undergraduate Office, 14N-410, x3-4443. Special concentrations may be arranged through Ruth Spear, Coordinator of the Humanities Undergraduate Office.

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 Ruth Spear. Students with questions pertaining to the Humanities, Arts, and Social Sciences Requirement should contact Ms. Spear.

Wellesley subjects may be used to fulfill departmental requirements with the permission of a faculty counselor.

Because their elementary- and intermediate-level language courses run for an entire year, students cannot begin studying a new language at Wellesley second semester. However, although Wellesley students are required to complete both semesters to receive academic credit, MIT students may elect to take only one semester, including second semester if they have the language background.

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 unable to complete their work due to grave emergency or illness, should contact the Exchange Coordinator at Wellesley within 24 hours of the deadline. A written explanation and supporting documents should then be submitted within two weeks to the Exchange Coordinator for consideration by Wellesley's Academic Review Board. If they fail to submit an adequate explanation by the deadline their case will be treated as unexcused incomplete work.

Instructors may submit a grade or an "I" (incomplete) if a student fails to complete in-term or end-of-term work by the end of the examination period and the lateness is not excused by the Academic Review Board. If a student receives an incomplete he or she may then complete the work during the next semester. The instructor may submit a grade to the Wellesley Registrar until May 15 for first semester incompletes and October 15 for second semester incompletes. Faculty need time to evaluate late work and submit grades so students should plan to complete their work at least two weeks prior to these dates. The notation "I" will appear on their record with the new grade beside it. If no new grade is submitted by the deadline, the "I" will be replaced by a permanent "INC."



Students may take physical education classes at Wellesley on a space-available basis. To obtain credit, they should make arrangements at the time of registration with the Physical Education Department so that MIT can be notified of their grade at the end of the term.

MIT students receive full library privileges at the Wellesley College Library.

The following is a list of majors at Wellesley:

Departmental
Anthropology
Art
Astronomy
Biological Sciences
Black Studies
Chemistry
Chinese
Computer Science
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
American Studies
Chinese Studies
Classical Civilization
Classical and Near Eastern Archaeology
French Studies
Italian Culture
Medieval/Renaissance Studies
Molecular Biology
Psychobiology
Women's Studies

Individual
East Asian Studies
Language Studies
Theatre Studies
Urban Studies

Information and copies of the Wellesley *Bulletin* 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 x2321 (through the MIT tie line: 187-2321).

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 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) financial registration material issued by the Bursar has been completed and returned, 3) all Institute charges have been paid when due, or satisfactory alternative arrangements have been made with the Bursar, 4) 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 5) 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 during his or her junior and senior year. 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, or to the Undergraduate Academic Support Office, Room 7-103.

The Registrar's Office sends out a "Status of Registration Form" to every student during the fourth week of the term. 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 a dean in the Student Assistance Services Section of the Dean's Office, Room 5-106.

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. In view of the requirement that ROTC students take one ROTC subject each term, all AS-, MS- and NS-numbered subjects are excluded from this credit limit. 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.*

Junior/Senior Pass/Fail Option

A student may opt to take a total of two subjects on a pass/fail basis during his or her junior and senior years. This option is intended to provide students an opportunity to broaden their education by taking subjects which may not be in their area of expertise without concern for its affect on their academic record. It is therefore expected that this option will be designated at the time the student initially registers for the subject, but the deadline for this decision is Add Date. Such subjects may not be used to fulfill either an Institute or a department requirement.

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 Bursar's 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 two months 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

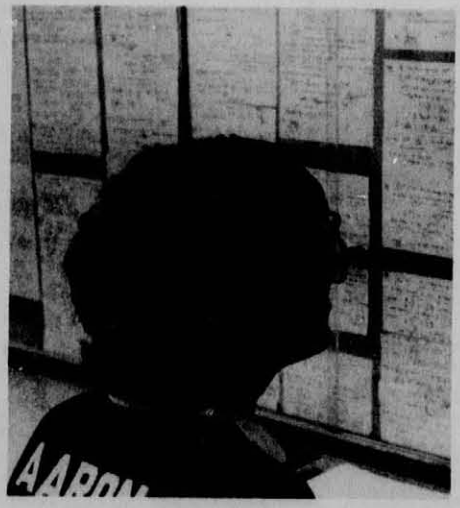
It is the responsibility of the Committee on Academic Performance (CAP) to see that minimum academic standards proposed by the individual departments are consistent throughout the Institute for undergraduates and conform with the rules and regulations approved by the faculty. In view of the individual 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 term, 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. [Note: Some departments may consider D-level work in certain prerequisite subjects within the departmental program to be inadequate preparation, and may ask students to do additional work, which could include retaking the prerequisite.]
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 semester. 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. When an Incomplete is completed within the time allowed, the final grade will be recorded on the student's permanent transcript beside the Incomplete.

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

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 of this catalogue.

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 8.012 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**
Writing Requirement Satisfied in two stages as specified on the next page.	
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.

Science Requirement

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 assumes a year of high-school calculus; 18.001 also assumes some 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.



Writing Requirement

The primary objectives of this General Institute Requirement are: to ensure minimum standards of writing proficiency for all undergraduates, with special emphasis on writing in students' professional fields, and to see that clear, effective writing is valued and fostered throughout the curriculum as an important part of an MIT education.

The basic features of the Requirement are early evaluation, a variety of modes of completing the Requirement, and Institute-wide involvement. The Requirement is to be satisfied in two phases: **Phase One** is concerned with basic expository writing competence that should be expected of any educated person. The options for satisfying this stage are:

a) achieving, prior to entry, a score of 750 or above on the College Board Achievement Test in English Composition with Essay.

b) passing the Freshman Essay Evaluation during Residence/Orientation Week. For certain designated students an optional English as a Second Language (ESL) version is available.

c) receiving a grade of pass in any **one** of the following expository writing subjects: 21.334 Expository Writing II for Undergraduates: English as a Second Language, or 21.730 Expository Writing, 21.731 Writing and Experience, 21.732 Introduction to Technical Communication, or any equivalent subject in Project Interphase, the Experimental Study Group, or Concourse.

d) submitting a five-page paper of expository prose written for any MIT subject during the past semester which is judged satisfactory by the professor of the subject and faculty evaluators for the Requirement.

Students normally complete this stage by the end of the freshman year.

Phase Two is designed to engage upperclass students in the more specialized forms of writing that are necessary within their professional disciplines. These encounters, which go beyond the writing experiences provided by the Humanities, Arts, and Social Sciences Requirement, occur over an extended period in the middle years of students' undergraduate careers. Phase Two should be satisfied by the end of the junior year.

Humanities, Arts, and Social Sciences Requirement

Options for completing this phase are:

a) receiving a grade of B or better for the quality of writing in a cooperative subject within the general area of a student's professional field. Many engineering subjects (especially in laboratory and design) include instruction by Writing Program faculty. Such cooperative arrangements provide opportunities for satisfying Phase Two.

   This phase can also be satisfied by receiving a B or better in any **one** of the following advanced subjects in scientific and engineering writing: 21.337 Workshop in Writing for Science and Engineering: English as a Second Language, 21.338 Workshop in Writing for the Social Sciences and Architecture: English as a Second Language, or 21.780 Science and Engineering Writing.

b) submitting a 10-page paper of expository prose from any MIT subject or UROP activity within the general area of a student's professional field which is judged satisfactory by the professor or supervisor and by faculty evaluators for the Requirement.

Students submitting papers must first pick up a cover sheet from the office of the Committee on the Writing Requirement (Room 4-246) for the subject instructor to sign. Instructors are encouraged to use the cover sheet to comment on the student's writing before signing the sheet and giving it to the student. The student then returns the paper and the cover sheet to the Committee office.

The Committee on the Writing Requirement has published a brochure on the Requirement and resources which may be used to satisfy it. Copies of this brochure and other material are available from Bonnie Walters, Coordinator of the Committee on the Writing Requirement, Room 4-246, (617) 253-3039.

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 following list 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
Film and Media Studies
Foreign Languages and Literatures
History
History of Art and Architecture
Labor in Industrial Society
Latin American Studies
Linguistics
Literature
Music
Philosophy
Political Science
Psychology
Russian Studies
Science, Technology, and Society
Technology, Culture, and Development
Traditions and Texts
Urban Studies
Visual Arts and Design
Women's Studies
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 Humanities Undergraduate Office.

HASS Information

For detailed information on Distribution subjects or on the Concentration requirements in any field, and for assistance with any aspect of the Humanities, Arts, and Social Sciences Requirement, students should visit the HASS Information Center, Room 14N-409, (617) 253-4441.

Distribution Subjects

Humanities Distribution subjects are humanistic in orientation, of broad general interest, with a subject matter clearly drawn from one or more of the disciplines in the Humanities, Arts, or Social Sciences. Such subjects meet in sections small enough to allow discussions in which every student can participate, and — except for some art subjects — they call for a substantial amount of writing. The character of such subjects varies from field to field, and each field has established criteria for the selection of Humanities Distribution subjects. These criteria have been published, along with a guide to Humanities Distribution subjects, by the Humanities, Arts, and Social Sciences Information Center.

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 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 list of subjects offered for **Humanities Distribution** credit:

American Studies

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

Anthropology and Archaeology

21.50 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 Technology
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 Topics in Economic History

Film and Media Studies

17.707 Mass Communication and American Culture
21.031 The Film Experience

Foreign Languages

21.203 French III
21.204 French IV
21.233 German III
21.234 German IV
21.256 Classical Greek II
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: 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
21.376 Imperial and Revolutionary Russia: Culture and Politics
21.390 American History to 1865
21.391 American History Since 1865
21.409 American Ideas and Culture: From the Puritans to the Civil War
21.451J The History of 20th Century Africa: Nationalism and Nation-Building [17.551J]
21.460 East Asian History: China
21.461 East Asian History: Japan
21.480 The Middle East From the Rise of Islam to World War I
21.481 The Middle East in the 20th Century

History of Art and Architecture

4.601 Topical Studies in the History and Theory of Art
4.605 Introduction to the History and Theory of Architecture
4.642 Modern Art from Impressionism to Cubism
4.651 Modern Art from Cubism to the Present

Labor in Industrial Society

14.63 Labor in Industrial Society

Linguistics

24.900J The Study of Language [21.321J]

Literature A[1]

21.001 Foundations of Western Literature: Homer to Dante
21.002 Classics of European Literature
21.003 Introduction to Fiction
21.004 Major Poets
21.005 Introduction to Drama
21.006 Introduction to American Literature
21.009 Shakespeare
21.010 Literature and Film
21.021 Comedy
21.022 Tragedy
21.079 Modern Russian Literature and Its Historical Structure
21.101 The American Novel
21.296 Introduction to European and Latin American Fiction
21.297 Sex Roles in Fiction: Europe and Latin America
21.298 The Don Juan Legend

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

21.302 Slavic Civilization: Magic, Vampires, and Witches
21.306 German Literature in Translation
21.310 Masterpieces of the Hispanic Tradition
21.311 Latin American Literature: Civilization vs Barbarism
21.316 The Roots of Russian Literature
21.317 Russian Novel of the 19th Century
Wellesley Italian 211

Literature B[1,2]

21.209 French Civilization I
21.210 French Civilization II
21.211 Introduction to French Literature
21.217 Introduction to French Poetry
21.218 Introduction to the French Short Story
21.225 Representations of Love in French Literature
21.226 Artistic and Intellectual Currents of Modern France: Literature and Ideology
21.239 Introduction to German Literature
21.240 German Romanticism: Fantasy vs Reality
21.242 German Short Fiction
21.246 German Culture and Society: 1789-1918
21.247 German Culture and Society: 1918-1933
21.248 German Culture and Society: 1933-1949
21.249 Introduction to German Poetry
21.250 Introduction to German Drama
21.268 Russian Culture and Civilization
21.270 Pushkin and His Successors
21.284 An Introduction to Latin American Culture
21.285 Introduction to Spanish Culture
21.286 Latin American Literature 1492-1898: Creation of a Continent
21.287 Twentieth-Century Latin American Literature: The Alchemist's Laboratory
21.290 Literature and Social Conflict: Perspectives on Modern Spain
21.314 Tolstoy: An Approach to Biography and Creativity

Music

21.60 Listening to Music
21.621 Western Music to 1750
21.622 Western Music after 1750
21.625 Vivaldi, Bach, and Handel
21.631 Symphonic Music
21.635 American Music
21.636 Jazz
21.637 Traditional Music in America

Philosophy

24.00 Introduction to the Problems of Philosophy
24.01 Contemporary Moral Issues
24.03 Logic, Language and Values
24.04 Moral and Legal Responsibility
24.05J Nature of Scientific Knowledge [STS 205J]
24.07 Classics in the History of Philosophy
24.08 The Human Mind
24.09J Classics in Political Philosophy [17.113J]

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
17.305J Rationality, Risk, and Choice in Industrial Society [STS 401J]
17.401 Just Wars, Total Wars, and Nuclear Wars
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
17.585 Religion, Politics, and Social Change

Religious Studies

Wellesley Religion 107: Crises of Belief in Modern Religion
Wellesley Religion 109: Introduction to Asian Religions
Wellesley Religion 252: Islamic Tradition

Sociology

Wellesley Sociology 102: The Sociological Perspective

Science, Technology, and Society

STS 100 Science, Technology, and Social Change
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 321 Military Enterprise and Technological Change: Historical Perspectives on the American Experience
STS 501 The Automobile: Mass Production and Mass Consumption
STS 502 The Profession of Engineering
STS 511 Capitalism and Its Critics
STS 555 Education in Society
STS 600 Technological Society and Its Critics
STS 602 Perspectives on Technology

Urban Studies

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

[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.

Visual Arts and Design

4.802	Visual Form and Expression
4.901	Creative Seeing

Traditions and Texts

21.708	The Bible
21.709	The Greeks
21.710	The East Asian Tradition: Past and Present
21.711	The Islamic Tradition: Past and Present
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
21.718	The Americans

Writing

21.735	Writing and Reading the Essay
21.755	Writing and Reading Short Stories
21.760	Writing and Reading Poems
21.777	The Scientific Essay

Interdisciplinary Subject

21.930J	Ancient Cosmology [STS 223J]

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 count toward the Requirement; however, a petition must be submitted. **Graduate Subjects** (designated "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]Sensation and Perception
9.36	Natural Computation and Control

Economics

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

Political Science

17.203	Evaluation Research Laboratory

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 fulfill 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 4.684
B)	4.801 through 4.871
C)	4.901 through 4.991

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]
11.012	Institutions and Communities
11.013J	American Urban History I [21.412J]
11.014J	American Urban History II [21.413J]
11.016	Introduction to Technology and Environmental Analysis
11.122	Environmental Policy and Regulation
11.131	The Urban Neighborhood
11.139	Introduction to Community Development
11.143	Urban and Regional Planning in Developing Countries
11.144	Urban and Regional Economic Issues in Developing Countries
11.166	Legal Institutions and Social Change
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]
1.16J	Ethics and Technocrats [STS 412J]
8.206J	Public Controversies on the Control of Technology [STS 413J]
22.003J	In Pursuit of Arms Control: Analysis of the Past and Choices for the Future [17.465J]
HST901J	Health Economics [14.21J]

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

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 3.091, 5.40, 5.41, 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	Introduction to Computers and Engineering Problem Solving (3-1-8)
1.04	Behavior of Physical Systems I (3-2-7)
1.12	Computer Models of 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 Engineering Systems (3-0-9)
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 Engineering Systems (3-0-9)
3.061J	Introduction to Polymer Science and Engineering (3-0-9)
3.07	Introduction to Ceramics (3-0-9)
3.091	[1]Introduction to Solid-State Chemistry (5-0-7)
3.093	Magnetic Materials (3-0-9)
3.10	Chemical Physics of Materials (3-0-6)
3.11	Mechanics of Materials I (4-0-8)
3.143J	Materials of Construction (3-0-9)
4.30	Basic Structural Theory (3-3-6)
4.43	Environmental Control — Acoustics (4-0-4)
5.40	[1]General Chemistry (5-0-7)
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)
6.034	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)
8.211	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	Physics of the Solar System (3-0-9)
8.293J	Dynamical Astronomy (3-0-9)
10.10	Process Synthesis (3-0-6)
10.11	Computer Models of Engineering Systems (3-0-9)
10.13	Mass and Energy Processing (4-0-8)
10.17	Air Pollution Fundamentals (2-0-4)
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)
12.109	History of Astronomy and Astrophysics: 1609-1982 (3-0-9)
12.110	Applied Astronomy and Celestial Navigation (3-2-7)
12.113	Astronomy: Stars and Galaxies (3-2-7)
12.114	Astronomy: Solar System (3-2-7)
12.115J	Dynamical Astronomy (3-0-9)
12.131J	Physics of the Solar System (3-0-9)
12.21	Physics of the Ocean (3-0-9)
13.001	Introduction to Fluid Mechanics for Ocean Engineers (4-0-8)
13.51	Computer Models of 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)

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

Laboratory Requirement

16.001 Unified Engineering I (5-2-5)
16.008 Computer Models of 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 (4-0-8)
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)
19.83 Modeling Oceanic Systems (3-0-9)
20.021 Nutrition and Metabolism (4-0-8)
20.113J Biostatistics I (3-0-9)
22.006 Computer Models of 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)

The Laboratory Requirement of 12 units may be met by enrolling in one or two laboratory subjects expressly designed for this purpose. The 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 Aquatic Chemistry and Biology Laboratory (2-6-4)
2.671 [1]Measurement and Instrumentation (2-3-4)
2.672 Project Laboratory (1-3-2)
2.86 [1]Manufacturing Processes (3-3-3)
3.081 Materials Laboratory I (1-6-5)
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)
6.141 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)
7.031 Experimental Microbial Genetics (2-16-6)
7.041 Experimental Cell Biology (2-16-6)
7.051 Experimental Biochemistry (2-16-6)
7.15 Experimental Molecular Biology: Biotechnology I (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)

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

12.066	Analysis of Geological Materials (2-6-4)
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)

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, ballet I, II, and II-III, jazz, movement for body conditioning, partner dance, tap dance, development, touch football, ultimate frisbee, golf, lacrosse, pistol, precision air rifle, rock climbing, rugby, sailing, scuba, sculling, self-designed fitness, swimming (beginning), T'ai Chi. tennis (beginning and intermediate), table tennis, and yoga.

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

IAP:
Badminton, baseball (hitting), ballet I, choreographed forms, partner dance, fencing, applied fitness, hockey, box lacrosse, pistol, precision air rifle, self-designed fitness, skating (beginning), figure skating, squash, advanced swimming techniques, T'ai Chi, tennis (intermediate and advanced).

Third Quarter:
Basketball, ballet I, II, and III, jazz, movement for body conditioning, partner dance, tap dance, development, fencing, figure skating, first aid (part 1), health/fitness education, hockey, judo, karate, pistol, small bore rifle, scuba, self-designed fitness, skating (beginning), skin diving, squash, swimming (beginning, advanced beginning, and advanced techniques), table tennis, volleyball, and Red Cross W.S.I. (part 1).

Fourth Quarter:
Archery, ballet I, II, and III, jazz, partner dance, movement for body conditioning, development, first aid (part 2), ultimate frisbee, golf (beginning), pistol, precision air rifle, rock climbing, sailing, scuba, sculling, self-designed fitness, softball, squash, swimming (beginning), tennis (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.

Independent Activities Period

Independent Activities Period (IAP) is a three and one-half week period in January in which faculty members and students are freed from the rigors of regularly scheduled classes to provide time for flexible teaching and learning and for independent study and research. Students are encouraged to explore the educational resources of the Institute not only by individually arranging projects with faculty members but also by organizing and participating in special IAP activities. Or they may pursue interests independently either on or off campus.

Although IAP is kept as unstructured as possible, it is part of the academic program of the Institute — the "1" in MIT's "4-1-4" academic calendar. Grades are deemphasized during IAP. However, students may earn academic credit for work directed by a faculty member.

Activities

Unlike subjects for the regular semesters, which are planned by departments about one year ahead, IAP activities are organized mostly by individual volunteers only one or two months in advance. More than 600 activities are offered each year on a wide range of subjects, both academic and nonacademic. They may be organized or attended by anyone at the Institute: faculty, student, or employee.

A planning sheet, called the IAP Announcement, offers tips on organizing an activity, and provides a special application form for publicizing the activity in the *IAP Guide*. Funds are available from the Institute as well as from individual departments and organizations to help defray expenses. New and student-led activities receive priority from the Institute's IAP Activities Fund.

Tuition, Room, and Board

Full-time students in either the first or second semester do not have to pay additional tuition or room fees to the Institute during IAP. Students can purchase additional points on their fall term food plan to cover IAP or they can purchase a new plan for IAP and the spring term at the beginning of January.

Academic Credit and Grades

Most activities do not offer credit. However, it is possible for a student to earn academic credit by doing work under the direction of a faculty member for a subject listed in the Bulletin. The total cumulative credits a student may earn for all subjects is limited to six credit hours, except by special authorization. A department head may approve the awarding of up to 12 units in a single subject, but in all other cases, undergraduates must petition for approval from the Committee on Curricula, and graduate students from the Committee on Graduate School Policy. Credits received by freshmen during IAP are not counted toward their credit limits for the spring or fall term.

A student wishing to receive credit must work out the details individually with a faculty supervisor who will choose an appropriate subject listed in the Bulletin and determine how much credit is to be offered. In keeping with the generally unstructured nature of IAP, there is no formal registration process.

During IAP all work done for credit under a special problem subject number is graded pass/fail. However, if a regular subject is offered in intensive form, letter grades may be given.

Students are asked to remind their faculty supervisors that their IAP grades must be turned in by the last day of IAP. Grade reports will be sent to the students and to their departments at the beginning of the spring semester. Students not receiving grade reports when expected should check promptly with their supervisors or the Registrar's Office to be sure the grades are submitted and recorded. Late credit and grades must be submitted on special reporting forms by the end of the following spring term. IAP grades will not be accepted after the end of the academic year.

Veterans' Benefits

Full-time students receiving Veterans' benefits have been certified for the entire academic year. Because the period between the first day of winter vacation and the beginning of the second term is more than a calendar month, VA regulations require that IAP be treated as a separate term, much the same as Summer Session. To ensure uninterrupted benefits for IAP, students must notify the Student Financial Aid Office, Room 5-119, (617) 253-4971, by December 1, of their intent to attend IAP full time. Students must receive credit, i.e., a letter or pass/fail grade, to be entitled to VA benefits. Anyone who receives VA benefits for IAP but fails to earn sufficient credit will have to return the money. Veterans should make sure their instructors turn in their grade sheets to the Registrar's Office immediately after the end of IAP.

Special Students

Applications for special-student status solely for IAP will not be accepted. Special students admitted to the first or second term do not automatically have IAP privileges. Those admitted by the Director of Admissions must consult the Admissions Office concerning their status during IAP. Former students readmitted as special students by the Committee on Academic Performance (CAP) or the Office of the Dean for Student Affairs (ODSA) must consult the appropriate office for permission to participate in IAP. If the special student has paid full tuition during the first term or is admitted to do so in the second, there will not be an additional tuition charge for IAP. If the student has not been paying full tuition, he or she will be charged either the minimum special student fee or the amount necessary to bring tuition for the term up to full tuition.

Special students wanting credit for IAP work should consult Ronald P. Smith, Room E19-341, (617) 253-4781, if they were admitted by CAP or ODSA, or the Admissions Office if they were admitted by the Director of Admissions.

Student Exchanges

A one-for-one exchange between an MIT student and someone from another school is permitted during IAP provided the students themselves assume responsibility for all arrangements, travel expenses, and any additional tuition and living expenses. If the other school waives tuition for the MIT student, MIT will reciprocate. The MIT Admissions Office may also waive the application fee if the other school does so.

MIT students wishing to set up an exchange should contact the IAP Office, Room 7-108, (617) 253-1668. Students from outside MIT should ask the appropriate office on their own campus to contact the IAP Office. Because MIT will not admit special students solely for IAP, students from other schools can attend IAP only as part of a one-for-one exchange.

The Institute's regular cross-registration with Wellesley College remains in effect during IAP. MIT students are encouraged to take advantage of their flexible schedules during IAP to participate in Wellesley's winter term. In return, Wellesley students are invited to join IAP activities.

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.

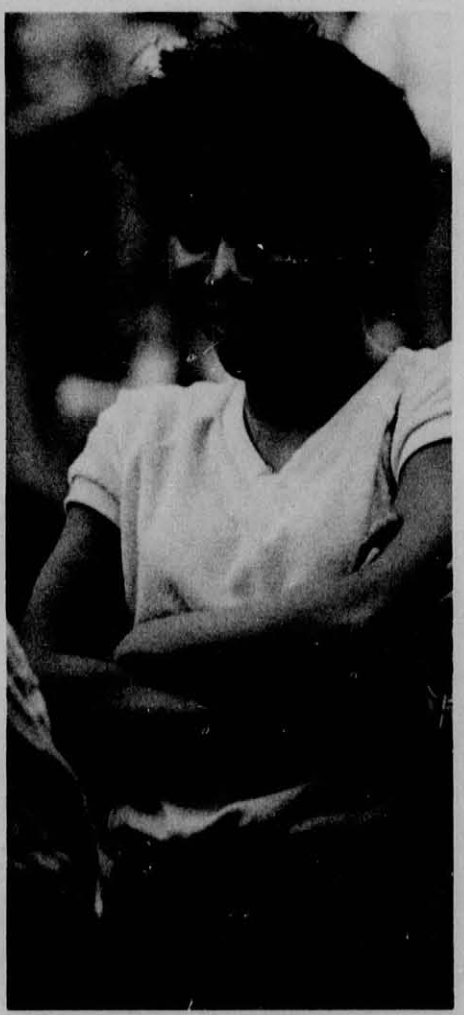
MIT commends the study of history and of foreign language in depth. The choice of languages should be guided by the educational opportunities open to each student, by special interests or cultural ties, and by the nature of his or her probable future work.

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.

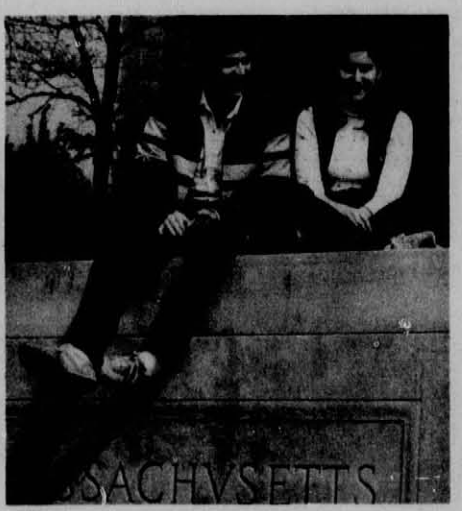
Prospective applicants and their families are welcome at the Admissions Office Monday through Friday between 9 am and 4 pm. Student-guided tours of the campus leave the Information Center each weekday (except holidays) at 10 am and 2 pm. Students and parents are welcome at the Admissions Office after the tour for a group session with a member of the staff.

Project Interphase

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) G.C.E. A-levels and the 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.

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 International 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 1984 must have completed the SATs and the three achievement tests by the January 1984 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.





International Undergraduate Admissions

The MIT undergraduate student body includes many 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 Preliminary Application form which should be returned promptly. Final Application materials will be forwarded to those whose Preliminary 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 — TOEFL) 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.

Preliminary Application forms or initial letters of inquiry about admission received after November 15 will be too late for the fall term.

Personal Conferences

Applicants will receive instructions about arranging 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 International Applicants

The College Board tests listed in the Entrance Examination section of this chapter are the required entrance examinations. If English is not the applicant's native language, 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.



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.

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.

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

Application Procedures

College students considering transfer to the Institute should file a Preliminary Application for Admission with Advanced Standing three months before the final application deadline. These forms can be obtained 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. Final applications should be submitted by April 1 for entry in September and by November 15 for entry in February.

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.

Costs for Undergraduates

Special Student Admissions

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.

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 other applications. 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, January 1 for spring term, and May 1 for summer term.

Undergraduate student costs for the academic year 1983-84 at MIT will be about $14,800. 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 $1,320. There are many kinds of dining and housing arrangements at MIT and the range of student expenses for room and board is broad. The Student Financial Aid Office uses a standard allowance of $3,880 for room and board. Thus, total costs for most undergraduates during the 1983-84 academic year will be in the range of $13,350 to $15,250 (excluding cost of travel), depending upon specific choices.

The following are the basic **tuition and fees** at MIT for the academic year 1983-84 (which are reviewed and likely to increase each year):

Tuition	$9,600
Hospital and Accident Insurance Policy[2]	216

The tuition for all regular undergraduates in the first and second terms is $4,800 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

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 $582. Hospitalization insurance for one or more children may be purchased for $192. 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.

$155 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 $930 for subjects and a minimum of $400 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 $155 per unit taken either for credit or not for credit. This unit fee applies up to a maximum of $4,800 per term and is subject to the following minimum fees:

Members of the MIT Community[3]	$930
Other Special Students	1,395

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), $9,600

Chemical Engineering Practice,
Course X-A
September-January or February-June, $4,800

Electrical Science and Engineering or
Computer Science and Engineering,
Course VI-A
Engineering Internship Program
July 1 to June 30, $9,600

Materials Science and Engineering,
Course III-B
September-August, $9,600

In each case, the first $4,800 is due on the date when the first-term tuition is normally due, and the additional $4,800 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 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.

If the student receives financial aid through one of the Title IV Federally based student financial aid programs, and aid is reduced as a consequence of the reduced tuition, the total amount of Title IV aid (minus work earnings) is divided by the total amount of aid awarded (minus earnings), to determine the amount to be credited toward the student's charges and the amount to be returned to the Title IV programs.

Miscellaneous Fees

Application fee for undergraduate admission	$30
Late registration fee	10
Fee for late filing of 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

Financial registration forms and instructions, and bills for tuition and other charges will be sent to admitted and continuing undergraduate students prior to the beginning of each term. Students must, by the due date specified in these instructions, either make their payment in full or elect the MIT Bursary Payment Plan which allows for monthly payments plus applicable finance charges.

If the Bursary Payment Plan is elected, it must be signed by the payment due date to avoid the late payment fee. A student not on the Bursary Payment Plan will be assessed the late payment fee each time a due date is missed.

All outstanding bills must be paid, or satisfactory arrangements made with the Bursar for their payment before a student will be allowed to register at the beginning of a term; or, if a candidate for a degree, be allowed entry of his or her name on the degree list.

Registered student status can be withdrawn at any time for delinquency in payment of bills.

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 seven 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 $90,000. 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.

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

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 Student Loan Program for students and the Parent Loans for Undergraduate Students Program are administered by individual states. Local banks and lending institutions should be able to answer initial inquiries concerning the availability of loans under these programs.

Parents of students considering MIT might also explore the Institute's 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.

MIT is fortunate in having received gifts from many benefactors, alumni, and friends to help support the educational needs of MIT students. There are currently more than 400 such scholarships, from which student aid is annually drawn. Additionally, there are about 40 loan funds which have been established for special purposes. 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 a 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, the Guaranteed Student Loan 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. This form must be submitted prior to January 1. In addition, the Financial Aid Form (FAF) appropriate to the applicant's state of residence must be submitted to the College Scholarship Service between January 1 and January 31. 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.



Prizes and Awards

Transfer Students

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

Upperclass Students

MIT awards are made on an annual basis, and recipients are required to reapply in early spring 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.**

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)
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
Albert G. Hill Prize
The James R. Killian, Jr., Community Service Award
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
The Irwin Sizer Award
William L. Stewart, Jr., Awards (1964)
Stratton Prizes (1930)
Louis Sudler Prize in the Arts
The Harry S. Truman Scholarship
The Kenneth R. Wadleigh Award
The Laya and Jerome B. Wiesner Awards (1979)
The Laya W. Wiesner Award

Aeronautics and Astronautics
Luis de Florez Awards (1960)
James Means Memorial Prize (1925)
Henry Webb Salisbury Memorial Award (1941)

Athletics
In addition to varsity letters, captain, manager, and most valuable player awards in 32 intercollegiate and two varsity club sports, the following awards are given to students for outstanding contributions to intercollegiate and intramural athletics.
Burton R. Anderson, Jr., Awards
The Class of 1948 Award
The Admiral Edward L. Cochrane Award
Gold Awards
The Malcolm G. Kispert Award
Harold J. Pettegrove Award
The Pewter Bowl Award
The Betsy Schumacker Award
The Straight T Awards
Varsity Club Award

Biology
John L. Asinari Awards

Chemical Engineering
AIChE Annual Chapter Scholarship Award
American Institute of Chemists Award
Chemical Engineering Special Service Award
Chevron Scholarship
Robert T. Haslam Cup (1959)
Hunneman Prize (1927)

Civil Engineering
A.S.C.E. Student Chapter Scholarship
Richard Lee Russel Prize (1967)
Steinberg Prize (1977)
Tucker-Voss Award (1953)

Earth, Atmospheric, and Planetary Sciences
Christopher Goetze Memorial Prize

Electrical Engineering and Computer Science
Computer Systems Prize
Ernst A. Guillemin Prize
William A. Martin Memorial Prize

Humanities
Robert A. Boit Prize (Writing)
William L. Hsu Prize (Music)
I. Austin Kelly III Prize (Humanities)
Ellen King Prize (Writing)
Ragnar D. Naess Scholarships in Performance (Music)

Management
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
AMP, Inc. Award
Luis de Florez Awards (1957)
Robert L. Hallock Award
Silent Hoist and Crane Company Materials Handling Award (1950)

Ocean Engineering
Society of Naval Architects and Marine Engineers Award
Robert Bruce Wallace Academic Prize (1980)

Sea Grant College Program
Dean A. Horn Award (1982)

Undergraduate Research Opportunities Program
Clapp and Poliak Engineering Design Awards
Class of 1970 Research Awards
Class of 1982 Research Awards
Eloranta Summer Fellowship Program
James McCormack Memorial Fund
New England Life Awards for Undergraduate Research
Joel Matthew Orloff Physics Undergraduate Research Program Prize
Sea Grant Research Awards
Sigma Xi Research Awards
Uniroyal Research Awards





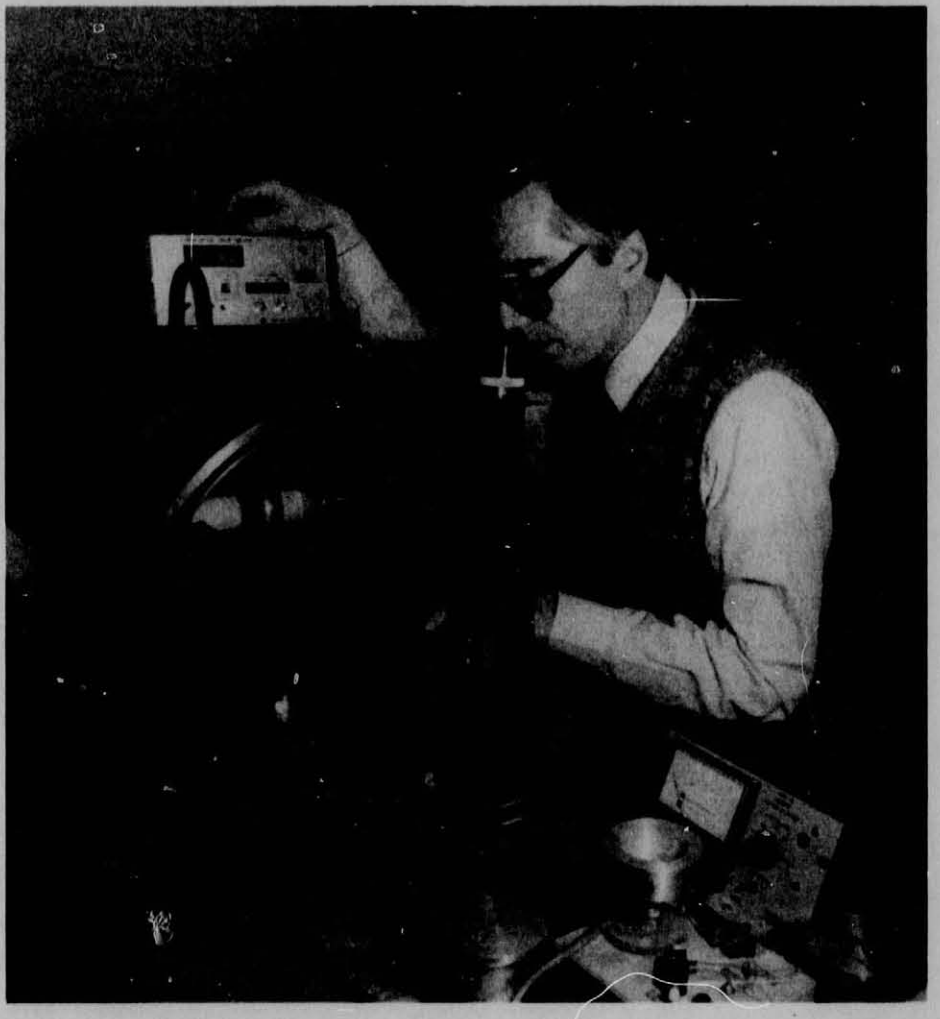




IV Graduate Education at MIT







Graduate Education at MIT

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 MIT has always welcomed women graduate students, it is within the last 15 years that an increasing number of women have been attracted to MIT's graduate programs, particularly those in nontraditional fields of study. 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.

Teaching assistantships for graduate students are considered an integral part of graduate education. These appointments as well as research assistantships offer the student professional experience.

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.

Resources for Graduate Study

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 select from and 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 of these 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, Wellesley College, and joint degree programs with 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 undergraduate and graduate students participate in intercollegiate competitions, as well as the intramural athletic program.

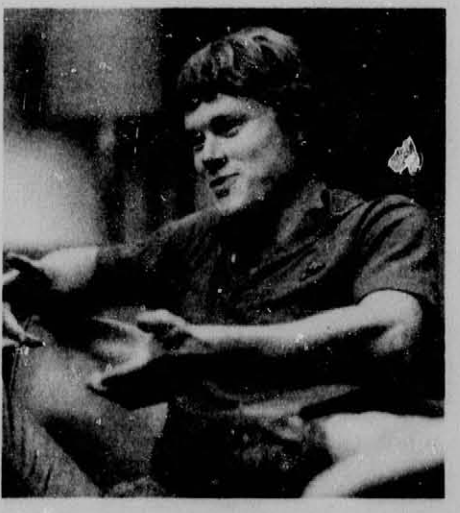
The cultural and social life and recreational facilities of the MIT campus are shared alike by undergraduate and graduate students. Concerts and dramatic performances are frequently given by Institute groups and professional performers. Leaders in many professional areas give lectures and seminars on the campus, which are open to all members of the Institute community. MIT students also take advantage of the many cultural and intellectual opportunities in the Boston area, including free admission to the Boston Museum of Fine Arts.

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 and Institute graduate procedures.

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 department 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 here. Graduate programs are described more specifically in individual department statements in Chapter VI.

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.

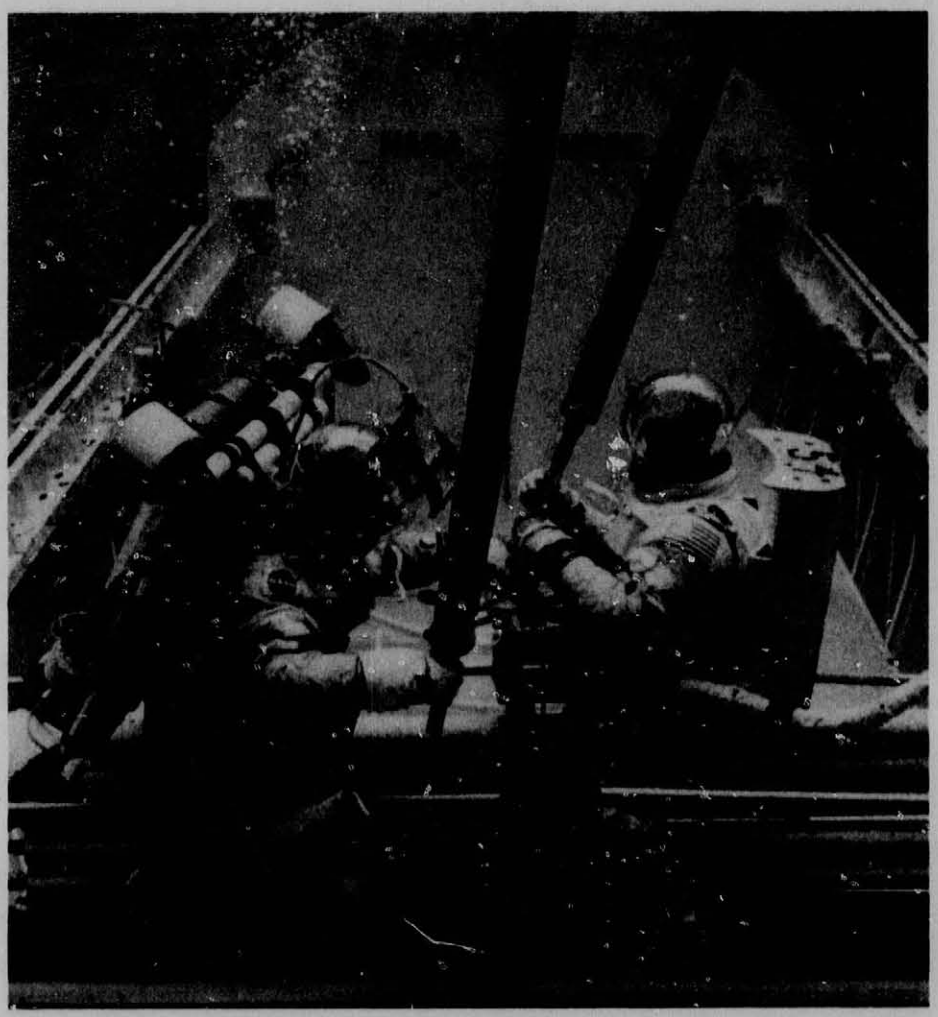
School of Architecture and Planning

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*
Computational fluid dynamics
Computer systems
Dynamic energy conversion
Estimation and control
Flight transportation
Fluid mechanics
Gas dynamics
Gas turbines



*Approved Interdepartmental Program

Gas turbine structures
Navigation and control systems
Instrumentation*
Management of technology* (S.M.)
Materials engineering*
Physics of fluids
Plasma physics
Space propulsion
Structural dynamics
Structures technology
Technology and policy* (S.M.)
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* (S.M.)
Materials
Materials engineering*
Polymers and plastics
Technology and policy* (S.M.)

Chemical Engineering Practice, Course X-A

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



Civil Engineering, Course I
Aquatic science
Civil engineering
Civil engineering systems
Coastal engineering
Construction engineering and management
Earthquake engineering
Environmental engineering*
Geotechnical engineering
Geotechnology
Hydrodynamics
Hydrology
Management of technology* (S.M.)
Materials engineering*
Operations research*
Structural engineering
Technology and policy* (S.M.)
Transportation* (S.M.)
Transportation economics
Transportation 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
Management of technology* (S.M.)
Operations research*
Quantum electronics
Solid state electronics
System engineering
Systems science
Technology and policy* (S.M.)

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

*Approved Interdepartmental Program

Materials Science and Engineering, Course III
Ceramics
Electronic materials
Management of technology* (S.M.)
Materials engineering
Materials science
Metallurgy
Polymers
Technology and policy* (S.M.)

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
Ecosystems
Energy conversion and conservation
Environmental engineering*
Fibers and polymers
Fluid mechanics
Heat transfer
Internal and external combustion engines
Management of technology* (S.M.)
Man-machine systems
Manufacturing
Materials and materials processing
Mechanical engineering
Mining and resource engineering
Polymers and polymer processing
Stress analysis
Technology and policy* (S.M.)
Thermodynamics
Transportation* (S.M.)
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
Environmental engineering*
Fluid mechanics
Hydrodynamics
Management of technology* (S.M.)
Marine data systems engineering
Naval engineering
Ocean engineering
Operations research*
Structural mechanics
Technology and policy* (S.M.)

Naval Architecture and Marine Engineering, Course XIII

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

Ocean Systems Management, Course XIII-B
Coastal zone utilization
Marine resource development
Marine transportation
Ocean engineering and law
Ocean systems management

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

Nuclear Engineering, Course XXII
Applied plasma physics
Applied radiation physics
Energy technology
Fusion reactor engineering
Management of technology* (S.M.)
Nuclear fuel management
Nuclear materials engineering
Nuclear reactor engineering
Nuclear reactor physics
Radiological sciences
Technology and policy* (S.M.)

School of Humanities and Social Science

Economics, Course XIV

Linguistics and Philosophy, Course XXIV
Linguistics
Philosophy
Linguistics and philosophy

Political Science, Course XVII
Political science and public policy (S.M.)

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

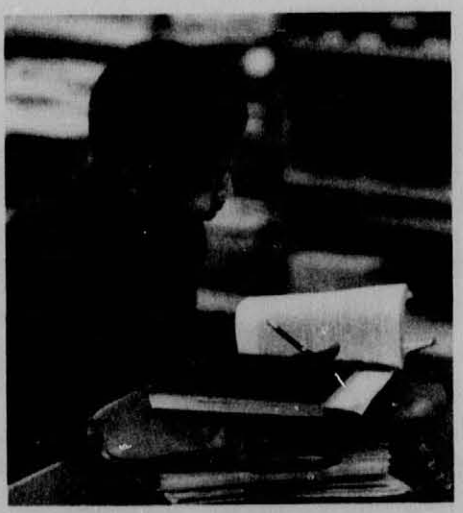
Sloan School of Management

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
Oceanography



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

Earth, Atmospheric, and Planetary Sciences, Course XII and Course XIX**
Geochemistry
Geology (classical geology, theoretical geology)
Geophysics
Meteorology
Oceanography
Physical oceanography (Ph.D.)
Planetary sciences

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

Mathematics, Course XVIII

Nutrition and Food Science, Course XX
Biochemical engineering
Biotechnology
Food science and technology
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

Whitaker College of Health Sciences, Technology, and Management

Health policy and management

*Approved Interdepartmental Program

**Numerical designation has not yet been resolved.

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 including additional subject units above the specified minimum 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 (registered as a full-time regular graduate student) 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 submit an application for Graduate School 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, urban studies and planning, and Whitaker College. 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.

Graduate study and research leading to a doctoral degree must be pursued under the direction of the Committee on Graduate School Policy for at least four academic terms. In some cases, the required period of residence may be reduced but in no instance may it be reduced to less than two regular academic terms and one summer session.

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.

Interdepartmental Degree Programs

Many recent developments in the physical and social sciences and engineering reflect interdisciplinary trends. Thus a number of graduate students wish to study 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, transportation, and health policy and management, special continuing committees provide guidance. In other fields, interdepartmental 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.

Cross Registration at Other Institutions

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 or writing. 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.

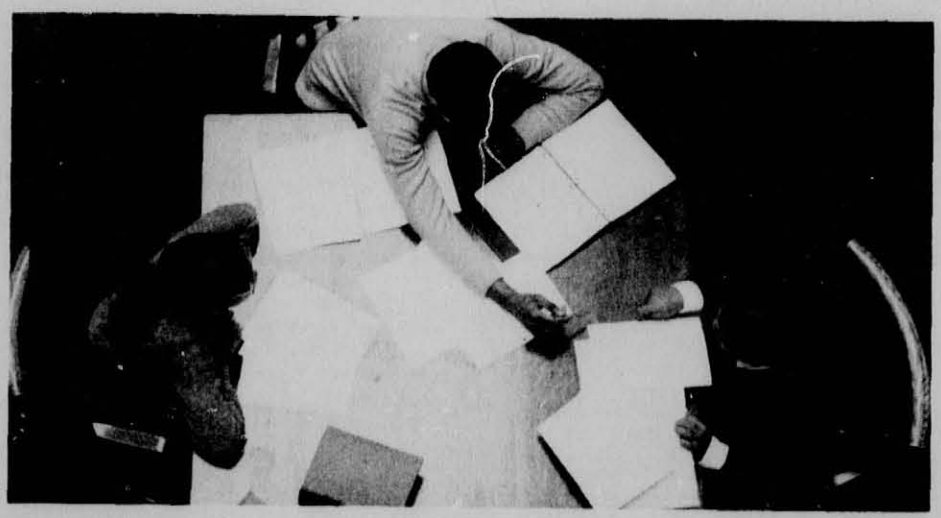
Harvard University

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-MIT Exchange

Graduate students are eligible to participate in the Wellesley-MIT Exchange Program. Wellesley courses are not considered (A) subjects, but they may be accepted for credit toward your degree with the approval of your department. For details about the Exchange, see the description of the Program in Chapter III of this catalogue.



Woods Hole Oceanographic Institution

MIT, in conjunction with the Woods Hole Oceanographic Institution, offers graduate degree programs in oceanography and oceanographic engineering. All decisions, from admission to the conferring of the joint degree, are made by consensus of MIT/WHOI joint discipline committees. The programs in oceanography involve the Departments of Biology and Earth, Atmospheric, and Planetary Sciences at MIT. The oceanographic engineering programs involve the MIT Departments of Civil, Chemical, Electrical, Materials Science, Mechanical, and Ocean Engineering. Information regarding the program may be obtained from the MIT Joint Program Office or the Education Office at WHOI.

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.

Graduate 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 *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 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) financial registration material issued by the Bursar has been completed and returned, 3) all Institute charges have been paid when due, or satisfactory alternative arrangements have been made with the Bursar, 4) the faculty counselor or registration officer has approved the student's registration form, 5) an ID validation sticker has been picked up according to instructions, and 6) the Graduate Need Determination Form, along with parental information when required, or the Graduate and Professional Schools Financial Assistance Services (GAPSFAS) form has been submitted 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 or as 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 in December 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 withdrawn and will be charged a pro-rated 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 units for each subject are indicated in the subject descriptions listed in Chapter VII of this catalogue. 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 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 Bursar's 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.

Independent Activities Period

During the January Independent Activities Period (IAP), graduate students may pursue their own interests, including research and preparation for qualifying exams. They also may lead or participate in activities specially organized for this three and one-half week program.

Graduate students should read the section on IAP in Chapter III of this catalogue for details concerning credit, VA benefits, and special student status.

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 applicant. While high academic achievement does not guarantee admission, such achievement, or other persuasive evidence of professional promise, is expected.

Some engineering departments 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 14; 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, and submit 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 all application forms. 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. A fee is not required of a currently registered student who applies to another department. 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 should be addressed to the chairman of the appropriate departmental committee on graduate students.

Graduate Record Examinations (GRE)

Many departments require applicants to submit scores in the Aptitude Test and the appropriate Advanced Test of the Graduate Record Examination. 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 graduate 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 Admissions 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 appropriate 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. A fee is not required for renewal applications within a two-year period. 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 nor for eligibility for nonresident status.

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.

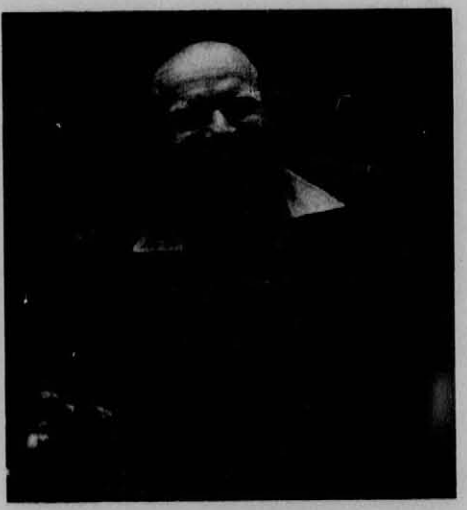
Graduate Student Status for Research Staff Members

In view of their full-time responsibilities on assigned research and their corresponding salary scales, staff members of the Office of Sponsored Programs, Lincoln Laboratory, 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 nor can research work performed while thus employed be included as part of the thesis for an advanced degree.

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 1983-84 (which are reviewed and likely to increase each year):

Tuition[1]	$9,600
Hospital and Accident Insurance Policy[2]	216

The tuition for all regular graduate students, including graduate student staff, in the first and second terms is $4,800 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 $7,200, if not registered during preceding regular term. The tuition for all regular graduate students including fellows, trainees, and academic staff in the 1983 summer session was $3,200. 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 $155 per unit taken either for credit or not for credit. This unit fee applies up to a maximum of $4,800 per term and is subject to the following minimum fees:

Members of the MIT Community[3]	$930
Other Special Students	1,395

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 $400 per week from the starting date of the term, with a minimum of $400 for the Master's or Engineer's degree and $800 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 $2,400. 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 ($720 per term for 1983-84). 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 $2,400. 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), $9,600

Chemical Engineering Practice,
Course X-A
September-January or February-June,
$4,800

Electrical Science and Engineering or
Computer Science and Engineering,
Course VI-A
Engineering Internship Program
July 1 to June 30, $9,600

Materials Science and Engineering
Course III-B
September-August, $9,600

In each case, the first $4,800 is due on the date when the first-term tuition is normally due, and the additional $4,800 is due on the date when the second-term tuition is normally due.

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 $582. Hospitalization insurance for one or more children may be purchased for $192. 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.

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 $275 per unit of registration, with a minimum charge of $2,475. There is a maximum charge of $7,800 per term for full-time special graduate students enrolled in the program. Students interested in the Management of Technology Program 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 costs (housing, food, and personal expenses) for a single graduate student generally average about $825; for a married graduate student, $1,115; and for a married graduate student with one child, $1,475. These cost estimates do **not** include tuition, books, or the Hospital and Accident Insurance Policy. 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	30
All other theses for advanced degrees	20

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

Financial registration forms and instructions and bills for tuition and other charges will be sent to admitted and continuing graduate students prior to the beginning of each term. Students must, by the due date specified in these instructions, either make their payment in full or elect the MIT Bursary Payment Plan which allows for monthly payments plus applicable finance charges. For Research and Teaching Assistants, the Plan allows for monthly payroll deductions to pay tuition without associated finance charges if the amount due is over $150.

If the Bursary Payment Plan is elected, it must be signed by the payment due date to avoid the late payment fee. A student not on the Bursary Payment Plan will be assessed the $50 late payment fee each time a due date is missed.

All outstanding bills must be paid or satisfactory arrangements made with the Bursar for their payment before a student will be allowed to register at the beginning of a term, or, if a candidate for a degree, be allowed entry of his or her name on the degree list.

Registered student status can be withdrawn at any time for delinquency in payment of bills.

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 $90,000. 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 from 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 private 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 usually eligible only for a supplementary award in accordance with MIT's guidelines. For further information on these guidelines, please see the *Graduate School Manual.*

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.

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.

Teaching and Research Assistantships

MIT employs about 425 graduate students each year as part-time or full-time instructors or teaching assistants to aid 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 Academic Council.

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 1,500 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.

Students who receive financial support from other sources (fellowships, scholarships, teaching assistantships, etc.) may receive supplementary stipends as Research Assistants in accordance with Institute and departmental guidelines.

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

Regular resident graduate students who have completed at least one graduate year at MIT or new students who have been MIT undergraduates may apply to the Dean for Student Affairs for positions as Graduate Residents. Such positions provide room and board but no stipend.

Scholarships and Fellowships for Graduate Students

National Fellowships for Graduate Study

American Association of University Women
Hertz Foundation
Mellon Fellowships in the Humanities
National Science Foundation
Office of Naval Research Fellowships

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). Individual applications are usually not necessary.

Edward Austin
Bell Laboratories Doctoral Scholarship Program
John F. Blackie Memorial
William Sumner Bolles
G. Y. Chu Fellowship
Helen Collamore
Victor J. Decorte Fund
Exxon Teaching Fellowships
Alfred W. French
Ida M. Green
Frank M. Greenlaw
Holland Hamilton Fellowship
Whitaker Health Sciences Fund
John A. Lyons
National Distillers and Chemical Corporation
Potter-Seltzer
Rockwell International
Henry Bromfield Rogers
Henry Saltonstall
James Savage
Susan H. Swett
Gerard Swope
Frank Hall Thorp
Tsang Fellowship Fund
Thomas Upham
An Wang Fellowship Fund
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
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
Arthur Rotch

Chemical Engineering

Amoco Foundation
Atlantic Richfield
Chevron (Standard Oil Company of California)
Exxon Teaching Fellowships
Edwin R. Gilliland
Halcon International, Inc.
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

Exxon Teaching Fellowships
W. H. Mills Construction Industry Fellowship

Earth, Atmospheric, and Planetary Sciences

Chevron (Standard Oil Company of California)
Exxon Teaching Fellowships

Economics

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

Electrical Engineering and Computer Science

Amoco Foundation
Analog Devices, Inc.
Cronin Fund
Digital Equipment Corporation
Exxon Teaching Fellowships
General Electric Foundation
Grass Instrument Company
GTE Foundation
IBM Corporation
RCA Corporation
Sanders Associates, Inc.
Schlumberger-Doll Research
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.
Council for Opportunity in Graduate Management Education Fellowships
Johnson & Johnson Leadership Awards

Materials Science and Engineering

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

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
The Edward L. Horton Fellowship Award
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)

Architecture

Alpha Rho Chi Medal (1932)
Student Certificate of the American Institute of Architects (1914)
Student Medal of the American Institute of Architects (1914)

Chemical Engineering

Chemical Engineering Special Service Award
Rosemary J. Wojtowicz Memorial Prize in Chemical Engineering Practice

Civil Engineering

Tucker-Voss Award (1983)
Richard Lee Russel Prize (1967)

Earth, Atmospheric, and Planetary Sciences

The Jule G. Charney and Victor P. Starr Awards (1981)
Christopher Goetze Memorial Prize
The Carl-Gustav Rossby Award in Meteorology

Electrical Engineering and Computer Science

Carlton E. Tucker Award for Excellence in Teaching
Harold L. Hazen Award for Excellence in Teaching
Frederick C. Hennie III Award for Excellence in Teaching

Management

Bendix Fellowship
E. Pennell Brooks Prize
Digital Equipment Corporation Scholarship
Henry B. duPont Scholarship
Editorships of the *Sloan Management Review*
Henry Ford II Scholarship
Thomas M. Hill Prize
Alexander Proudfoot Fellowships
Seley Scholarship

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)

Ocean Engineering

Society of Naval Architects and Marine Engineers Award

Mechanical Engineering

Allied Chemical Corporation Fellowship
Exxon Teaching Fellowships
General Electric Foundation
MTS Systems Corporation
Weyerhauser Company Foundation Fellowship

Nuclear Engineering

Sherman R. Knapp Fellowship in Nuclear Power Engineering
Theos J. Thompson Memorial Fellowship

Nutrition and Food Science

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

Ocean Engineering

American Society of Naval Engineers
Society of Naval Architects and Marine Engineers

Physics

Karl Taylor Compton Fellowships

Urban Studies and Planning

William Emerson Fund
Alan M. Voorhees
Frederick J. Adams
Charles Abrams
Avalon Foundation









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 various interdepartmental organizations and research facilities available at MIT.

These interdepartmental educational opportunities and research facilities are listed here and described in detail in this chapter. The specific opportunities available for **undergraduate** and **graduate** students in each of these areas are outlined within the description of the program or facility.

Some of the interdepartmental programs and research facilities provide opportunities for **undergraduates** to engage in research or study as part of a departmental major, and some provide a way to broaden a student's educational experience. Undergraduates enrolled in a variety of departments may find valuable possibilities for thesis work and participation in the Undergraduate Research Opportunities Program (UROP).

Most of the Institute's major interdepartmental organizations and research facilities listed in this chapter offer **graduate students** opportunities for interdepartmental research, including thesis topics (and often research assistantships). Some of the interdepartmental educational programs have been formally approved for graduate students by the Committee on Graduate School Policy. An interested student must be admitted by one of the regular academic departments in order to participate in an interdepartmental program (except in Operations Research). Each of these programs has a standing faculty committee which administers the program, but degrees in the field of study are granted by the student's department of registration. The descriptions of these programs indicate in the title the advanced degree(s) which are offered; e.g., **(S.M.), (Ph.D.).** Other study or research opportunities **may** be fields of study which lead to advanced degrees, either as part of departmental degree programs or as interdepartmental programs administered on a more ad hoc basis.

The opportunities for interdepartmental study and research at MIT include:

Acoustics
Archaeology and Ancient Technology (see Center for Materials Research in Archaeology and Ethnology)
Artificial Intelligence Laboratory
Arts and Media Technology
Astronomy and Astrophysics
Bates Linear Accelerator (see Laboratory for Nuclear Science)
Biomedical Engineering
Bitter National Magnet Laboratory
Cell Culture Center
Center for Advanced Engineering Study
Center for Advaned 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
Cognitive Science Programs (see Center for Cognitive Science)
Communications Policy Program
Concourse Program for First-Year Students
Draper Laboratory
Economics and Urban Studies
Electric Power Systems Engineering Laboratory
Energy Laboratory
Energy Study and Research
Environmental Studies
ESG (Experimental Study Group)
Health Sciences and Technology
Humanistic Studies Combined with Engineering or Science (S.B. Degree Programs)
Innovation Center
Interdisciplinary Programs in Humanities
Interdisciplinary Research Opportunities for Undergraduates (see UROP)
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
Law-Related Studies
Lincoln Laboratory
Management of Technology Program
Materials Processing Center
Mineral Resources Engineering and Management
Mining and Mineral Resources Research Institute
Nuclear Reactor Laboratory
Oceanography and Oceanographic Engineering
Operations Research Center
Operations Research
Plasma Fusion Center
Polymeric Materials
Power Engineering
Research Laboratory of Electronics
Science, Technology, and Society
Sea Grant College Program
Spectroscopy Laboratory
Statistics Center
Technology Adaptation Program
Technology and Policy
Transportation (see Center for Transportation Studies)
Undergraduate Research Opportunities Program (UROP)
Undergraduate Seminars
Unspecified S.B. Degree Programs for Interdisciplinary Study
Wallace Astrophysical Observatory (see Astronomy and Astrophysics)
Wallace Geophysical Observatory

Acoustics

Acoustical study and research are carried out within the Departments of Mechanical Engineering, Ocean Engineering, Electrical Engineering and Computer Science, Aeronautics and Astronautics, and Architecture.

Acoustical work generally supports the principal activities within the departments, such as in communications, machine design, propulsion and guidance, and structural design. Subjects in acoustics have few prerequisites and can be readily taken by students from any department. **Undergraduates** should be able to take several acoustics courses from the offerings of various departments. At the **graduate level,** it is possible to set up more specialized interdepartmental programs of study and research in acoustics. The unspecified master's degree in engineering allows one to specialize in acoustics. 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 consists of basic subjects at both undergraduate and graduate levels. These subjects are taught within the Departments of Electrical Engineering and Computer Science, Mechanical Engineering, and Architecture. A second group of subjects supports 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 is in "professional practice," and includes noise control, architectural acoustics, and sonar applications. A complete listing of the various acoustics subjects is contained in the brochure *Acoustics at MIT.*

Students wishing further information should contact Professor Richard H. Lyon, Department of Mechanical Engineering, Room 3-366, MIT, Cambridge, Massachusetts 02139, (617) 253-2214.

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 robotics, English-language understanding, learning and automatic debugging, commonsense reasoning, engineering problem solving, manufacturing productivity, computer architecture, and human development.

Graduate students typically are enrolled in the Departments of Electrical Engineering and Computer Science, Mechanical Engineering, Psychology, Mathematics, or Linguistics. **Undergraduates** get involved through UROP projects.

Robotics. This area includes studies in vision, tactile sensing, manipulation, and the intelligent connection of perception with action. Central problems are the formulation of representations and the exploitation of natural constraints.

Design and Analysis Systems. 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. 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 programming languages and computer architectures are a major research theme. Current work focuses on a connection memory machine with a million processors and on scalable, message-oriented models of computation.

Further information is available from Professor Patrick H. Winston, Director, Artificial Intelligence Laboratory, Room NE 43-816, MIT, Cambridge, Massachusetts 02139, (617) 253-6218.

Arts and Media Technology

A new Arts and Media Technology facility under construction at MIT will be completed in 1984. The facility will house exhibition galleries and performance spaces as well as research and educational activities in media arts and sciences. The academic program associated with the building will emerge from a redefined Master of Science in Visual Studies (S.M.Vis.S.) degree program that will include interdisciplinary alliances with related MIT activities. A description of the present S.M.Vis.S. program may be found under the School of Architecture and Planning in Chapter VI.

Astronomy and Astrophysics

Observatories and Facilities

Teaching and research in astronomy at MIT are truly interdepartmental, involving more than 25 faculty members of the Departments of Physics, Earth, Atmospheric, and Planetary Sciences, Mathematics, Electrical Engineering and Computer Science, and Chemistry. The subjects offered and the opportunities for **graduate** and **undergraduate** 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.

The **George R. Wallace, Jr., Astrophysical Observatory** is a versatile facility for research and teaching in optical astronomy, and directly supports the growing student and faculty interest at MIT in astronomy and related sciences. The Observatory, located in nearby Westford, Massachusetts, has two optical telescopes of

16- and 24-inch diameter with unique electronic instrumentation. The telescopes are used in formal instruction, for student research projects, and as testbeds for instrumentation to be used with larger instruments. Further information on the Wallace Observatory may be obtained by contacting Professor James L. Elliot, Department of Earth, Atmospheric, and Planetary Sciences, Room 54-422, MIT, Cambridge, Massachusetts 02139, (617) 253-7556 or 253-6308.

The **Haystack Radio Observatory** provides opportunities for undergraduate and graduate student research, both for spectroscopy of the interstellar medium and for very-long-baseline interferometry. The Haystack Observatory is also located in Westford.

The **McGraw-Hill Observatory** at Kitt Peak in Arizona is operated jointly by MIT, the University of Michigan, and Dartmouth College. It has a 52-inch telescope with modern instrumentation, and a 95-inch telescope is currently being constructed at the site. Active experimental programs with student participation involve instruments launched in balloons, rockets, satellites, and interplanetary spacecraft. MIT is participating in X-ray observatory projects, and students participate actively in these programs.

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.

Astronomy and astrophysics subjects, which are offered at the **undergraduate** and **graduate** levels, are primarily given by the Departments of Physics and Earth, Atmospheric, and Planetary Sciences.Further information, including a complete list of astronomy and astrophysics subjects, may be obtained by contacting Professor Bernard Burke, Room 26-335, MIT, Cambridge, Massachusetts 02139, (617) 253-2572.

Biomedical Engineering

There are many **graduate** degree opportunities (Sc.D., Ph.D.) in biomedical engineering at MIT, and students and faculty in many departments are conducting research in this area. These research interests, spanning the life sciences, physics, and engineering, have led to the development of programs of graduate study for students wishing to pursue careers in these rapidly evolving fields. Each of these programs 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 currently 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; and 4) combined M.D.-Ph.D. programs in the Harvard-MIT Division of Health Sciences and Technology.

The choice among the first three of these programs 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.

1) 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. Further information on departmental programs in the School of Engineering may be obtained from the graduate registration officer of the appropriate department. Active biomedical research is pursued in the Departments of Aeronautics and Astronautics, Chemical Engineering, Electrical Engineering and Computer Science, Materials Science and Engineering, Mechanical Engineering, and Nuclear Engineering.

2) 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. The program is 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 aerospace medicine; 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. Graduate students from any department who possess or are completing 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, Room 37-219, MIT, Cambridge, Massachusetts 02139. 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.

3) A student who wishes intensive exposure to the medical sciences as preparation for a career of research on important clinical programs is advised to apply for the HST Doctoral Program in Medical Engineering and Medical Physics. Further information may be obtained from the Admissions Office of the Harvard-MIT Division of Health Sciences and Technology, Room E25-513B.

4) The biomedical sciences curriculum of the Harvard-MIT Division of Health Sciences and Technology leads to the M.D. 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. Further information may be obtained from Professor E. Cravalho, Room E25-335, MIT, Cambridge, Massachusetts 02139, (617) 253-1414.

Biomedical engineering is also of increasing interest to **undergraduate students** at MIT. 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. Undergraduates wishing to explore this developing area have ample opportunity within their 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.

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 30 tesla are available in a variety of configurations. High magnetic field and high resolution nuclear magnetic resonance spectrometers are used for studies of molecules of biological interest. Both the high field magnets and the nuclear magnetic resonance spectrometers are made available on a routine basis to research groups from other MIT departments and from institutions throughout the world. In addition, the Laboratory operates pulsed magnets giving fields up to 75 tesla and a magnetically shielded room of walk-in size.

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, studies of magnetic separation techniques, and development of magnetic acceleration systems for terrestrial and space applications.

Collaborative programs are carried out with the Departments of Physics, Electrical Engineering and Computer Science, Mechanical Engineering, Nuclear Engineering, Materials Science and Engineering, Chemistry, and with the Plasma Fusion Center. These collaborative programs include participation by **undergraduate** and **graduate students** working on theses. Undergraduate students in the UROP program and others are also employed.

Additional information may be obtained from the Director of the Laboratory, Professor Peter Wolff, Building NW14-3220, MIT, Cambridge, Massachusetts 02139, (617) 253-5478.

Cell Culture Center

The Cell Culture Center was 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. A limited number of **graduate** and **undergraduate students** can participate through the Departments of Biology or Nutrition and Food Science in studies carried out in the Center involving large-scale animal cell production. Recently a Cell Sorter Laboratory was added which provides instrumentation to analyze various light scatter properties and any compatible fluorescent label on a rapid, single-cell basis, providing statistical quantitation of each desired parameter on a given suspended cell population. The laboratory is equipped with Ortho Diagnostic Instrumentation and an on-line computer system for data acquisition, storage, and analysis.

Further inquiries may be addressed to the Office of the Director, Dr. 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 CAES is described in detail under the School of Engineering in Chapter VI.

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; interacton 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. Undergraduates** may participate in the Center through UROP. A catalogue listing the Center's educational offerings, in association with the Department of Architecture, is available in the Office of the Director, Professor Otto Piene, 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. The Center's faculty are drawn from the Department of Biology. **Graduate students** in any of the MIT departments 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 through the UROP program. Seminars in cancer research both for credit and as public colloquia of the Center are available. Further information may be obtained by contacting the Office of the Director, Professor Salvador Luria, Room E17-110, MIT, Cambridge, Massachusetts 02139, (617) 253-6400.

Center for Cognitive Science

Cognitive Science Programs

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.

Members of the Center represent the Departments of Electrical Engineering and Computer Science, Linguistics and Philosophy, and Psychology (which offer subjects appropriate for training in cognitive science), as well as 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 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. The Center also 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 may be obtained from the Office of the Director, Professor S. J. Keyser, Room 20D-213, MIT, Cambridge, Massachusetts 02139, (617) 253-4143.

The **undergraduate** bachelor's degree program in cognitive science is described under the Department of Psychology in Chapter VI of this catalogue.

At the **graduate level,** 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 the chairman of the Committee on Graduate Studies in the Cognitive Sciences, Professor Samuel J. Keyser, Room 20D-213, MIT, Cambridge, Massachusetts 02139, (617) 253-4141.

Center for Computational Research in Economics and Management Science

This Center's purpose is to advance knowledge about modeling in economics, statistics, and management. This is accomplished through algorithmic research and related software development, 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 using 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 and also provides a modeling environment for applied studies. The system provides all standard techniques, and many experimental ones, for building and using econometric models.

Recent research at the Center has focused on the evaluation and improvement of model reliability, simultaneous equation estimation, nonlinear optimization, robust estimation, and ARIMA time series models.

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 Center 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.

Several **graduate students** work as research assistants at the Center, and **undergraduates** participate in UROP projects. Students sometimes use the Center's resources in doing theses.

Further information may be obtained from the Director, Professor Edwin Kuh, Room E40-149, MIT, Cambridge, Massachusetts 02139, (617) 253-8413.

Center for Health Effects of Fossil Fuels Utilization

The Center for Health Effects of Fossil Fuels Utilization, under the aegis of the Harvard-MIT Division of Health Sciences and Technology and the MIT Energy Laboratory, was established through the collaborative efforts of combustion scientists and engineers, toxicologists, and analytical chemists in the Departments of Chemical Engineering, Nutrition and Food Science, and Chemistry. The Center is funded by the National Institute of Environmental Health Sciences. Its associated research programs are funded by NIEHS, the US Department of Energy, and other governmental agencies. These research programs have provided challenging interdisciplinary problems for **graduate** and **undergraduate students.** Of particular importance is the emphasis on providing information sufficient to guide engineering design for combustion systems with lowered levels of biologically active emissions.

The primary mode of research involves analytical chemists working with combustion engineers to measure and identify the chemical components from experimental and practical combustion systems. Toxicologists first evaluate the biological activity of the raw exhausts by measuring their mutagenic potency in bacteria and human cells. The combination of analytical chemistry and toxicology is then used to identify the specific compounds in the exhausts which are responsible for the biological activity. A second area of research is the study of the effects of gaseous and particulate combustion effluents on respiratory physiology. A third area is the development of means to measure the presence and biological effects of combustion-generated chemicals directly in humans.

The findings of studies in all three areas have stimulated primary research efforts in understanding both the mechanisms of compound formation and the mechanisms of inactivity in inducing cancer and genetic change.

The Director of the Center is Professor Gerald N. Wogan, Professor of Toxicology and Head of the Department of Nutrition and Food Science. Further information may be obtained from Professor William G. Thilly, Associate Director and Associate Professor of Genetic Toxicology, Room E18-666, MIT, Cambridge, Massachusetts, 02139, (617) 253-6221, or from the Center Office, Room 20A-104, 253-8800.

Center for Information Systems Research

The Center for Information Systems Research (CISR) was established at the Sloan School of Management in 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 policymakers in the public sector. There is a recognized need to institute more effective relationships between academics and private and public sector managers in a joint effort to improve computer-based information systems.

Research at CISR is pragmatic, problem-based, and application-driven. Research efforts are performed primarily in application areas of immediate interest to managers and policymakers. A set of corporate sponsors, representing several different commercial viewpoints, provides assistance in defining and investigating significant research areas. Research on fundamental issues affecting both the public and private sectors is being performed in such areas as 1) decision support systems, 2) the information needs of managers, 3) technology, and 4) the management of the information systems function. CISR disseminates significant research findings to the information systems user community through teaching, seminars, working papers, and publications.

The background of CISR's faculty ranges from computer science and electrical engineering to law, psychology, and organizational behavior.

Each year, a number of master's degree **graduate students** in management information systems perform their thesis work and course projects in conjunction with ongoing CISR research. In addition, Ph.D. and master's students are often involved in CISR projects as research assistants.

Further information about the Center may be obtained by contacting the Office of the Director, Dr. John F. Rockart, Room E40-193, Sloan School of Management, MIT, Cambridge, Massachusetts 02139, (617) 253-2348.

Center for International Studies

The Center for International Studies engages in research 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:

science and public policy
arms control and defense studies
US-Japan science and technology
energy policy
risk management
communications policy
migration
international effects of regulatory policies
technology and development
food and nutrition
problems of advanced industrial societies
international political problems and conflict
political and economic development

Further information 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

Archaeology and Ancient Technology Program

The **Center for Materials Research in Archaeology and Ethnology** (CMRAE) encourages new directions 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 Center was established in 1977 by nine 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. MIT serves as the Center's coordinating institution.

The Center's research activities are carried out in a network of shared laboratories at member institutions, which are 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, archaeobotany, and zooarchaeology. 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 offers graduate-level subjects in the CMRAE Graduate Laboratory (20B-012). These are open to **graduate students** and **senior undergraduates** from all participating institutions. Each subject is heavily laboratory oriented, runs for a full year, and covers a single class of materials (e.g., ceramics or metals), or a method for interpreting archaeological data (e.g., computers in archaeology).

The Center runs a Summer Institute, which offers a one-month, intensive laboratory course open to graduate students and scholars from institutions throughout the United States.

Further information about the Center may be obtained from the Director, Professor Heather Lechtman, Departments of Materials Science and Engineering and Humanities, Room 8-138, MIT, Cambridge, Massachusetts 02139, (617) 253-1375.

MIT also offers an **undergraduate** program in **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 cultures, interacting with materials, produced technological systems which, in turn, helped to shape the cultures themselves. 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 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, and on the ethnographic record of the use of materials and techniques in the production of art and material culture in general.

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, a study of ceramic production in the American Southwest, and an investigation of the change from tempera to oil medium in painting of the Italian Renaissance. Interested students should contact Professor Heather Lechtman, Room 16-401, MIT, Cambridge, Massachusetts 02139, (617) 253-2172, Professor Arthur Steinberg, Room 20B-131C, 253-6956, or Professor Suzanne DeAtley, Room 20D-105, 253-6955.

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: 1) flow and fracture in high temperature alloys; 2) structure and properties of microcrystalline and glassy alloys produced by rapid solidification; 3) catalytic activity and surface structure; 4) defects in solids; 5) phase transitions; 6) deformation and fracture in polymer composites; 7) materials research using synchrotron radiation. Major funding for these interdisciplinary programs is provided under the National Science Foundation Materials Research Laboratories Program.

Participating in CMSE-funded programs are faculty groups from the Departments of Chemical Engineering, Chemistry, Electrical Engineering and Computer Science, Materials Science and Engineering, Mechanical Engineering, and Physics. **Graduate** and **undergraduate students** participate actively in all aspects of the CMSE research program. Actual appointments are handled by the academic departments.

CMSE maintains excellent modern central service facilities such as crystal growing and characterization laboratories; spectroscopic facilities; scanning, transmission, and scanning-transmission electron microscopy; analytical compositional analysis; X-ray diffraction; microelectronics fabrication and characterization; an 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 student machine shop. Annual CMSE reports entitled *Research in Materials at MIT* and *Polymer Research at MIT* cover research in these areas and are available through the Center by contacting the Administrative Office, Room 13-2098, MIT, Cambridge, Massachusetts 02139, (617) 253-6841. Further information may be obtained from the Office of the Director, Room 13-2090, MIT, Cambridge, Massachusetts 02139.

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 signficant 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 including science, engineering, law, economics, and philosophy. 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 methodologies.

During 1982-83, some of CPA's research areas included science and technology policy, energy policy, communications policy, technological innovation, workplace and environmental regulation, and consumer policy.

A Master of Science degree program in Technology and Policy was initiated in 1975 by the School of Engineering with the collaboration of CPA (see description under Technology and Policy in this chapter). Several CPA staff members teach courses in the Technology and Policy Program, are on its Steering Committee, and oversee a number of master's theses in the program.

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, Professor Nicholas A. Ashford, Room E40-209, MIT, Cambridge, Massachusetts 02139, (617) 253-1664.

Center for Space Research

The Center for Space Research offers students, faculty, and professional research staff opportunities to participate in a broadly based program of space-related research. Its projects draw upon the interests and expertise of scientists and engineers from many MIT departments and laboratories. Research programs are carried on, for example, in X-ray astronomy, space plasma physics, and the life sciences. These experimental studies usually involve experiments carried by balloons, sounding rockets, orbiting satellites, or deep space probes. The experimental programs are supplemented by closely related programs of ground-based research in similar fields and by laboratory development of suitable instrumentation for the space-based and ground-based experiments. An active program of theoretical studies in astrophysics is also supported by the Center.

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 group of engineers and technicians provides design, construction, and testing of experiments in support of the flight programs.

The variety of scientific and technical problems that arise in these investigations affords numerous opportunities for **graduate** thesis research. In addition there is major participation by **undergraduate students** in programs of data analysis and in the development of new instruments. Further information may be obtained from the Office of the Director, Professor Herbert S. Bridge, Room 37-241, MIT, Cambridge, Massachusetts 02139, (617) 253-7501.

Center for Transportation Studies

Transportation (S.M.)

The **Center for Transportation Studies** was established to promote interdepartmental cooperation in innovative research in transportation and to provide a focal point for educational programs in transportation within the Institute. The Center's research emphasis is problem-oriented and covers a wide spectrum including broad conceptual planning; operation and management of transportation problems; and new methods of transportation analysis, planning, and decision making.

The Center promotes interaction among faculty members from all Schools at MIT as well as other universities and organizations concerned with transportation, recognizing that the solution of complex problems in this area requires close ties between technological possibilities and their social, economic, ecological, and political ramifications.

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 governmental and industrial organizations affording students wide opportunities for involvement in newly evolving research frontiers. Several full-time and part-time research assistantships are awarded to **graduate students** each year. **Undergraduates** also may participate in sponsored research through UROP.

Graduate programs leading to the master's and doctoral degrees, as well as professional training, are available through the departments associated with the Center, including Aeronautics and Astronautics, Civil Engineering, Economics, Mechanical Engineering, Ocean Engineering, Political Science, Sloan School of Management, and Urban Studies and Planning.

The **Master of Science in Transportation,** an interdisciplinary degree offered by graduate departments in cooperation with the Center, 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 (including 18 units in core subjects, 36 units in a program area, and 18 units of electives) and the presentation of an acceptable thesis. The specified core consists of two subjects — Transportation Systems Analysis and Applied Microeconomics — and establishes a common methodological framework for analyzing transportation problems.

The remainder of the program builds upon specific program areas of professional interest, such as: 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.

Students must take at least four related subjects in their program area. Since the research associated with the Master's thesis usually requires one or two terms to complete, students generally should expect to take three or four terms to complete the program (though 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.) and Master of City Planning (M.C.P.). This would require 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 toward the other. 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 the relevance of the student's prior degree and work experience, and the complementarity of the two degree programs being pursued.

The Center for Transportation Studies attempts to provide financial assistance, in the form of fellowships and research and teaching assistantships, in most of the fields in which the Center is active.

Students interested in coming to MIT for transportation studies or in learning more about the Center and its programs should write to the Office of the Director of the Center for Transportation Studies, Professor Daniel Roos, 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.

Clinical Research Center

The MIT Clinical Research Center, a small, fully equipped and staffed research hospital on campus, enables interested scientists to perform research with human subjects and allows students at all levels to gain experience in working directly with human subjects and human disease. Research projects in progress are in the areas of nutrition, psychology, cardiology, endocrinology, gastroenterology, and mechanical, chemical, and electrical engineering, and largely involve collaboration between basic scientists and clinical scientists.

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 area, a significant number are referred from other parts of the United States or from abroad.

There are numerous ways in which **undergraduate** and **graduate students** may take advantage of the Center's programs, including 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 by contacting the Office of the Director, Dr. Nevin Scrimshaw, Room E17-445, MIT, Cambridge, Massachusetts 02139, (617) 253-3091 or 3092.

Communications Policy Program

Rapid technological change and the critical importance of communications to society have combined to generate intense concern with policymaking 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 a graduate degree program in Communications Technology and Policy within the Department of Political Science. Some **graduate students** have developed their own interdisciplinary course of study in communications through the Program in Technology and Policy, or through other departments including Electrical Engineering and Computer Science, Economics, the Sloan School of Management, and the School of Architecture and Planning. **Undergraduates** may wish to review the course listings of the Film and Media Concentration and consult with the field advisors in that program. Further information is available from the Literature Faculty Office, Room 14N-305, MIT, Cambridge, Massachusetts 02139, (617) 253-3581.

The Research Program on Communications Policy is a collaborative effort between the Center for International Studies, the Center for Policy Alternatives, the Center for Information Systems Research, 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 graduate 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, policymaking 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, 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.

Concourse Program for First-Year Students

Freshmen who wish to have a more interdisciplinary approach to first-year studies may elect the Concourse Program. Concourse 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. The Program covers, and provides credit for, the Institute Requirements of the first year. See detailed description in Chapter III, Undergraduate Education.

Draper Laboratory

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 maintains a relationship with the Institute that permits students to engage in joint research activities.

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. 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. Probably the most publicized achievement of the Laboratory has been the Apollo guidance and control system. 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.

The Laboratory experience in instrumentation has resulted 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, including basic theory, mathematical analysis, computer studies, component design and evaluation (mechanical, electrical, and optical), and system synthesis. Students are in direct daily association with the professional staff of engineers and scientists of the Laboratory, and thus learn to appreciate the economic and human, as well as the technical, aspects of a system. **Undergraduate** and **graduate 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 students' 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 Edwin H. Porter, Jr., (617) 258-2374, or Institute extension 182-82374.

Economics and Urban Studies (Ph.D.)

A doctoral program 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.

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 innovative approaches to state-of-the-art problems in electric energy generation, conversion, and control, including the development and application of new components such as unique rotating machines, power semiconductor devices, and microprocessors. Close contact with industry is maintained through on-campus research, consulting activities, and participation in the activities of professional societies.

Research programs currently in progress include microprocessor control of electric energy systems; design, construction, and testing of a superconducting alternator; new motor design and controls; control of power systems and power plants during emergency situations; load demand modeling, innovative load management, dynamic control schemes; new simulation techniques for studying power electronic energy conversion and control systems; thin-film nonlinear varistors, high-efficiency combined cycle systems, and ac electrostatic precipitators. Since most of the research is experimentally oriented, design and instrumentation is a major additional research area.

Most of the programs are carried out by students, both **undergraduate** and **graduate**, under the supervision of faculty members in the Departments of Electrical Engineering and Computer Science and Mechanical Engineering.

Further information may be obtained by contacting the Office of the Director, Professor Thomas H. Lee, Room 10-171, MIT, Cambridge, Massachusetts 02139, (617) 253-4631.

Energy Laboratory

Energy Study and Research

The **Energy Laboratory** was established in 1972 to provide a focus for strengthening and broadening energy activities on campus, with emphasis on conducting research to answer energy questions or illuminate energy issues. Energy Laboratory research projects this year involve over 100 research staff, 50 faculty, and 200 students from departments in all five MIT Schools. Graduate and undergraduate students are an integral part of the interdisciplinary research teams working on both fundamental and mission-oriented projects that address both 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 (oil, nuclear fuels, and other energy commodities). 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 involves faculty and research staff from engineering and policy science departments at MIT who analyze utility operations and growth, both in the short and the long run, and is focused on: 1) electric utility operations and control; 2) economics and policy decisions associated with adoption of new energy technologies; 3) development of modeling tools for utility operation and utility capacity expansion analysis; and 4) economics of regulation/deregulation of the electric power system.

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. Current projects include research on macroeconomic consequences of energy supply shocks and price uncertainty; the wealth and income distribution effects of changing energy supply and price conditions; the structure and regulation of the US electric utility industry; and the relation between energy prices and availability, and capital formation and replacement.

The **Center for Energy Policy Research** focuses on policy research and analysis and on making results available and useful to policymakers. With support from its Associates, a wide range of US and international corporate and noncorporate interest groups, the Center holds conferences and seminars to bring together key government and private organizations to work on energy-related policy issues. The work of the Center is done by professional staff members from the Energy Laboratory and faculty and students from several MIT departments (particularly the Sloan School of Management and the Department of Economics), and specialists from the Center's Associates.

The **Energy Systems Assessment** program studies options for future energy systems by 1) evaluating the short- and long-term impact of energy systems and 2) identifying R & D needs and initiating projects to solve the identified problems. International cooperative activities are planned for this program. The integration of distributed photovoltaic systems into a power grid is also under study.

The **Combustion Research Facilities** program emphasizes parallel modeling and experimental investigations of combustion processes of gaseous, liquid, and solid fuels in both steady and unsteady operation. A special feature of the experimental studies is that fundamental flame data are obtained in large-scale pilot plant combustors in which the combustion-heat transfer processes closely simulate industrial practice.

Research in the **High-Temperature Reactions and Health Effects** program concentrates on the oxidation and pyrolysis of fuels and on techniques for controlling emissions from these processes. Studies of the formation of mutagens in hydrocarbon combustion involve a team effort among engineering, analytical chemistry, and biological sciences.

The **Synthetic Fuels Center** focuses on research on conversion of coal, oil shale, and other energy resources to liquid and gaseous fuels.

The **Transportation Propulsion** program is based on the activities of the Sloan Automotive Laboratory. The work includes fundamental combustion studies, internal combustion engine research, gas turbine and burner research, and policy and technology studies.

The **Advanced Energy Materials** program examines new and emerging technologies in such areas as electrodes and electrolytes for high-density batteries and fuel cells; synthesis of ceramic powders using laser heat sources; rapid solidification of molten ceramics; solar heating/cooling; amorphous photovoltaics; and broad band antireflective coatings.

Research in the **Environmental** program seeks to identify and reduce the environmental impacts of energy-related facilities and involves a diverse range of research projects, including cooling systems for electric power plants, water management issues associated with coal development, impacts of acid rain, local effects of air emissions, and environmental implications of ocean thermal energy conversion.

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The **Electric Utility** program serves to inform participating companies about ongoing MIT research activities, to identify and discuss utility needs and priorities, and to develop research projects responsive to those needs. The member companies currently participating in the program include eight utilities and nine other companies involved in supplying fuel, equipment, or services to the industry.

The **Nuclear** program has the following broad objectives: 1) to provide direct technical contributions to nuclear plant reliability and safety; 2) to investigate possible improvements in nuclear plant design for more efficient utilization of nuclear fuel resources; and 3) to develop and communicate information that will contribute to public understanding of nuclear power.

The **Energy-Efficient Buildings and Systems** program examines the behavior of existing buildings and components and seeks to develop new technologies with better energy efficiency. Current projects include studies of the transfer and accumulation of moisture in structures retrofitted with insulation, heat loss from building foundations, and the insulating value and aging characteristics of closed-cell foam insulation.

Further information about the Energy Laboratory may be obtained by contacting the Office of the Director, Professor David C. White, E40-463, MIT, Cambridge, Massachusetts 02139 (617) 253-3400.

Undergraduate programs in energy study and research are available in most departments at MIT, including all those in the School of Engineering. These 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, is available through the Office of the Dean of Engineering, Room 1-206, MIT, Cambridge, Massachusetts 02139.

Graduate programs that prepare students for careers **in the energy field** are available in all of the Schools at MIT. 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 **undergraduate** and **graduate students** are available through a variety of departmental and interdepartmental subjects 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, Atmospheric, and Planetary Sciences, and Urban Studies and Planning, and the Program in Science, Technology, and Society. The areas of environmental studies available at MIT include 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.

Graduate students may pursue environmental studies in various ways. Through its several departments, the School of Engineering sponsors the degree of Environmental Engineer. The Energy 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. (The above programs are described in this chapter and in Chapter VI.)

Graduate students may also arrange special programs with the help of their advisors in aspects of the environment which are closely related to their disciplinary interests, and they may pursue interdepartmental programs leading to advanced degrees under the auspices of the Dean of the Graduate School. 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, lists of departmental advisors, and subjects offered on environmental issues for both undergraduate and graduate students are available through the Office of the Provost, Room 3-234, MIT, Cambridge, Massachusetts 02139.

ESG (Experimental Study Group)

ESG is open to **freshmen** and **sophomores** interested in participating in a small, informal academic program which offers credit in core subjects through tutorials, seminars, and independent study projects. The details of the program can be found in Chapter III, Undergraduate Education. Information can be obtained directly from ESG by contacting Professor R. L. Halfman, Room 24-612, MIT, Cambridge, Massachusetts 02139, (617) 253-7786.

Health Sciences and Technology

MIT's programs in health sciences and technology are organized within the Whitaker College of Health Sciences, Technology, and Management and the Harvard-MIT Division of Health Sciences and Technology (HST). The Center for Health Effects of Fossil Fuels Utilization and the Biomedical Engineering portions of the HST program are described in this chapter. Additional information about HST and the Whitaker College may be found at the end of Chapter VI in this catalogue.

Humanistic Studies Combined with Engineering or Science (S.B. Degree Programs in Courses XXI, XXI-E, XXI-S)

MIT has developed programs for **undergraduate students** who have an active interest in the relationship between humanistic and scientific/technical knowledge. The first (XXI) is a *double-degree* arrangement leading to two S.B. degrees, one centered in the curricula of the Department of Humanities and the Program in Science, Technology, and Society (STS); the other in one of the degree programs in the School of Science or the School of Engineering. The second (XXI-E, XXI-S) is a *joint-degree* major which brings together components of humanities/STS and engineering/science within the dimensions of a single S.B. program.

Both of these plans require substantial knowledge in each of the two chosen areas, and both are grounded in a rigorous system of seminars and other subjects expressly designed to relate scientific learning and technological choice to social and cultural issues.

More detailed descriptions of these programs, including outlined degree requirements, are included in the Department of Humanities and STS descriptions in Chapter VI of this catalogue.

Further information may be obtained from Professor Travis Merritt of the Course XXI Office, Room 14N-407, MIT, Cambridge, Massachusetts 02139, (617) 253-4447; or Professor Kenneth Manning of the Program in Science, Technology, and Society, Room E51-116, 253-4066.

Innovation Center

The MIT Innovation Center offers an educational program on technological innovation. **Undergraduate** and **graduate students** learn about generating creative solutions to fill market needs, transforming ideas into marketable products, developing new business enterprises, and forming and leading new ventures within larger organizations. The Innovation Center is a division 36the School of Engineering, with logistic support provided by the Department of Mechanical Engineering.

The educational opportunities offered by the Center include a classroom teaching program and active participation in the technological innovation process through laboratory experience. Classroom subjects include Invention (2.941J, 6.941J, 10.802J, 13.77J, 16.671J), Entrepreneurship (2.942, an Engineering School-Wide Elective), and a new subject, The Idea/Product Transformation. These are all graduate-level subjects. Students who wish to take laboratory subjects or participate in a UROP program should contact the Center.

Laboratory activity centers around the Industry/Innovation Center Cooperative Program. Member companies provide market-oriented product and process needs that call for innovative solutions. Opportunities for research include thesis, UROP, and independent projects for both graduate and undergraduate students. Authentic participation in the technological innovation process is an invaluable supplement to an engineering education. The Center is also open to those in the MIT community with inventive ideas of their own which they would like to pursue.

Further information may be obtained by contacting the Office of the Director, Dr. D.G. Jansson, Room W59-202, MIT, Cambridge, Massachusetts 02139, (617) 253-5180.

Interdisciplinary Programs in Humanities

The School of Humanities and Social Science offers a number of subjects and programs of an interdisciplinary nature for **undergraduates**. Descriptions of the various interdisciplinary programs can be found under the Department of Humanities in Chapter VI of this catalogue.

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, provides an interdisciplinary focus for **graduate 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. 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.

Representative areas in which IFNP works include the following: a) monitoring the nutritional status of populations, including assessing 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, agriculture policy, and 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 populations; e) food and agriculture policies of food-exporting nations as these relate to international food needs; f) international food data systems.

Primary activities of the IFNP include: 1) graduate-level courses providing in-depth analysis of the 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 based on field activities in developing countries involving national and regional nutrition planning, and programs to combat problems of malnutrition among target populations); and 3) advice, program analysis and evaluation, and advanced training ser-

vices to governments and international agencies dealing with nutrition planning, policy identification, and programming.

IFNP sponsors a seminar series involving distinguished visitors and multidisciplinary topics, and two series of publications.

Further information may be obtained from Professor Nevin S. Scrimshaw, Director of the IFNP, Room 20A-201, MIT, Cambridge, Massachusetts 02139, (617) 253-5101.

Laboratory for Computer Science

The Laboratory for Computer Science is an interdepartmental laboratory whose principal goal is research in computer science and engineering. The Laboratory includes 16 research groups, currently staffed by approximately 300 faculty, students, and staff members. The academic members of the Laboratory are from the Departments of Electrical Engineering and Computer Science, Humanities, Mathematics, Architecture, 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. In the 1970s, highlights of the Laboratory's work were MACSYMA, a 2-Megabyte program with knowledge in symbolic mathematics; the dataflow concept, which is important for harnessing thousands of processors to work on a common task; the use of computers in clinical decision making; and public cryptography algorithms aimed at insuring privacy in distributed/networked computer systems. The Laboratory is now engaged in a broad front of research activities that span four principal areas: 1) Knowledge-Based Systems; 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 UROP. Facilities are provided for thesis research and special projects to both graduate and undergraduate students.

Further information may be obtained by contacting John J. Hynes, Room NE43-101, MIT, Cambridge, Massachusetts 02139, (617) 253-2006.

Laboratory for Information and Decision Systems

The Laboratory for Information and Decision Systems is an interdepartmental laboratory for research and education in systems, communications, and control. Computers and computation play an important role in this research. The laboratory is staffed by over 100 faculty, research scientists, and graduate students principally from the Departments of Electrical Engineering and Computer Science, Mechanical Engineering, and Ocean Engineering. Research falls into three main areas:

1) Research in **Communication Science and Systems** ranges from studies of the underlying information theoretic properties of networks and point-to-point systems to architectural design. A major research program in this area deals with reliable, efficient communication in data networks. Some of the topics in this program are routing, flow control, the communication complexity of distributed algorithms, contention resolution in broadcast networks, protocols, failure recovery, and topological design.

2) Research in **Systems and Control Science** ranges from fundamental studies in deterministic and stochastic systems, multivariable and adaptive control, nonlinear estimation and model-based signal processing, and large-scale and distributed systems to application areas such as command and control systems and operation and control of complex manufacturing processes. In addition, development of algorithms and special computer structures for estimation, signal processing, and control is an integral part of this research.

3) Research in **Computer and Information Systems** is concerned with basic problems in the use of computers in complex information transfer and retrieval systems. One study involves expert intermediary systems to assist end-user access to heterogeneous databases. A second project deals with analytical and experimental investigations of electronic document-delivery networks applicable to interlibrary resource sharing.

Research opportunities are available in the laboratory for both **undergraduate** and **graduate students**. Undergraduates may participate through UROP.

Further information may be obtained by contacting the Office of the Director, Professor S. K. Mitter, Room 35-304, MIT, Cambridge, Massachusetts 02139, (617) 253-2160, or the Associate Director, Professor R. G. Gallager, Room 35-206, 253-2533.

Laboratory for Manufacturing and Productivity

The Laboratory for Manufacturing and Productivity is an interdisciplinary center for education and research in manufacturing and productivity at MIT. The goal of the Laboratory is the advancement of manufacturing science and technology.

The Laboratory educates scientists and engineers in the analysis and synthesis of products, processes, and manufacturing systems. Fundamental research conducted in the Laboratory leads to innovation in products, manufacturing process technology, and better understanding of planning, design, and production operations. The Laboratory seeks to establish a rational foundation for productivity increase based on a systematic understanding of the complex interactions among the many areas of manufacturing including design, processing, assembly, inspection, and quality control. The impact of the new manufacturing technology on society is also addressed.

The Laboratory draws upon faculty and staff in the Departments of Mechnical 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. Important perspective is contributed by the representatives of industrial firms associated with the Laboratory's cooperative research programs.

Topics of current interest include:

Axiomatics (a scientific approach to the decision-making process related to manufacturing — an approach which facilitates rational design of processes, products, and optimization of manufacturing systems)

Computer Integrated Manufacturing, including CAD/CAM

Polymers Processing
Flexible Materials Processing
Metals Processing

Tribology (science of friction, wear, and lubrication)

Machine Dynamics

Robotics/Intelligent Machines (including intelligent welding, sheet-metal forming, and injection molding)

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 are the MIT-Industry Polymer Processing Program, the MIT-Industry Flexible Materials Processing Program, the Machine Dynamics Program, the Industrial Robotics Program, and the Tribology Research Program.

Opportunities for **undergraduate** and **graduate students** are available for thesis research and UROP projects. A limited number of postdoctoral research positions are also available.

Additional information may be obtained from the Director, Professor N. P. Suh; the Associate Director, Professor S. Dubowsky; or the Assistant Director, Dr. G. Chryssolouris, Room 35-136, MIT, Cambridge, Massachusetts 02139, (617) 253-2234.

Laboratory for Nuclear Science

Bates Linear Accelerator

The **Laboratory for Nuclear Science** performs basic research in nuclear and elementary particle physics. It supports research interests of faculty in the Department of Physics by maintaining and administering 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 (and is described below). The Laboratory operates a computer facility available to staff and students.

As part of the nuclear physics program, members of the Laboratory are engaged in experiments at the MIT Bates Linear Accelerator, the Brookhaven Tandem Accelerator, and the Oak Ridge National Laboratory's Holifield Tandem facility. The high-energy physics program involves experiments at the Fermi National Accelerator Laboratory, the Stanford Linear Accelerator, and at the German high-energy electron-positron storage ring facility in Hamburg. Also several small groups within the Laboratory are engaged in the application of nuclear and particle physics instrumentation to medical and biological problems.

Among many projects are theoretical studies of the atomic nucleus and elementary particles; experimental programs using a variety of detector techniques to study strong, electromagnetic and weak interactions of elementary particles and other high-energy phenomena; application of high-speed electronic computer techniques to the problems of nuclear and elementary particle data analysis; nuclear studies using heavy-ion accelerators; and programs in radioactivity and in medium- and low-energy photonuclear and nuclear particle research.

Students participate in the entire range of research programs in fulfilling their **graduate** and **undergraduate** degree requirements or as participants in UROP.

Further information may be obtained from the Office of the Director, Professor Arthur Kerman, Room 26-505, MIT, Cambridge, Massachusetts 02139, (617) 253-2395.

The **William H. Bates Linear Electron Accelerator,** funded by the US Department of Energy 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 has been completed successfully during the past year to raise the accelerator's beam energy to more than 750 MeV, almost doubling its previous energy capability. A polarized electron source is under development which will make possible studies of parity violation in electron scattering and spin effects in nuclear reactions. A program has been proposed for the further extension of the accelerator's beam energy to the greater than 1 GeV at 100 percent duty factor.

The research participation of physics students, as **undergraduate** laboratory assistants working on UROP projects 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, Professor Peter T. Demos, Room 26-565, MIT, Cambridge, Massachusetts 02139, (617) 253-7592.

Laboratory of Architecture and Planning

The Laboratory of Architecture and Planning (LAP), part of the School of Architecture and Planning, fosters research contributing to the understanding, education, and practice of architecture, planning, and closely related fields.

Projects currently administered by the Laboratory focus on: energy conservation and appropriate technology; development of techniques for assessing the environmental impacts of development and for mediating disputes concerning such developments; solar architecture; neighborhood and community development; 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.

The Laboratory involves a wide variety of people and institutions both inside and outside MIT, including 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 such as firms, public agencies, and community organizations. LAP research involves **graduate** and **undergraduate students** from several MIT departments, through research assistantships and UROP.

Further information may be obtained from the Office of the Director, Michael Joroff, Room 4-209, MIT, Cambridge, Massachusetts 02139, (617) 253-1350.

Law-Related Studies

Undergraduate and **graduate students** interested in the legal or public policy aspects of their field, the legal profession, or our legal structure and processes as a part of a general education may do so through a wide range of undergraduate or graduate subjects, research projects, 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, ocean resources, construction, transportation, industrial safety, computer science, and technology.

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.

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 in future practice. There is a series of open seminars 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, Professor Lawrence Bacow, also have additional information regarding the Law-Related Studies Program at MIT.

Lincoln Laboratory

The Lincoln Laboratory 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 and located in Lexington, Massachusetts.

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 satellite communications, reentry studies and technology, computer systems and digital signal processing, image processing, space surveillance, 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 **undergraduate** and **graduate students**. Inquiries may be directed to Dr. Melvin A. Herlin, Assistant to the Director, LIN A-163, (617) 863-5500, extension 7024, or Institute extension 181-7024.

Management of Technology Program (S.M.)

The Management of Technology Program is a 12-month master's degree program, beginning only in June of each year, for scientists and engineers with a minimum of five years of work experience. Offered jointly by the School of Engineering and the Sloan School of Management, the program focuses on management principles for technical professionals whose careers require increasing managerial responsibility on the technical side of the organization.

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: 1) underlying core subjects in management principles and analytic methods, 2) in-depth studies on management of technical programs and organizations, and 3) a thesis relating to the management of technical programs and organizations. Participating departments include the Sloan School of Management and all eight departments in the School of Engineering.

Application material is available only through the Program office and is due back in that office by February 1. Requirements for admission include: five years of work experience, an undergraduate science or engineering degree, and prior course work in macro- and microeconomic theory and calculus. In addition, all applicants must take the GMAT. Chemical engineers and foreign ocean engineers must also take the GRE, and all foreign applicants must submit scores from the TOEFL.

Complete information on Program objectives, the curriculum, and application procedures is available from the Program Director, Professor Edward B. Roberts, or from the Program Manager, Jane M. Morse, Room E52-125, MIT, Cambridge, Massachusetts 02139, (617) 253-3733.

Materials Processing Center

The Materials Processing Center focuses on technological problems related to 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, and electronic materials. The Center interacts with industry and government in seeking to develop the scientific and technological base of materials processing, and to broaden its educational base.

The underlying themes of the Center are that: 1) performance of materials can be controlled through control of internal structure, from the macroscopic to the atomic level, and that 2) 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, as well as developing new curricula, workshops, and continuing education programs. It sponsors appointments of industry and government personnel as visiting faculty, adjunct faculty, and postdoctoral researchers. Faculty and staff participate in the Center from a number of departments, principally Materials Science and Engineering, Mechanical Engineering, Electrical Engineering and Computer Science, and Chemical Engineering.

The Center offers UROP appointments and special summer scholarships to **undergraduate** students. **Graduate students** may participate in research programs supported by grants and contracts through the Center as well as fellowship appointments.

Further information may be obtained from Professor H. Kent Bowen, Director, at (617) 253-6892, Room 12-007, or Dr. G. B. Kenney, Assistant Director, at 253-3244, Room 12-007, MIT, Cambridge, Massachusetts 02139.

Mining and Mineral Resources Research Institute

Mineral Resources Engineering and Management (S.M., Eng., Ph.D.)

The **Mining and Mineral Resources Research Institute** (MMRRI) was founded to support and aid in the coordination of the wide variety of academic activities and research programs related to mineral resources. In particular, it encourages interdisciplinary activities for both **undergraduate** and **graduate students,** and calls attention to opportunities for careers in mineral resource engineering and management. The direct support of the MMRRI which comes from the US Department of the Interior includes funding for a limited number of fellowships and scholarships, and for some research activities.

The Departments of Civil Engineering, Mechanical Engineering, Materials Science and Engineering, Earth, Atmospheric, and Planetary Sciences, Ocean Engineering, Economics, Management, and Political Science are involved, as is the Energy Laboratory. Some of the major problems being addressed are: finding mineral resources, extracting and processing them economically and in an environmentally acceptable manner, and reducing our need for mineral resources and substituting one for the other. Joint academic subjects and seminars, and particularly the undergraduate and graduate interdisciplinary programs of study in Mineral Resources Engineering and Management (described later), represent the academic side of the MMRRI.

Undergraduate students may pursue study of mineral resources through a variety of programs and laboratories. Related activities may be found in the departments associated with the MMRRI listed above. 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 the various activities of the Mining and Mineral Resources Research Institute and on departmental advisors and special programs of study may be obtained from the Office of the Director, Professor John F. Elliott, Room 4-138, MIT, Cambridge, Massachusetts 02139, (617) 253-3305.

The **Mineral Resources Engineering and Management** (S.M., Eng., Ph.D.) program provides formal educational opportunities to **graduate students** with interests in the mineral resources field. The academic subjects and research available throughout the Institute make it possible to offer programs in several areas of concentration, leading to a variety of careers 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: 1) The exploration subprogram exposes students to the geological, technical, and decision theoretical aspects of exploration. 2) 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. 3) The processing subprogram deepens the student's physical and chemical education and leads to the analysis and design of industrial processes including their managerial and environmental aspects. 4) The resource management subprogram encompasses a wide range — systems engineering, economics, and public policy, as well as problems of substitution and of related resources (water, energy). Students' emphasis in the resource management subprogram can be placed on engineering, management, or public policy. The resource management subprogram also provides an MREM general overview, aimed at students desiring a broader education.

For the Master of Science degree, 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 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. Students will be awarded the graduate degree in this department. The participating departments are listed earlier under MMRRI.

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.

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, Atmospheric, and Planetary Sciences, Chemical Engineering, Mechanical Engineering, Nuclear Engineering, and Nutrition and Food Science are supported by the capabilities in the NRL. Facilities of the Nuclear Reactor Laboratory are also used for teaching and research activities by other institutions. The NRL provides special services to regional hospitals and industries, e.g., short-lived isotopes for medical purposes.

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.

The NRL operates a 5-million watt research reactor (MITR-II), which is one of the largest university reactors. Recent redesign and rebuilding of MITR-II has significantly enhanced the neutron and gamma ray intensity and the reactor's versatility.

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; nuclear detection equipment; trace analysis facilities; a materials characterization laboratory; and shielded hot cells for handling and testing radioactive materials.

Undergraduate students are involved in the operation of the reactor and in the research activities through special projects or senior thesis. **Graduate** student thesis research is carried on in the various research areas mentioned earlier.

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, Professor Otto K. Harling, Room NW12-208, MIT, Cambridge, Massachusetts 02139, (617) 253-4201 or 253-4202.

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 geochemistry, 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 program is described in detail at the end of Chapter VI.

Operations Research Center

Operations Research (S.M., Ph.D.)

The **Operations Research Center** offers interdepartmental master's and doctoral degree programs in the field of operations research while providing applied and basic research opportunities to its graduate students. The interdepartmental structure of the program is designed to take advantage of the expertise of faculty from many MIT departments, including Management, Electrical Engineering and Computer Science, Mathematics, Urban Studies and Planning, Physics, Aeronautics and Astronautics, and Civil, Mechanical, and Ocean Engineering. This breadth has fostered a diversity of interdisciplinary applications and brings a variety of relevant theoretical issues to the Center. Students benefit from this structure by being able to design programs that are specifically tailored to their research interests and career objectives. The high faculty-to-student ratio within the Operations Research Center provides students with effective guidance and supervision to pursue well-designed programs.

Operations Research seeks to build a science and technology of decision making. The field is concerned with the operational and planning aspects of engineering, scientific, and management problems. Current areas of basic research include mathematical programming, decision analysis, and stochastic systems. Applied research areas include corporate and logistics planning systems; marketing; public systems applications; health services; police operations; and housing, energy, and transportation systems.

The core **graduate curriculum** for both S.M. and Ph.D. degrees consists of Applied Probability (6.431), Decision Analysis (15.065), Applied Statistics (15.075), and Introduction to Mathematical Programming (15.081J/6.251J). Master's degree students continue with three additional graduate-level subjects and prepare a thesis in an area of research concentration. Employment opportunities for graduates of the S.M. program exist in technical staffs of private firms, as planners in governmental agencies, and in private consulting firms.

Doctoral degree students are expected to take, in addition to the core, Markov Models and Their Applications (6.262), Introduction to Stochastic Processes (15.073J/18.445J), Statistics for Model Building (15.076J/18.457J), Network Optimization (15.082), Combinatorial Optimization (15.083), and Nonlinear Programming and Discrete-Time Optimal Control (15.084J/6.252J). Doctoral degree candidates must qualify for continuation in the program by passing Qualifying and General Examinations which are taken in the second year of a typically four-year program. Course work in a minor program follows, in addition to pursuing an original research project under the guidance of a doctoral dissertation committee. The formal academic program is supplemented by teaching and research assistantship opportunities for most doctoral candidates. Graduates of the Ph.D. program often assume faculty positions in the US and abroad.

Further information about the Operations Research Center and the degree programs is contained in a brochure entitled *Graduate Education at the Operations Research Center* and is available from the Operations Research Center, Webster Building (E40-164), MIT, Cambridge, Massachusetts 02139. Individual questions may be addressed to either of the Co-directors, Professors Richard C. Larson and Jeremy F. Shapiro.

Plasma Fusion Center

The Plasma Fusion Center, formed in 1976, provides a focus for experimental and theoretical studies in plasma fusion physics and related engineering disciplines. It provides the leadership required for effectively undertaking 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.

The Plasma Fusion Center fosters independent creativity, and helps integrate the collective fusion activities into a cohesive program with the following broader Institute goals:

— to provide, both nationally and internationally, strong technical leadership for the development of fusion energy;

— to provide the intellectual environment for the expert educational training of students, research scientists, and engineers.

Fusion research activities fall into five major programmatic Divisions.

The **Fusion Systems** Division is concerned with overall design and reactor physics investigations of the next generation of major toroidal fusion devices; understanding the potential characteristics and technology requirements of power-producing fusion reactors; and developing new reactor design concepts and advanced component technology.

The **Mirror Confinement Systems** Division is developing an increased understanding of basic tandem mirror physics with emphasis on microstability properties, thermal barrier formation, and RF heating. The subprogram areas include the TARA tandem mirror experiment.

The **Fusion Technology and Engineering** 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 **Applied Physics Research** Division is developing the basic experimental and theoretical understanding of plasma heating and confinement properties (including research on tokamak and mirror systems, advanced fusion concepts, fusion theory and computations, MACSYMA, diagnostics and laser development, and intense-charged particle beam research).

The **Toroidal Confinement Experiments** Division is developing practical understanding of the stability, transport, and radiation properties of high-temperature fusion plasmas at near-reactor conditions, as well as methods for heating plasmas to fusion temperatures.

In the last decade, many results of great significance to the international effort to develop fusion energy have been obtained in the ALCATOR A and C high-field tokamaks, the major experimental facilities in the Plasma Fusion Center program. For example, ALCATOR C currently holds the world record in obtaining the highest product of plasma density times confinement time, and is also a world leader in developing techniques to drive current by radio-frequency waves. TARA, a new experiment based on the tandem mirror concept, is nearing completion and is expected to make major contributions to mirror fusion development. VERSATOR II and CONSTANCE II are used to study particular research aspects of toroidal and mirror-confined plasmas, respectively. The overall 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, as well as the Research Laboratory of Electronics, are affiliated with the Plasma Fusion Center.

The Center's programs provide an excellent forum for the training of students and professional researchers. Approximately 80 **graduate** and 30 **undergraduate students** are curently involved at all levels of thesis work; undergraduates also participate through UROP.

Further information may be obtained from the Office of the Director, Professor Ronald C. Davidson, Room NW16-202, Cambridge, Massachusetts 02139, (617) 253-8102.

Polymeric Materials

Polymeric materials span a remarkable range of structures and properties, presenting a diversity of challenges and opportunities for several interacting disciplines, and 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.

Students interested in interdepartmental **graduate** degree programs focusing on polymeric materials may register in the Departments of Civil Engineering, Mechanical Engineering, Materials Science and Engineering, or Chemical Engineering, and have their programs 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

Interdepartmental academic and research programs in power engineering are available in the Departments of Aeronautics and Astronautics, Electrical Engineering and Computer Science, Mechanical Engineering, Ocean Engineering, and Nuclear Engineering. These programs cover a broad range of energy-related issues.

A **graduate student** enrolled in any of these departments 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.

In addition to the departments listed above, research in power systems is conducted 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.

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, contact the Graduate Registration Officer of one of the participating departments.

Research Laboratory of Electronics

Established at the end of World War II as the Institute's first interdepartmental laboratory, the Research Laboratory of Electronics provides faculty members and their students, both **graduate** and **undergraduate**, with the diverse services and facilities of a large laboratory to conduct research in three broad areas: general physics, plasma dynamics, and communication sciences. At present there are approximately 20 research groups. Participants come primarily from the Departments of Electrical Engineering and Computer Science, Physics, Chemistry, and Linguistics and Philosophy.

Research in **general physics** primarily concerns the structure of matter and 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. (See also Plasma Fusion Center.)

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. The research in RLE provides opportunities for a broad spectrum of student thesis projects.

Additional information may be obtained by contacting the Office of the Director, Professor Jonathan Allen, Room 36-413, MIT, Cambridge, Massachusetts 02139, (617) 253-2509.

Science, Technology, and Society

The Program in Science, Technology, and Society (STS) 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. STS draws its faculty from the social and natural sciences, engineering, and the humanities. Various opportunities for research and study are available at the **undergraduate** and **graduate levels**. A more detailed description of the Program is given in the School of Humanities and Social Science section in Chapter VI. Further information may be obtained from the Office of the Director, Professor Carl Kaysen, Room E51-110, MIT, Cambridge, Massachusetts 02139, (617) 253-4062.

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 and coordinates multidisciplinary research projects, educational opportunities, and advisory services. Following the lead of the National Sea Grant Program, created by Congress in 1966, 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 can help 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. The principal departments involved in Sea Grant research include Civil Engineering, Ocean Engineering, Mechanical Engineering, and Nutrition and Food Science. Students participate directly in most Sea Grant research projects at both **graduate** and **undergraduate levels**, and support is available for UROP projects.

The Sea Grant Program also supports innovative education at MIT in ocean utilization and coastal zone development. Each year, an interdisciplinary design subject provides graduate and undergraduate students with the chance to apply classroom knowledge to "real-world" situations. The Program has supported new curricula and textbooks in the field of ocean engineering. A joint project with the Massachusetts Maritime Academy is providing new educational opportunities for professional fishermen.

MIT Sea Grant's Advisory Services publish technical reports, sponsor symposia, and work with local governments, business, and organizations to transfer comprehensive information to the public on the many facets of resource development in the oceans and coastal zones.

More information on Sea Grant Program projects and services may be obtained from the Office of the Director, Professor Chryssostomos Chryssostomidis, Room E38-302, MIT, Cambridge, Massachusetts 02139, (617) 253-7041.

Spectroscopy Laboratory

The George Russell Harrison Spectroscopy Laboratory is dedicated to advancing 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.

The Spectroscopy Laboratory encourages participation and collaboration among staff members in various disciplines of science and engineering. At present, several departments (principally, Chemistry, Physics, Biology, Electrical Engineering and Computer Science, and Mechanical Engineering), are involved. 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, laser optical pumping of atoms, infrared and optical double resonance experiments using coherent sources, laser saturation spectroscopy, coherent transience, 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 technical holography.

Within the Laboratory is the Regional Laser Center, supported by a grant from the National Science Foundation. This Center makes available to researchers from various university and industrial research institutions one of the most extensive collections of lasers assembled in the US for spectroscopic research. Research in the Center includes 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.

Many **graduate** and **undergraduate students** perform thesis research in the Laboratory; UROP projects are offered in many areas of laser research.

Further information on the Laboratory may be obtained from the Office of the Director, Professor Michael Feld, Room 6-014, MIT, Cambridge, Massachusetts 02139, (617) 253-7707.

Statistics Center

Research, teaching, and consulting activities in statistics, while occurring in a number of departments at MIT, are the principal focus of the Statistics Center. Students considering MIT for **graduate study** in statistics should seek the advice of the Statistics Center about which department or School would be most appropriate for admission to MIT, since there is no separate department of statistics. Once admitted to a department (or School), students pursue an S.M. program through the department; a Ph.D. program in statistics can be pursued in the department or under the general guidance of an ad hoc committee established through the Dean of the Graduate School. The Statistics Center can also provide assistance in obtaining financial support. (**Undergraduates** can focus on statistics in a number of departments, particularly Mathematics, Economics, and the Sloan School of Management.)

Usually, S.M. degree programs can be completed in one year by students with backgrounds in linear algebra, probability, and statistics. A thesis is required for the S.M. degree and almost all theses in recent years have made contributions to applied projects. The doctoral programs for students in statistics can be individually planned in collaboration with various MIT departments.

Major theoretical fields of interest at the Statistics Center are pattern recognition and cluster analysis, robust regression, categorical data analysis, statistical computing and graphics, detection of influential data, time series analysis, stochastic control and sequential analysis, Bayesian statistics and risk assessment, as well as probability theory.

Fields of application have ranged from microbiology and astrophysics to political science, and from the health sciences to the Massachusetts lottery. Departments in which Center members are involved include Mathematics, Electrical Engineering and Computer Science, Earth, Atmospheric, and Planetary Sciences, Economics, Nutrition and Food Science, and the Sloan School of Management.

The statistical consulting service at the Center gives students and faculty the opportunity to collaborate with researchers at MIT and neighboring institutions on projects covering the full range of statistical theory and practice on real problems.

While much of theoretical statistics draws heavily on mathematics, applied statistics is increasingly linked to computing science via numerical analysis, graphics, and the development of large statistical analysis computing packages. These topics are a part of the rapidly growing field of statistical computing which often forms a basic part of interdepartmental statistics programs. Research in statistical computing is often carried out in association with the Center for Computational Research in Economics and Management Science.

Further information, including a list of the 60 statistics subjects offered at MIT, may be obtained by contacting the Offices of the Directors, Professor Herman Chernoff, Room E40-107, (617) 253-8721, and Professor Roy Welsch, Room E40-129, 253-8411, MIT, Cambridge, Massachusetts 02139.

Technology Adaptation Program

The Technology Adaptation Program (TAP) is concerned with:

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 have specific research projects under TAP largely come from these Schools.

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.

TAP provides educational and research opportunities for **master's candidates** who are interested in the tranfer 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. (Specifications are available upon request.) 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 who elect this program should note that 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.

Students interested in working on TAP projects who cannot fulfill all the requirements of the program may be accepted for participation in special cases.

Further information about the program, including a list of current research projects, may be obtained from the Office of the Director, Professor Fred Moavenzadeh, 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 provides to educate "engineers with a difference," that is, persons with both strong technical foundations and competence in dealing with policy issues. Challenging jobs in industry, consulting, and the public sector, both in the US and abroad, are open to men and women who combine a base in technology with skills in identifying, analyzing, and implementing policy issues.

Students in the Program study problems of interest in a wide range of technological fields available at MIT, for example: computers, electronic systems, and communications; energy production and management; industrial innovation and productivity; disarmament; regulation of chemicals and pollution; transportation; marine and mineral resources; office automation; space technology; and solar and nuclear energy. A complete list of theses completed in the Program is available on request.

The Master of Science in Technology and Policy leads directly into public or private practice, or to continued graduate or professional study at MIT or elsewhere. Many students in the Program proceed to doctoral studies, either through departmental or interdepartmental arrangements. Others obtain further technical degrees or go on to law or business schools.

The small size of the Program, about 20 new students per year, provides a supportive context for students and encourages close interaction. We operate on the expectation that all new students are highly qualified, and we encourage collegial and cooperative relationships.

The Program helps the students develop: 1) advanced competence in a specific technological area of the student's choice, 2) skills in policy analysis, and 3) an understanding of the context of policy issues. Students either take or demonstrate competence in: 1) a concentration of advanced subjects in a chosen field of technology, 2) intermediate subjects in systems analysis and economics, 3) subjects in law and political processes, and 4) a sequence of integrative subjects and a thesis, intended to bring the previous subjects together. Academic credit is routinely granted for comparable studies done 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. To provide a common base for all participants in the Program, students are generally expected to enroll in the following subjects: TPP 21 Engineering Systems Analysis; TPP 11J and TPP 12J Project Proseminar in Technology and Policy; 15.012 Applied Micro- and Macroeconomics; TPP 22J The Policy-Making Process; TPP 13J Engineering Policy Thesis Seminar. All students complete a thesis before graduation.

The Proseminar helps students confront policy issues as they really are — complex, difficult, often ill defined, and full of conflicting values. It is the element that distinguishes this Program from just a set of subjects, and 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, and they are often done over the summer.

Students with prior interest and capabilities in technology and policy are expected to complete the degree program in one calendar year. Other students may need 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. Students can obtain part-time jobs as research assistants on MIT projects that match their areas of specialization, for example, in the Center for Policy Alternatives and the Energy Laboratory.

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 soon 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 faculty members and student representatives from the Departments of Aeronautics and Astronautics, Chemical Engineering, Civil Engineering, Electrical Engineering and Computer Science, Materials Science and Engineering, Mechanical Engineering, Nuclear Engineering, Ocean Engineering, Political Science, and Urban Studies and Planning, as well as from the Center for Policy Alternatives, the Energy Laboratory, and the Program in Science, Technology, and Society.

Further information may be obtained by contacting the Chairman, Professor Richard de Neufville, Room 1-138, MIT, Cambridge, Massachusetts 02139, (617) 253-7693, or the Associate Chairman, Professor Joel Clark, Room 8-413.

Undergraduate Research Opportunities Program (UROP)

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 *UROP Directory*, published each year, give details on how to get started. Students are urged to read this before they embark on their research. 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, Room 20B-141, or by calling (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 of the various interdepartmental laboratories, centers, and programs in the *Directory* and in this chapter of the catalogue.

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 are oriented around small, informal class discussions while others bring in speakers, go out on field trips, or involve extensive laboratory projects. Many of the topics are interdisciplinary and taught jointly by members of several departments. Other seminar topics are of particular interest to faculty members but are outside of their department's usual scope. Therefore, 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, Ms. Peggy Richardson, Room 7-105, MIT, Cambridge, Massachusetts 02139, (617) 253-3621.

Unspecified Degree Programs for Interdisciplinary Study (S.B.)

In a number of departments it is possible to take a less intensive "major," leading to an **undergraduate** degree which does not specify a professional field. To enroll for such a degree without specification, the student registers in the normal way in the department chosen. The added flexibility of an unspecified degree program, coupled with appropriate advice from the home department and from other departments, can give students a valuable opportunity for interdepartmental study.

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 nine-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 are telemetered directly to the Department of Earth, Atmospheric, and Planetary Sciences (Rooms 54-517 and 54-527). The data from the Observatory and the New England seismic network are recorded, analyzed, and displayed by a dedicated HP-1000 computer system. Data from the Observatory along with the numerous resources of the Department provide a unique facility for **undergraduates**, **graduate students**, and staff to pursue research concerning the interior of the earth.

Further information may be obtained by contacting the Director, Professor M. Nafi Toksöz, Room 54-518, MIT, Cambridge, Massachusetts 02139, (617) 253-6382.





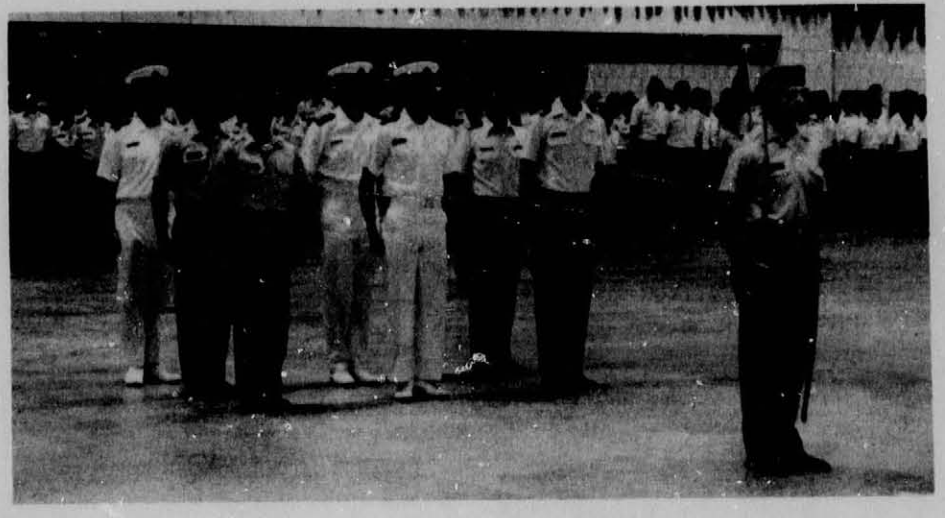


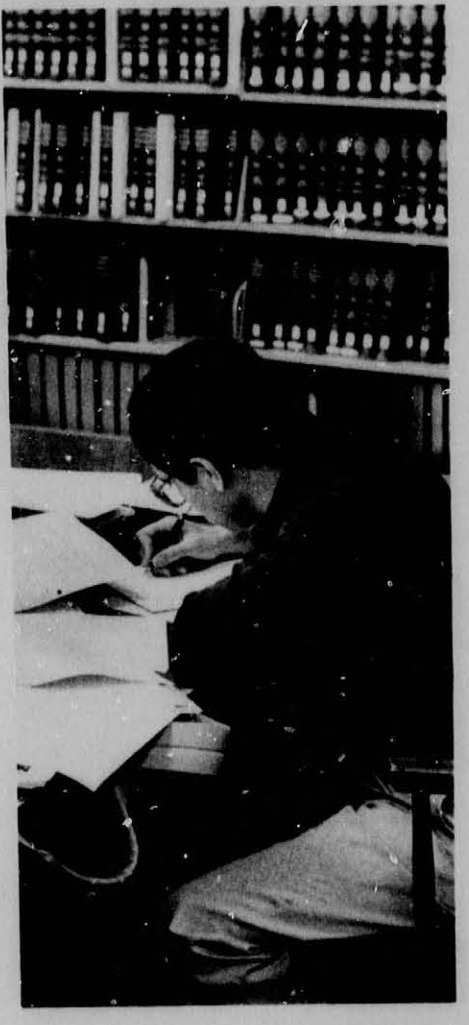


VI Departmental Programs and Requirements









School of Architecture and Planning



The first school of architecture in the United States was established at MIT in 1861 and the second college program in planning in 1932. The present School of Architecture and Planning continues in the forefront of architecture and planning education, benefiting from the special collaborations fostered in a university of science and technology.

Today the School prepares students to understand and structure the complex interaction of social influences, public policies, human requirements, aesthetic values, and technology, which leads to creative and equitable environments. The School views professional action as including a commitment to the release of others' resourcefulness and to the service of communities that have lacked access to professional services. These goals are nourished by a culturally diverse student body and faculty, recruited with a special emphasis on minorities and women.

Departments and Special Programs

The School consists of the Department of Architecture, the Department of Urban Studies and Planning, and a multidisciplinary research division, the Laboratory of Architecture and Planning. The Departments offer undergraduate, graduate-professional, and doctoral programs in architecture, planning, and visual studies, which prepare students for practice, research, and further study. Two special programs allow mid-career practitioners from minority communities who work in urban and regional development in the US and developing countries to study and pursue independent research during one academic year. In addition, the general Institute support for cross-registration at Harvard University gives professional students the opportunity to enrich their education at the Graduate School of Design and the Kennedy School of Government.

Departmental self-sufficiency is balanced by a strong interaction with other academic units at MIT. Several faculty members hold joint appointments in both departments of the School. Others have joint appointments in departments such as Economics, Civil Engineering, and Humanities. Teaching and research in several areas, such as urban economics, building technology, energy, communications, law, operations research, transportation, and the arts, are linked to other parts of the Institute. The most recent collaboration is the newly established joint program for Energy Efficient Buildings and Systems with the School of Engineering and the Energy Laboratory.

International engagements and their relation to educational and professional goals are an important factor in the reach and influence of the

School. These include the Special Program in Urban and Regional Studies (SPURS); the Technology Adaptation Program (TAP) for Egypt; the Aga Khan Program in Islamic Architecture; and teaching and exchange activities in South America, Japan, and China.

Arts and Media Technology

In the late 1940s MIT pioneered in relating experiments in science and engineering to the arts, which suggested an alliance through visual education of scientists and through the opportunity for artists to be stimulated by the tools and constructs of science and technology. In 1963 innovations in computer systems manipulating spatial data were introduced at MIT; in 1972 the Department of Architecture introduced television-based computer graphics, which resulted in the merger of video with computers.

The legacy of these concerns has been a range of professional programs in visual design, photography and video, and graphics in the School. Today the technologies from within those fields, from computer graphics, and from the related research in the interaction between people and machines, have led to a new era of collaboration in Arts and Media Technology. For a School concerned with the quality of the human environments, an extension of scope to include the media environment has been as reasonable as the extension years ago from the physical to the social environment.

Research and Field Experience

The School is also in the forefront of developing types of research, which can become as integral to practice as they are necessary to education. Approximately $3 million of research is being conducted in the School, much of it fostered and administered by the School's Laboratory of Architecture and Planning (LAP), described in Chapter V.

Research has informed course content, curricular structure, student careers and experience, and knowledge of practice. Sponsored research increasingly provides major financial support for students and faculty. Reports produced through research projects are distributed nationally, and a special education program provides opportunities for researchers to present their findings through continuing education courses, symposia, and special institutes. Researchers have also developed a number of collaborative ventures with colleagues in other universities and government.

Current research reflects the wide spectrum of student and faculty interests. These include studies of reinvestment in urban neighborhoods; the impact of telecommunications policy on human settlement; models for community analysis; the effect of major cutbacks in property taxes on public services; the effect of housing and its environs on special needs groups, including the elderly; passive solar energy systems; computer graphics for design; land use and facilities siting; and multiregional input/output analysis of economic activity and transportation. Research, particularly in the field of housing policy, is also conducted with the Joint Center for Urban Studies of MIT and Harvard.

As research assistants, students not only participate in existing projects but also help to formulate ideas for new proposals. In both architecture and planning, students have had a wide variety of field-related experiences in private and public sector programs. These include programming public services for the City of Cambridge; research assistance to Boston neighborhood organizations; staffing citizen land use planning organizations; advocacy planning and design assistance for citizen groups; and work in design, construction, and planning firms.

Office of the Dean

John de Monchaux, M.Arch.
Professor of Architecture and Urban Planning
Dean

Lois A. Craig, B.A.
Associate Dean

Barbara Lister-James
Assistant to the Dean

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Director, Laboratory of Architecture and Planning

Cynthia Ware, B.A.
Communications Coordinator

Department of Architecture

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Professor of Architecture
Head of the Department

Leon Bennett Groisser, Sc.D.
Professor of Structures
Executive Officer

Professors

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Professor of History and Architecture

Julian Beinart, M.C.P., M.Arch.
Professor of Architecture

Horacio Caminos, Arq.
Professor of Architecture

John de Monchaux, M.Arch.
Professor of Architecture and Planning
Dean, School of Architecture and Planning

Kurt W. Forster, Ph.D.
Professor of the History of Architecture

N. John Habraken, B.I.
Professor of Architecture
(On leave, fall)

Imre Halasz, Dipl. Arch.
Professor of Architecture

Richard Leacock, D.F.A.
Professor of Cinema

Henry A. Millon, B. Arch., M.Arch., Ph.D.
Professor of History and Architecture (Visiting)

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.
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Director of the Aga Khan Program for Islamic Architecture, MIT

Robert Ormerod Preusser
Professor of Visual Design

Maurice Keith Smith, B.Arch.
Professor of Architecture

Waclaw Piotr Zalewski, D. Tech. Sci.
Professor of Structures

Associate Professors

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Associate Professor of Media Technology

Muriel Cooper, B.F.A.
Associate Professor of Visual Studies

Eric Dluhosch, M.Arch., Ph.D.
Associate Professor of Building Technology

Fernando Domeyko-Perez, Dipl. Arch.
Associate Professor of Architecture

Richard Filipowski, B.A.
Associate Professor of Visual Design

David Hodes Friedman, Ph.D.
Associate Professor of the History of Architecture

Sandra C. Howell, Ph.D.
Associate Professor of Behavioral Science in Architecture

Andrew Lippman, M.S.
Associate Professor of Media Technology

Patrick Purcell, Ph.D.
Associate Professor of Computer Graphics
(Visiting)

Robert J. Slattery, M.Arch.
Associate Professor of Architecture

Chester Lee Sprague, M.Arch.
Associate Professor of Architecture

Jan Wampler, M.Arch.
Associate Professor of Architecture

Assistant Professors

Ranko Bon, Ph.D.
Assistant Professor of Economics in Architecture

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

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

Yasser Tabbaa, Ph.D.
Assistant Professor of the History of Architecture
Aga Khan Development Professor in the History of Islamic Architecture

Adjunct Professors

Wayne V. Andersen, Ph.D.
Adjunct Professor of the History of Art

Giancarlo De Carlo, L.A.
Adjunct Professor of Architecture

Robert Bradford Newman, M.Arch.
Adjunct Professor of Environmental Controls

Richard Chester Tremaglio, M.Arch.
Adjunct Professor of Architecture

Principal Research Scientist

Richard A. Bolt, Ph.D.

Principal Research Associate

Timothy E. Johnson, S.M.

Research Associate

Reinhard Goethert, M.Arch.

Lecturers

Nishan Bichajian
Glorianna Davenport, M.A.
John Furlong, M.L.A.
Dennis Frenchman, M. Arch., M.C.P.
Shun Kanda, M.Arch.
Gunter Nitschke, Dipl. Arch.

Technical Instructors

Ignacio Garabieta-Orueta, Dipl.
William F. Kelley, B.B.A.
Lee R. Silverman, M.F.A.
Brian Swift, M.F.A.

Administrative Officer

Anne Shepley, B.A.

Assistant to the Head of the Department

Nancy Jones, B.A.

Administrative Assistant

Linda Laplante, 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

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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 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 in 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, but rather six semesters of design (for the M.Arch. degree) which are divided into three levels. In the first level, the studios are coordinated. They deal with the same problems, based on the same documentation dealt with in the same sequence. The second level offers a choice of different studios with a range of programs and scales of intervention. The third level aims for greater complexity and/or greater depth.

Architectural design is taught from a broad range of perspectives -- as many as there are design professors. Linking these perspectives are several common concerns: site and context, reciprocal relationship between use and form, building systems and materials, and the architect's role. Context is considered in terms of existing and historical physical form (natural and constructed) and sociological patterns of use. Some studios deal with additive processes for the design and construction of environments responsive to people's needs and activities. All architectural design studios are centrally concerned with form-making.

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 and Spatial Imaging, 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.

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.

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.

Undergraduate Study

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 and spatial imaging, 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, arts, and social sciences 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	3 3 6
	Group 2 Design Information	
4.231	Computers and Graphics	4 2 6
4.26	Built-Form Observations	2 3 7
	Group 3 Environmental Technology	
4.30	Basic Structural Theory[2]	3 3 6
4.402J	Building Construction I	3 3 6
4.41	Materials, Techniques and Form	3 3 6
	Group 4 History of Art and Architecture	
4.605	Introduction to the History and Theory of Architecture	4 0 5
4.642	Modern Art from Impressionism to Cubism	3 0 6
4.645	Selected Topics in Architecture — 1750 to the Present	3 0 6
4.646	American Landscapes, Towns, and Buildings	3 0 6
4.651	Modern Art from Cubism to the Present	3 0 6
	Group 5 Social Context	
11.001	Introduction to Urban Development and Design	3 0 9
11.002	Introduction to Public Policy Analysis and Government Action	3 0 9
11.131	The Urban Neighborhood	3 0 9
	Restricted Electives (continued)	
	Group 6 Arts	
4.821	Visual 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	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 Department faculty members.

Graduate Study

Bachelor of Science
Course IV-B

	General Institute Requirements	Total Units
	Specific science and humanities, arts, and social sciences 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	3 3 6
	Group 2 Design Information	
4.231	Computers and Graphics	4 2 6
4.26	Built-Form Observations	2 3 7
	Group 3 Environmental Technology	
4.30	Basic Structural Theory[2]	3 3 6
4.402J	Building Construction I	3 3 6
4.41	Materials, Techniques and Form	3 3 6
	Group 4 History of Art and Architecture	
4.605	Introduction to the History and Theory of Architecture	4 0 5
4.642	Modern Art from Impressionism to Cubism	3 0 6
4.645	Selected Topics in Architecture — 1750 to the Present	3 0 6
4.646	American Landscapes, Towns, and Buildings	3 0 6
4.651	Modern Art from Cubism to the Present	3 0 6
	Group 5 Social Context	
11.001	Introduction to Urban Development and Design	3 0 9
11.002	Introduction to Public Policy Analysis and Government Action	3 0 9
11.131	The Urban Neighborhood	3 0 9
	Restricted Electives (continued)	
	Group 6 Arts	
4.821	Visual 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	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.

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 Studies 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; spatial imaging; 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. Subareas 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, and assistantships may be obtained from: Department of Architecture, Room 7-303, MIT, Cambridge, Massachusetts 02139, (617) 253-7791.

Department of Urban Studies and Planning

Gary Hack, M.Arch, M.U.P., Ph.D.
Associate Professor of Urban Studies and Environmental Design
Head of the Department

Professors

Alan A. Altshuler, Ph.D.
Professor of Urban Studies and Political Science
(On leave)

Philip David, M.B.A., Ph.D.
Professor of Urban Land Development
(Visiting)

John de Monchaux, M.Arch.
Professor of Architecture and Planning
Dean, School of Architecture and Planning

Aaron Fleisher, Sc.D.
Professor of Urban and Regional Studies

Robert M. Fogelson, Ph.D.
Professor of History and Urban Studies

Bernard Joel Frieden, M.C.P., Ph.D.
Professor of City Planning

Ralph A. Gakenheimer, M.R.P., Ph.D.
Professor of Urban Studies and Planning and Civil Engineering

Bennett Harrison, Ph.D.
Professor of Political Economy and Planning

Frank Sidney Jones, M.B.A.
Ford Professor of Urban Affairs

Langley Carleton Keyes, Ph.D.
Professor of City and Regional Planning

Richard Charles Larson, S.M.E.E., Ph.D.
Professor of Electrical Engineering and Urban Studies
Co-Director, Operations Research Center

Gary T. Marx, Ph.D.
Professor of Sociology

Lisa Redfield Peattie, Ph.D.
Professor of Urban Anthropology

Karen R. Polenske, Ph.D.
Professor of Regional Political Economy and Planning

William Lyman Porter, M.Arch., Ph.D.
Professor of Architecture and Planning
Director of the Aga Khan Program for Islamic Architecture, MIT

Martin Rein, M.S.W., Ph.D.
Professor of Sociology

Lloyd Rodwin, M.P.A., Ph.D.
Ford International Professor
Director, Special Program for Urban and Regional Studies (SPURS)
Head of Steering Committee
Joint Center for Urban Studies at MIT and Harvard

Donald Allen Schon, Ph.D.
Ford Professor of Urban Studies and Education

Lawrence E. Susskind, M.C.P., Ph.D.
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Associate Professors

Lawrence Bacow, J.D., Ph.D.
Associate Professor of Law and Environmental Policy

Leonard G. Buckle, Ph.D.
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Phillip L. Clay, Ph.D.
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Joseph Ferreira, Jr., S.M.E.E., Ph.D.
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Tunney F. Lee, M.Arch.
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(On leave)

William Wheaton, Ph.D.
Associate Professor of Economics and Urban Studies

Robert Yin, Ph.D.
Associate Professor of Urban Studies and Planning
(Visiting)

Assistant Professor

Yohel Camayd-Freixas, M.A., M.Ed., Ph.D.
Assistant Professor of Planning and Community Psychology

Merrie G. Klapp, Ph.D.
Assistant Professor of Environmental Studies and Planning

Lynne Beyer Sagalyn, M.C.P., Ph.D.
Assistant Professor of Planning and Real Estate Development

Adjunct Professors

Philip Barnard Herr, M.C.P.
Adjunct Professor of City Planning

Melvin H. King, M.Ed.
Adjunct Professor of Urban Studies and Planning
Director, Community Fellows Program

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Michael Joroff, M.C.P.
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Lecturers

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Belden Daniels, J.D.

Louise Dunlap, Ph.D.

Mark Schuster, Ph.D.

Alan Strout, Ph.D.

Richard Tabors, Ph.D.

Administrative Officer

Rolf R. Engler, A.S.A.

Professors Emeriti

Roland Bradford Greeley, M.C.P.
Professor of Regional Planning, Emeritus

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 (DUSP) offers several degree and nondegree programs: Bachelor of Science in Planning; 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 less developed areas); the Community Fellows Program (for mid-career professionals from communities of color 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 experience 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. Planners operate at the neighborhood, metropolitan, state, or national level, in the public and private sector. Their tasks are the same: to help frame the issues and problems which receive attention, 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 national 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 educate professionals and scholars who as practitioners 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 working with capable practitioners and then bringing field experiences back into the academic setting for reflection and discussion. Students may work in community organizations or government agencies, or 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, learn, and teach. In many instances, student organized activities begun during the Independent Activities period have subsequently been incorporated into the basic academic program.

Bachelor of Science in Planning
Course XI — Option 1

The Department of Urban Studies and Planning offers an interdisciplinary preprofessional program designed to prepare students for careers as planners, analysts, advisors, and managers in either the public or private sectors. Course work stresses knowledge and skills for: 1) defining and responding to community needs, 2) evaluating and designing public policies and programs, and 3) allocating resources in an efficient and equitable manner.

The core of the program provides basic knowledge of community and environmental systems, the social science concepts used to describe them and the methods and techniques with which they can be analyzed, planned, and changed. Students begin with one introductory subject linked to either the design or policy side of planning, plus three social science subjects introducing basic concepts from the disciplines of sociology, political science, and economics. The two-subject sequence in planning and applied social research then builds on these introductory subjects to develop skills in practical problem solving. Students are also expected to sharpen their analytic skills through both the required statistics subject and the laboratory.

Student participation in departmental research and public sector internships is an important part of the program. Faculty members will help students formulate, design, and undertake a personal project synthesizing what they have learned. The project may involve a focused attempt at analysis, or a report on a problem-solving experience accomplished through a fieldwork assignment or the result of a workshop.

Students are free to develop their own specializations in consultation with their advisors. Three areas of specialization are suggested by the Department.

Environmental Planning serves students seeking careers in managing and analyzing the quality of the environment. Students may subsequently become specialists in planning, law, engineering, or 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. Possible subjects include:

11.014J American Urban History II
11.122 Environmental Policy and Regulation
11.123 Environmental Quality Assessment
11.334 Environmental Ecology and Natural Resource Management

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. Possible subjects include:

11.131 The Urban Neighborhood
11.139 Introduction to Community Development
11.336J Site Planning

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. Possible subjects include:

11.165 Law and Public Policy
11.166 Legal Institutions and Social Change

Bachelor of Science in Urban Studies Course XI—Option 1

	General Institute Requirements	Total Units
	Specific science and humanities, arts, and social sciences subjects[1]	132
	The Science Distribution Requirement may be satisfied by 18.057 which is required in the Departmental program plus two additional subjects[2]	24
	The Laboratory Requirement may be satisfied by 11.188 which is required in the Departmental program.	
	Departmental Program	
	Required Subjects	**at least 100**
	Group I: Introduction	
11.001	Introduction to Urban Development and Design	3 0 9
	or	
11.002	Introduction to Public Policy Analysis and Government Action	3 0 9
	Group II: Social Science	
11.005	Urban Social Structure and Process	3 0 6
11.007J	Politics and Public Policy	3 0 9
14.01	Economic Principles I	3 0 6
	Group III: Planning and Applied Social Research	
11.003	Planning and Applied Social Research I	4 0 8
11.004	Planning and Applied Social Research II	4 0 8
11.188	Laboratory in Research Methods	2 5 5
18.057	Introduction to Applied Statistics	3 2 7
	Group IV: Senior Project	
	Senior Project	10-24
	Planned Electives	**at least 45**
	A coherent selection of five subjects in planning and applied social science developed in consultation with the student's departmental advisor. The student must include at least one additional social science subject such as 11.008J Urban Economics or 11.014J American Urban History II; at least 12 units of approved internship, fieldwork, or workshop experience; and at least three subjects comprising an approved area of specialization.[3]	
	Unrestricted Electives[4]	**at least 59**
	Total Units Required for the S.B. Degree	**360**

Bachelor of Science in Planning 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 S.B. in Planning, but a letter provided upon graduation by the Combined Program Committee confirms the student's participation in the program.

1
Of this total, the Requirement in Humanities, Arts, and Social Sciences accounts for eight subjects totaling at least 72 units. Normally, five of these eight subjects (all but the three Distribution Subjects) are contained within the Departmental Program. This has the practical effect of increasing the number of unrestricted electives by 45, to a total of 95.

2
A computer-related subject such as 1.00 Introduction to Computers and Engineering Problem Solving is suggested as one of the two unspecified science distribution subjects.

3
Students may define their own area of specialization in consultation with their advisor or select one of the three structured by the Department: Environmental Planning; Neighborhood and Community Planning; and Public Policy, Urban Management and the Law.

4
Up to 45 additional units of unrestricted electives may be obtained if subjects required in the Departmental program are counted toward the Humanities, Arts, and Social Sciences Requirement. The social science subjects in the Departmental Program (Group II) qualify as electives and three of the planned electives in the Departmental Program can be designated as the student's Field of Concentration.

Graduate Study

Bachelor of Science in Planning Course XI—Option 2

	General Institute Requirements	Total Units
	Specific science and humanities, arts, and social sciences subjects[1]	132
	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[2]	12
	Departmental Program	
	Required Subjects	72
1.00	Introduction to Computers and Engineering Problem Solving 3 1 8	
1.01J	Engineering Aspects of Economic Analysis 4 0 8	
1.02	Civil Engineering Systems Analysis I 3 2 7	
1.03	Civil Engineering Systems Analysis II 3 2 7	
11.001	Introduction to Urban Development and Design 3 0 9	
	or	
11.002	Introduction to Public Policy Analysis and Government Action 3 0 9	
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
Of this total, the Requirement in Humanities, Arts, and Social Sciences accounts for eight subjects totaling at least 72 units. Normally, at least one subject required in the Departmental Program can be counted toward this Requirement. This has the practical effect of increasing the number of unrestricted electives.

2
Suggested subject — 11.188

3
Up to 27 additional units of unrestricted electives may be obtained if three of the planned electives in the Departmental Program are designated as the student's Field of Concentration.

Bachelor of Science in Planning 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, 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 planning 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, environmental studies, architecture, political science, civil engineering, economics, sociology, law, management, geography, 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, and financial aid may be obtained from the Graduate Admissions Secretary, Room 7-338, MIT (617) 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 at the end of the first semester of study 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

Three subjects, taught in conjunction with each other during the first term of the student's career in the Department, constitute a "core experience" which we view as central to the professional degree course of study as well as effective planning practice itself. M.C.P. candidates are required to complete core subjects during their first term. Briefly the core subjects are:

- 11.200 Planning and Institutional Processes: basic paradigms and theories of planning practice. Evaluation of historical and current developments in the field of planning with special emphasis on the institutional setting of planning in American society. Lectures, case studies, and comparative analyses explore the changing roles of the planner and the key dilemmas in planning practice. Focuses on strategies of institutional intervention and implementation.
- 11.210 Political Economy for Planners: introduction to political economy for planners, emphasizing economic institutions and structural analysis of standard economic theory and public policy grounded in that theory. Models of individual and aggregative economic behavior, institutional analysis of economic power, introduction to Marxian political economy. Topics vary (e.g., poverty and discrimination, changing urban form, industrial location).
- 11.220 Quantitative Reasoning and Statistical Methods for Planning: development of logical, empirically based arguments using statistical techniques and analytic methods. Covers elementary statistics, probability, and other types of quantitative reasoning useful for description; estimation, comparison, and explanation. Emphasizes uses and limitations of analytical techniques in planning practice.

In addition, a first-year M.C.P. student is expected to complete two methods modules chosen from a series of modules (averaging six to nine weeks in length) covering: decision analysis, impact assessment, cost-benefit analysis, multivariate analysis, analysis of neighborhood and regional change, survey design, and several other analytic and communications techniques.

Students have an opportunity to test out of 11.210 and 11.220, and are encouraged to take the place-out exams if only to diagnose their own strengths and weaknesses. There is no exam to test out of 11.200.

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 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; learning 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 toward 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 and Real Estate Development focuses on the planning and management of urban development, and especially on the design, location, and financing of housing. Emphasis is on analysis of the financial dimensions of real estate, public policies that affect housing conditions and private development, incentives in the development sector, land use regulations, and assessment of markets and housing needs. Public-private partnerships for real estate development construction issues, and the operation of financial markets are other important subjects.

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. Work spans developed and less developed countries.

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.

Thesis

All students are required to submit a thesis on a topic of their choice.

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 provides 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.). The details of this dual degree are described in Chapter V under the Center for Transportation Studies.

Doctor of Philosophy

Students 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. We do not require a M.C.P. or equivalent for admission for Ph.D. studies.

The doctoral program emphasizes the role of knowledge acquired through research in the formulation of public policy, the development of fundamental research competence, and flexibility in the exploration of questions which no single discipline can address. Students work under the mentorship of faculty advisors. They may center their work on any field where there is faculty expertise. Some current faculty research preoccupations include: 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; the nature of planning practice; public-private relationships in development; and infrastructure rehabilitation.

After successful completion of a required first-year doctoral seminar, a subject covering qualitative and quantitative methods of research, 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 be registered for at least 30 credit units each term.

Students must take oral and written examinations in three fields: a broad intellectual discipline (urban economics, urban history, environmental design, institutional analysis); an area to which this is applied (infrastructure planning, transportation planning, settlement design, housing, economic development); and a specific subject within this area in which the student is likely to center his or her thesis. The examination committee may include faculty from other MIT departments and may be chaired by a DUSP faculty member.

Doctoral candidates usually require at least two terms of study in residence before taking their examinations and beginning their dissertations, although the process 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 count 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 to 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 10-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 rogular 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.

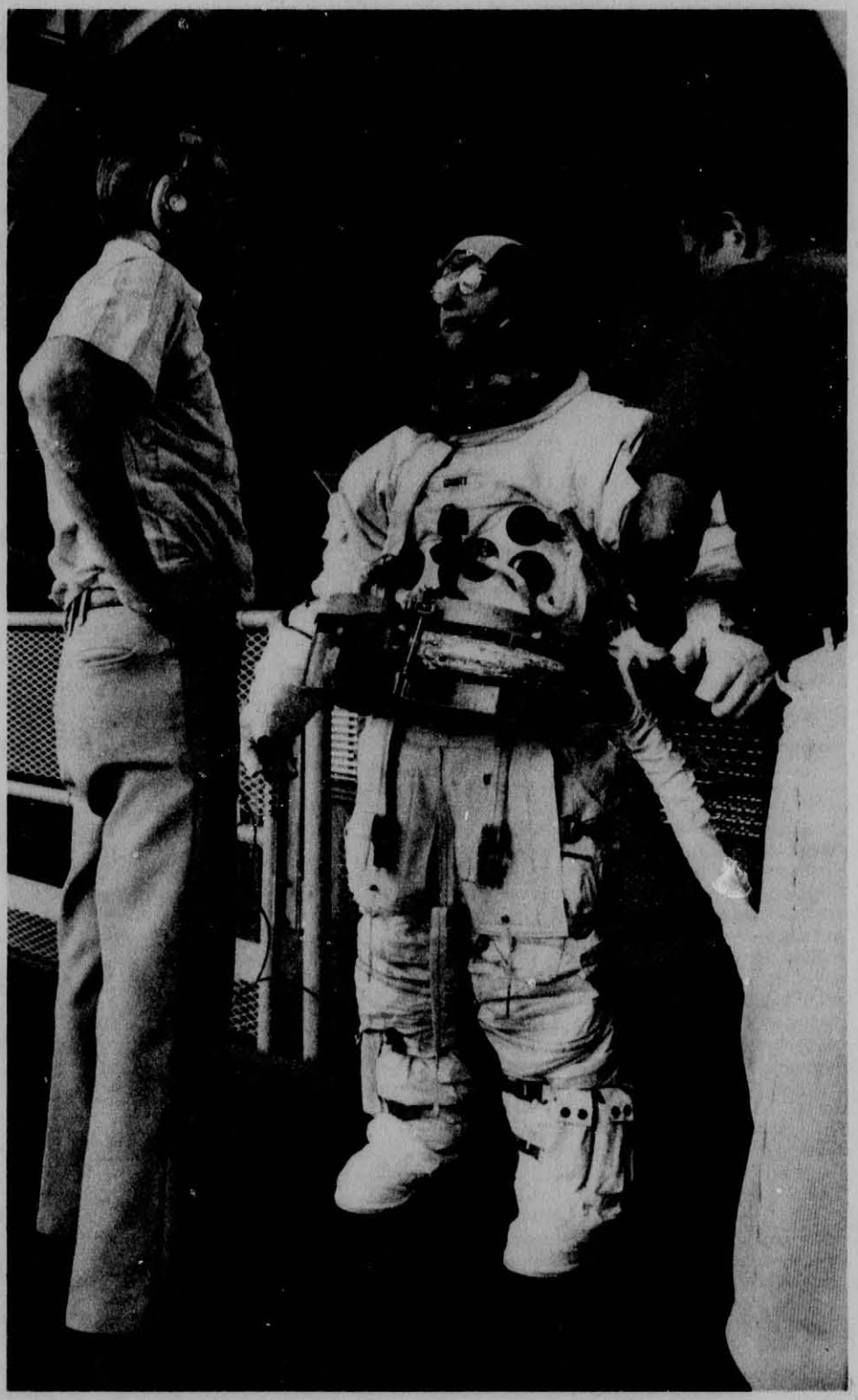
Areas of special emphasis include: development of urban and regional growth strategies within the framework of national development and planning; problems of low-income and migrant housing and settlement in cities; environmental planning; transportation; project evaluation; social aspects of the development 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 Food and Nutrition 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, nor the opportunities of engineering 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 standard of living and quality of life. Never has the role of the engineer been more exacting.

Engineering is a creative profession 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 engineering education to other fields such as law, medicine, management, and government.

The School of Engineering at MIT recognizes today's educational challenges and is meeting 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, government, and educational institutions. Hence their education at MIT is viewed as being only one step in a lifelong 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.

Engineering Internship Program

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.

The academic departments provide the primary homes for faculty, students, and degree programs and provide continuity and stability for the basic engineering disciplines. However, the departments increasingly share common interests in the broad applications areas to which their individual disciplines and technologies apply. Among the major applications of concern to faculty and students from most of the engineering departments are: energy supply, conversion, and conservation; transportation (air and space, ocean, urban, rail, and automotive); communication and information processing (including computer design and utilization); manufacturing and processing; construction; materials and the extraction and processing of natural resources; environmental issues; and biomedical engineering and biotechnology. The interdepartmental centers, laboratories, and programs provide the mechanisms and facilities for faculty and students to undertake collaborative research and engage in educational programs dealing with these and other interdisciplinary applications of importance to society.

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 disciplines from the Schools of Science, Management, Humanities and Social Science, and Architecture and Planning with those of the School of Engineering.

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 make more informed choices from among the various on-campus educational offerings, and 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 at the end of the subject description chapter of this catalogue.

Computer Models of Physical and Engineering Systems U(1) SD
1.12, 2.101, 3.05, 10.11, 13.51, 16.008, 22.006

Introduction to Technology and Law U(1)
1.165, 2.998, 10.803, 15.97, 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)
1.155, 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, TPP 21

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, Programs, 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 Construction Research and Education

Center for Materials Science and Engineering

Center for Policy Alternatives

Center for Sensory Aids Evaluation and Development

Center for Transportation Studies

Cryogenic Engineering Laboratory

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

Lincoln Laboratory

Man-Vehicle Laboratory

Materials Processing Center

MIT Sea Grant College Program

Nuclear Reactor Laboratory

Operations Research Center

Program for Energy-Efficient Buildings and Systems

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

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 degree programs are accredited by the Accreditation Board for Engineering and Technology. However, given their more general nature, the School of Engineering has not sought accreditation for any undesignated degree programs. Holders of an accredited-program degree can generally take examinations for professional registration with fewer years of experience than holders of unaccredited or non-engineering program 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.
Vannevar Bush Professor
Professor of Electrical and Mechanical Engineering
Dean

Herbert Heath Richardson, Sc.D.
Professor of Mechanical Engineering
Associate Dean

Eric Johnson, S.B., M.S.
Assistant Dean for Resource Development

Donna R. Savicki, B.S., M.S.
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

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.
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Director, Center for Policy Alternatives

Lawrence L. Bucciarelli, Ph.D.
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James M. Utterback, Ph.D.
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Director, Industrial Liaison Program

Professor Emeritus

Alfred Adolf Heinrich Keil, Dr. Rer. Nat.
Professor of Ocean Engineering, Emeritus
Ford Professor of Engineering, Emeritus

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Richard Cockburn Maclaurin Professor of Aeronautics and Astronautics
Head of the Department

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Institute Professor, Emeritus
Professor of Aeronautics and Astronautics, Emeritus
Senior Lecturer

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James Elliot McCune, Ph.D.
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Senior Lecturer

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Charles Oswald Cary
William Rede Hawthorne, Sc.D.
Donald John Jordan, B.S.
John Regnier Wiley, S.B.

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Zong-Shu Tian
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Senior Lecturer

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Senior Lecturer

Walter Wrigley, Sc.D.
Professor of Instrumentation and Astronautics, Emeritus

The objectives of the Department of Aeronautics and Astronautics are two-fold: 1) to provide a broad and fundamental undergraduate program such that our students will have a basic understanding of all facets of the aeronautics and astronautics profession, and 2) to provide a basic- and research-oriented graduate program which will enable faculty and students to conduct research for the advancement of aeronautics and astronautics.

The aerospace community is unusual with its demands on advanced technology, and in its responsibility for large complex vehicles and systems which demand excellence in engineering and management. It encompasses a wide range of talent, frorn 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 education 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 industry, which is served by the Department of Aeronautics and Astronautics, is concerned with flight transportation and space systems. The most important component of either system is the vehicle. Thus, the primary focus of the Department is directed toward vehicles such as transport aircraft, high-performance military aircraft, launch vehicles, spacecraft such as the Orbiter of the Space Transportation System, satellites, and space stations. The subjects of instruction are designed to impart the understanding of those disciplines which form the engineering foundation necessary to design, build, and operate those vehicles. The research has as its basic goal the improvement and enhancement of the vehicle and, thereby, the transportation or space system. There is a wide variety of challenging positions in the aerospace industry for qualified engineers. While the Course XVI program is focused on flight transportation and space vehicles, it also covers the basic disciplines found in other departments. Thus, our undergraduate and graduate programs are a preparation for all areas of engineering.

Undergraduate Study

The required undergraduate curriculum does not encourage specialization, but instead prepares the student to become either a practicing engineer or to continue on to graduate studies in any of the specialties. This is accomplished by the following core Departmental requirements of the Bachelor of Science Degree: 1) a fall-spring introductory subject called Unified Engineering requiring 48 units of effort, 2) a tier of disciplinary subjects, 3) an Experimental Projects Laboratory, and 4) a Systems Engineering subject. The Unified Engineering subject includes all the disciplines required by aerospace systems and is taught by a team of faculty in a way which emphasizes the interrelationships required for design of aerospace systems such as airplanes and spacecraft. Basic concepts are introduced in Unified Engineering and then are given additional mathematical and physical foundations in the next tier of subjects, which are taught separately and in the more traditional manner. The Undergraduate Projects Laboratory has all the attributes of an undergraduate experimentally oriented thesis and additionally requires students to make oral presentations of their progress and final results to their peers and faculty. The written project reports are critically reviewed for writing style and exposition by faculty from the School of Humanities and Social Science. Finally, the Systems Engineering subject requires students, as a team, to pull together their undergraduate education through the design of an operating system such as a manned space station or a vertical takeoff airplane. As an extra dimension to their education, undergraduates are encouraged to become involved in the research activities of the Department through UROP, the Undergraduate Research Opportunities Program. Many of the faculty actively seek undergraduates to become a part of their research team. Research opportunities are outlined under Graduate Study. It also should be noted that the advanced undergraduate student, through careful selection and scheduling of the elective freedom, can progress to graduate subjects in one or more areas of interest.

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.

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. Research is conducted in the Departmental laboratories: Fluid Dynamics Laboratories, the VTOL 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 Computational Fluid Dynamics Laboratory, the Laser Systems Laboratory, the Flight Transportation Laboratory, the Low-Turbulence Facility, the Molecular Beam Laboratory, the Wright Brothers Wind Tunnel Facility, and the Space Systems Laboratory. Each of these is described briefly in the section on Graduate Study.

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 six 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, 5) Aeronautical and Astronautical Systems, and 6) Biomedical Engineering. 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) or Space Gas Dynamics (16.06), 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 Gas Dynamics (16.06), 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 or 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 Accreditation Board for Engineering and Technology. 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, arts, and social sciences 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	5 2 5	
16.002	Unified Engineering II	5 2 5	
16.003	Unified Engineering III	5 2 5	
16.004	Unified Engineering IV	5 2 5	
18.03	Differential Equations	4 0 8	
	Advanced Required Subjects		75
	Either		
16.02	Aerodynamics	4 0 8	
	or		
16.06	Space Gas Dynamics	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

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 16.292 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.

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 be taken as early as possible, and c) that 21.780 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.

An undergraduate program concentrating in instrumentation, guidance, and control should include 16.30 Principles of Automatic Control, 16.311 Principles of Instrumentation and Control, 16.312 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 Models of 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 or sophomore year, in addition to a two-term sequence of humanities which should be selected with a view to understanding the growth and structure of society. 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, arts, and social sciences 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 or 102**
6.002	Circuits and Electronics	4 2 9
	Either	
6.012	Electronic Devices and Circuits	4 0 8
	or	
6.003	Signals and Systems	4 2 9
8.03	Physics III	5 0 7
16.001	Unified Engineering I	5 2 5
16.002	Unified Engineering II	5 2 5
16.003	Unified Engineering III	5 2 5
16.004	Unified Engineering IV	5 2 5
18.03	Differential Equations	4 0 8
	Advanced Required Subjects	**84**
6.111	Introductory Digital Systems Laboratory	3 7 2
	Either	
6.301	Solid State Circuits	3 3 6
	or	
16.61	Microcomputer Laboratory	2 8 2
	One of the following subjects:	
16.02	Aerodynamics	4 0 8
	or	
16.06	Space Gas Dynamics	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
	Advanced Required Subjects (continued)	
	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 or 378**

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 be taken as early as possible, and c) that 21.780 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.

Graduate Study

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 alternating with periods of 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.

Double Degree Program

Students may pursue two S.B. degrees under the Double Degree Program outlined in Chapter III of this catalogue. In particular, some students may wish to combine a professional education in Aeronautics and Astronautics with a liberal education which links the development and practice of science and engineering with their social, economic, historical, and cultural contexts. For them the Department of Aeronautics and Astronautics and the Department of Humanities in cooperation with the Program in Science, Technology, and Society offer a double degree program which combines majors in Course XVI and Course XXI. A detailed description of that integrated degree program will be found among the Humanities Programs described later in this chapter.

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 lowspeed 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. The focus of the Computational Fluid Dynamics Laboratory is on algorithm development and its application to external and internal flow fields, but each laboratory has access to several computational systems interactively and to specialized experimental equipment. 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 low-turbulence wind tunnel particularly suited to studies of boundary layer transition and turbulence, as well as suited to airfoil studies, supports an active research program in these areas. An additional 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 composites, 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 exploitation of space has begun in earnest with the success of the Shuttle and the Space Transportation System, and research is beginning on how best to exploit the zero-g and high vacuum environment of space.

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, 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, estimation, lasers, digital systems, and other related topics.

One 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 and offers opportunities for participation to students of US citizenship. 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.

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.

Other control-related research projects are carried out in the Space Systems Laboratory and elsewhere in the Department. Much of this work currently relates to control of large flexible assemblies in space.

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. 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 18.03 Differential Equations or its equivalent 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, of which at least 21 units must be in Departmental 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 and engages the student in significant project work integrating technology and policy. 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 under Biomedical Engineering. 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). 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.

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Charles Leland Cooney, Ph.D.
Professor of Chemical and Biochemical Engineering

Lawrence Boyd Evans, Ph.D.
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Jack Benny Howard, Ph.D.
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Edward Wilson Merrill, Sc.D.
Carbon P. Dubbs Professor of Chemical Engineering

Robert Clark Reid, Sc.D.
Chevron Professor of Chemical Engineering
Graduate Officer

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
Vice President for Research

Johnson Edward Vivian, Sc.D.
Professor of Chemical Engineering, Emeritus
Senior Lecturer

Daniel I.C. Wang, Ph.D.
Professor of Chemical and Biochemical Engineering

Glenn Carber Williams, Sc.D.
Professor of Chemical Engineering

Associate Professors

Robert Calvin Armstrong, Ph.D.
Associate Professor of Chemical Engineering
(On leave, spring)

Robert Arthur Brown, Ph.D.
Associate Professor of Chemical Engineering

William Murray Deen, Ph.D.
Associate Professor of Chemical Engineering

Ulrich Werner Suter, Dr.Sc.Techn.
Texaco-Mangelsdorf 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

Preetinder Singh Virk, Sc.D.
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Assistant Professors

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Station Director, School of Chemical Engineering Practice

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Du Pont Assistant Professor of Chemical Engineering

Trevor Alan Hatton, Ph.D.
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George Albert Huff, Jr., Sc.D.
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Joseph R. Mares Assistant Professor of Chemical Engineering

Herbert Harold Sawin, Ph.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)
David John Goldstein, Sc.D.
(Visiting)
Michael Patrick Manning, Sc.D.
Barry Alan Solomon, Ph.D.
(Visiting)
Peter McAllum Walsh, Ph.D.
Warren Myron Zapol, M.D.
(Visiting)

Instructors

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Brian Eric Thompson, M.S.
Assistant Station Director, School of Chemical Engineering Practice

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Charles V. Berney, Ph.D.

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David Meyer Yarmush, Ph.D.

Postdoctoral Fellow

Romain Wolf, Ph.D.

Technical Instructor

Stanley Robert Mitchell

Visiting Engineers

James Peyton Enniss, M.S.
Amitava Mitra, M.Sc.

Visiting Scientists

Eric Bulot, Eng.
Jack Nelson Lindon, Ph.D.
Michael Pagitsas, Ph.D.
Edwin W. Salzman, M.D.
Michael Bernard Stemerman, M.D.

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 Accreditation Board for Engineering and Technology 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, arts, and social sciences 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	
	Chemical Engineering	**at least 18**
	The subjects 10.10, 10.11, 10.801, 10.802J, 10.803, 10.804, 10.805J, 10.806, 10.808, and 10.816 may not be used to satisfy this requirement.	
	Technology	**at least 18**
	Any subject in Chemistry, Biology, or Materials Science and Engineering (except 3.171, 3.19, and freshman seminars), and the subjects 6.071, 6.101, 6.150J, and 20.002 may be used to satisfy this requirement.	
	Restricted Electives (continued)	
	Laboratory Work. Eighteen (18) units included in the 36 units in the above categories must be associated with laboratory subjects. Thesis may be elected to satisfy 12 units. The subject 10.91 or equivalent may be used to satisfy no more than 6 units. The ungraded subject 10.UR or equivalent may not be used.	
	Unrestricted Electives[2]	**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
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.

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, 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, arts, and social sciences 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 10.10, 10.11, 10.801, 10.802J, 10.803, 10.804, 10.805J, 10.806, 10.808, 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. Students in the five-year program normally enroll in the School of Chemical Engineering Practice.

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, and financial aid may be obtained by writing to Professor C. M. Mohr, Undergraduate Officer, Department of Chemical Engineering, Room 66-405, MIT, Cambridge, Massachusetts 02139, (617) 253-2015.

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 and Chemical Process Pathways
10.40	Chemical Engineering Thermodynamics
10.59J	Biochemical Engineering
10.591J	Biochemical Engineering Laboratory
10.60	Heterogeneous Catalysis and Catalytic Processes
10.65	Chemical Reactor Engineering
10.655	Multiphase Chemical Reactors
10.67	Polymer Science Laboratory
10.681	Physical Chemistry of Polymers
10.691	Synthesis of Polymers
10.75	Principles of Fuel Conversion

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. Recent achievements in molecular biology have greatly stimulated interest in biotechnology and offer exciting opportunities to the chemical engineer. Biotechnology is the integration of biochemistry, microbiology, and chemical engineering. The interface between biological sciences and engineering principles is

achieved through biochemical engineering. Important problems in this field are biocatalysis, microbial kinetics, transport phenomena in biological and particularly microbial systems, bioseparations, bioreactor design, and control of microbial reactions. The Department has active research programs in all these fields. Students interested in biochemical engineering have the opportunity to participate in an active research program while taking coursework in a variety of relevant subjects offered by the Department including:

10.25	Industrial Chemistry and Chemical Process Pathways
10.50	Heat and Mass Transfer
10.565	Seminar in Separation Processes for Biochemical Products
10.65	Chemical Reactor Engineering
10.59J	Biochemical Engineering
10.591J	Biochemical Engineering Laboratory

Also recommended are subjects in biochemistry, microbiology, enzymology and molecular biology which are taught in other Departments (Biology, Chemistry, and Nutrition and Food Science).

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 Heat and Mass Transfer
10.641	Molecular and Morphological Engineering 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.

Reaction Engineering. Chemical reactor engineering is concerned with the science and technology of chemical reactions that take place in reactors, leading to the production of useful chemicals and materials. It is the counterpart to Unit Operations, which is concerned only with physical processes. The heart of a chemical plant or refinery is a reactor, surrounded by pumps, heat exchangers, and separation equipment. Many exciting new advances were made in the past decade on innovations in catalysts and reactor design.

Active research programs in many aspects of this field are being carried out, and the following set of courses are especially relevant:

10.25	Industrial Chemistry and Chemical Process Pathways
10.33	Analytical Treatment of Chemical Engineering Processes
10.40	Chemical Engineering Thermodynamics
10.50	Heat and Mass Transfer
10.59J	Biochemical Engineering
10.591J	Biochemical Engineering Laboratory
10.60	Heterogeneous Catalysis and Catalytic Processes
10.65	Chemical Reactor Engineering
10.651J	Fluidization
10.655	Multiphase Chemical Reactors

Process and Systems 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
10.331	Nonlinear Analysis in Chemical Engineering
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
10.40	Chemical Engineering Thermodynamics
10.50	Heat and Mass Transfer
10.51	Macromolecular Hydrodynamics
10.52	Mechanics of Fluids
10.54	Advanced Topics in Heat and Mass Transfer
10.615	Integrated Circuit Processing
10.651J	Fluidization
10.655	Multiphase Chemical Reactors
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 also 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:

Advanced Degrees

10.39	Energy Technology
10.40	Chemical Engineering Thermodynamics
10.48J	Gas-Solid Reactions
10.50	Heat and Mass Transfer
10.52	Mechanics of Fluids
10.60	Heterogeneous Catalysis and Catalytic Processes
10.65	Chemical Reactor Engineering
10.651J	Fluidization
10.655	Multiphase Chemical Reactors
10.70	Principles of Combustion
10.72	Seminar in Air Pollution Control
10.73	Seminar in Fuel Conversion and Utilization
10.74J	Radiative Transfer
10.75	Principles of Fuel Conversion

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
10.615	Integrated Circuit Processing
10.641	Molecular and Morphological Engineering 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	Structure and Shape of Macromolecules
10.691	Synthesis 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, polymers in turbulent drag reduction, and polymers for medical application. 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. The Practice School program stresses problem solving in an engineering internship format, where students undertake projects at industrial sites under the direct supervision of resident MIT faculty. Credit is granted for participation in Practice School in lieu of preparing a master's thesis.

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 contnoutions 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 in the Practice School Program are required to demonstrate proficiency in or take one graduate subject in each of the following areas: Thermodynamics, Heat and Mass Transfer, Applied Process Chemistry, Kinetics and Reactor Design, and Applied Mathematics.

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 unit 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 36 units of practice school experience 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 eco-

nomics, systems analysis, political science, and law and engages the student in significant project work integrating technology and policy. 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 at the end of this chapter on MIT's Joint Program in Oceanography and 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

Jerome Joseph Connor, Jr., Sc.D.
Professor of Civil Engineering

Richard Lawrence de Neufville, Ph.D.
Professor of Civil Engineering
Chairman, MIT Technology and Policy Program

Peter Sturges Eagleson, Sc.D.
Professor of Civil Engineering

Herbert Heinrich Einstein, Sc.D.
Professor of Civil Engineering

Ann Fetter Friedlaender, Ph.D.
Professor of Civil Engineering and Economics
Head, Department of Economics

Ralph A. Gakenheimer, Ph.D.
Professor of Civil Engineering and Urban Studies and Planning

Lynn Walter Gelhar, Ph.D.
Professor of Civil Engineering

Donald R.F. Harleman, Sc.D.
Professor of Civil Engineering
Ford Professor of Engineering

Charles Cushing Ladd, Sc.D.
Professor of Civil Engineering

Steven Richard Lerman, Ph.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

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

Frank Edward Perkins, Sc.D.
Professor of Civil Engineering
Associate Provost

Daniel Roos, Ph.D.
Professor of Civil Engineering
Director, Center for Transportation Studies

Erik Hector Vanmarcke, Ph.D.
Professor of Civil Engineering

Daniele Veneziano, Ph.D.
Professor of Civil Engineering

Robert Van Duyne Whitman, Sc.D.
Professor of Civil Engineering
(On leave, spring)

Nigel Henry Moir Wilson, Ph.D.
Professor of Civil Engineering

Associate Professors

Mohsen Mohamed Baligh, Ph.D.
Associate Professor of Civil Engineering

Gregory Bert Baecher, Ph.D.
Associate Professor of Civil Engineering

Moshe Emanuel Ben-Akiva, Ph.D.
Associate Professor of Civil Engineering

Rafael Luis Bras, Sc.D.
Associate Professor of Civil Engineering

Oral Buyukozturk, Ph.D.
Associate Professor of Civil Engineering

Sallie W. Chisholm, Ph.D.
Associate Professor of Civil Engineering
(On leave)

Harold Field Hemond, Ph.D.
Henry L. Doherty Career Development Associate Professor of Civil Engineering

Henry G. Irwig, Ph.D.
Gilbert W. Winslow Career Development Associate Professor of Civil Engineering

Eduardo Kausel, 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

Michael D. Meyer, Ph.D.
Associate Professor of Civil Engineering
(On leave, fall)

Yosef Sheffi, Ph.D.
Associate Professor of Civil Engineering

Keith Densmore Stolzenbach, Ph.D.
Associate Professor of Civil Engineering
(On leave)

Assistant Professors

Amr S. Azzouz, Sc.D.
Assistant Professor of Civil Engineering

Philip M. Gschwend, Ph.D.
Assistant Professor of Civil Engineering

George Andrew Kocur, Ph.D.
Assistant Professor of Civil Engineering

Victor C. Li, Ph.D.
Esther and Harold E. Edgerton Assistant Professor of Civil Engineering

S. Shyam Sunder, Ph.D.
Assistant Professor of Civil Engineering

John H. Slater, Ph.D.
Assistant Professor of Civil Engineering

Clifford Winston, Ph.D.
Assistant Professor of Civil Engineering

Senior Lecturers

James Martin Becker, Ph.D.
Edward Emmet Newman, S.M.
William Walther Seifert, Sc.D.

Lecturers

E. Eric Adams, Ph.D.
John T. Germaine, Ph.D.
Thomas F. Humphrey, M.S.

Senior Administrative Officer

Trond H. Kaalstad, M.S.

Administrative Assistants

Paulette Chiles
Theresa Demeris
Patricia Dixon
Victoria H. Murphy, B.A.

Senior Research Associate

Robert T. Martin, Ph.D.

Principal Research Associate

Carl D. Martland, C.E.

Research Associates

Charles H. Helliwell, S.M.
Susan Huntsman, Ph.D.
Michael J. Markow, M.S.

Research Engineer

Brian D. Brademeyer, M.S.

Postdoctoral Associates

Veronique Camille Garcon, Ph.D.
Gail I. Harrison, Ph.D.
Robert J. Olsen, Ph.D.
Carl J. Watras, Ph.D.

Visiting Engineers

Fabrice Aurian, M.A.
Mustafa Gencer, Sc.D.
Peter Hufschmid, M.S.
Qinliang Wang, B.S.

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

John Melvin Biggs, S.M.
Professor of Civil 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

John Benson Wilbur, Sc.D.
Professor of Engineering, Emeritus

Department of Civil Engineering

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 scope of civil engineering education and research activities at MIT is quite broad and multifaceted. This stems directly from our recognition of the underlying characteristics of the civil engineering projects with which the civil engineer must ultimately deal. Such projects are typically large and costly, with potentially profound environmental, social, and financial impacts. The design of such projects requires the civil engineer to deal with complex technological and scientific issues as well as difficult social and public policy questions. Therefore, our Department's programs emphasize the highest levels of **technology** available, an understanding of the behavior of the engineering facility at a **systems** level, and an understanding of the **management, organizational,** and **institutional** settings within which such engineering systems operate. On the technology dimension, our programs deal with areas such as structural analysis and design, analytical mechanics, geotechnical engineering, materials, hydrodynamics, hydrology, and aquatic science. In the engineering systems area, we focus on such topics as economic analysis, information and computer systems, engineering risk assessment, and operations analysis and optimization. In the management, organizational, and institutional area, we address issues such as management of very large-scale engineering projects, government regulation, industry structure, and institutional issues in engineering project implementation.

Civil engineering professionals are concerned with the critical problems of today's society. For example, our energy needs demand projects of extraordinary scope and potential environmental impact (e.g., the Trans-Alaska Pipeline, offshore extraction facilities) with substantial requirements for advanced technologies and methodologies in the structural and construction area and in the assessment of geotechnical conditions on land and beneath the sea floor. Rebuilding the decaying infrastructure (e.g., highways, bridges, urban water systems) in the United States represents a major technical and economic challenge, as does the construction of new infrastructure in the developing world. The technology of underground facilities for such applications as the safe disposal of hazardous wastes and tunnels for transport of people and commodities requires new methodologies for analysis, design, and risk assessment. The efficient transport of goods and people requires 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 productivity of natural bodies of water depends upon a deeper understanding of the interaction of manufactured substances with the biological systems existing therein. Ensuring 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, design, and operation of facilities as well as an understanding of the demands of society for this resource. Civil engineers play a leadership role in the conception, planning, realization, and operation of facilities and systems and solution of problems in all the above areas and others concerned with basic human and societal needs.

These applications illustrate the broad scope of civil engineering activities embracing planning, analysis, design, construction, management, operation, and maintenance of a variety of facility types, and the solution of many kinds of complex, multidimensional problems. In this light, it is our belief that the education of civil engineers for future leadership positions should provide a rigorous perspective on the latest technology and analytic methods, and 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.

Job opportunities in civil engineering are quite varied. Positions are available in large and small consulting organizations, firms in a variety of industries, and agencies at all levels of government, both in the US and in the international sector. Many of our students build upon the technical, planning, and management skills emphasized in our program to become involved in the entrepreneurial activity of owning and managing their own enterprises. Further, our programs are considered excellent entries to graduate study in engineering as well as such fields as law and management.

The Department of Civil Engineering is organized into three functional Divisions: Constructed Facilities, Transportation Systems, and Water Resources and Environmental Engineering. These Divisions represent the major professional thrusts of the Department, and much of our education and research efforts are focused in these areas. 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, including those of its Center for Construction Research and Education, which draw upon and integrate the techniques and concepts of the major functional areas. Detailed descriptions of the programs of the Divisions and the Center are contained in the following pages.

In addition, the Department offers a number of undergraduate and graduate subjects that are primarily disciplinary in orientation in the following areas: Information Systems and Computational Methods; Analytical Mechanics; Engineering Systems, Economics, and Management; Engineering Risk Assessment and Probabilistic Analysis; and Institutions and Public Policy. Subjects listed under these headings will be of interest to students with a variety of backgrounds, both within civil engineering and from outside the Department. A number of subjects more oriented to applications based on these methodologies are offered in the divisional programs and are so indicated in the subject portion of this catalogue.

Undergraduate Study

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) is accredited by the Accreditation Board for Engineering and Technology.

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. 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, arts, and social sciences subjects[1]	132
	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	Introduction to Computers and 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 2 7	
1.03	Civil Engineering Systems Analysis II 3 2 7	
1.04	Behavior of Physical Systems I 3 2 7	
1.05	Behavior of Physical Systems II 3 2 7	
18.03	Differential Equations 4 0 8	
	Planned Electives	78 to 69
	One of the following options:	
	Transportation Option	
1.102	Transportation Laboratory 0 3 3	
1.20	Transportation Systems Analysis 4 0 8	
1.213	Introduction to Freight Transportation 4 0 8	
1.214	Public Transportation 4 0 8	
	plus	
1.218	Case Study in Transportation Planning 3 3 9	
	or	
1.ThU	Undergraduate Thesis Arr.	
	plus	
	Additional transportation-related subject(s) sufficient to bring total planned electives to minimum of 69.	
	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
1.01J, required in the Departmental Program, may be counted as one subject toward the Humanities, Arts, and Social Sciences Requirement.
2
2.10 may be accepted by petition as substitution for 1.00.

	Planned Electives (continued)	
1.70	Analysis Methods in Water Resources and Environmental Engineering	3 3 6
1.80	Fundamentals of Ecology	3 1 8
	Plus *three* of the following:	
1.107	Aquatic Chemistry and Biology Laboratory	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/ Element Cycles in the Environment	4 0 8
1.ThU	Thesis	0 12 0
	OR	
	Constructed Facilities Option	
1.30	Soil Mechanics	3 1 8
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
1.105J	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	Building Construction II	2 4 3
1.413	Construction Technology and the Building Development Process	3 0 6
	or	
	Structural Engineering	
1.51	Structural Mechanics	4 1 7
1.52	Structural Analysis and Design	3 1 8
	Unrestricted Electives[3]	**at least 48 up to 57**
	Total Units Required for the S.B. Degree	**360**

3
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 Accreditation Board for Engineering and Technology. 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, arts, and social sciences subjects[1]	132
	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[2]	12
	Departmental Program	
	Required Subjects	**60**
1.00	Introduction to Computers and Engineering Problem Solving[3]	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 2 7
1.04	Behavior of Physical Systems I	3 2 7
	or	
1.02	Civil Engineering Systems Analysis I	3 2 7
1.03	Civil Engineering Systems Analysis II	3 2 7
	or	
1.04	Behavior of Physical Systems I	3 2 7
1.05	Behavior of Physical Systems II	3 2 7
	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[4]	**up to 72**
	Total Units Required for the S.B. Degree	**360**

1
1.01J, required in the Departmental Program, may be counted as one subject toward the Humanities, Arts, and Social Sciences Requirement.
2
Recommended subjects: 1.102, 1.103, 1.104, 1.105J, 1.106, 1.107 (Laboratory projects in various areas).
3
2.10 may be accepted by petition as substitution for 1.00.
4
Schedules of students in Course I-A Option 1 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, arts, and social sciences subjects[1]	132
	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[2]	12
	Departmental Program	
	Required Subjects	72
1.00	Introduction to Computers and Engineering Problem Solving[3] 3 1 8	
1.01J	Engineering Aspects of Economic Analysis 4 0 8	
1.02	Civil Engineering Systems Analysis I 3 2 7	
1.03	Civil Engineering Systems Analysis II 3 2 7	
11.001	Introduction to Urban Development and Design 3 0 9	
	or	
11.002	Introduction to Public Policy Analysis and Government Action 3 0 9	
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[4]	up to 60
	Total Units Required for the S.B. Degree	360

1
1.01J, required in the Departmental Program, may be counted as one subject toward the Humanities, Arts, and Social Sciences Requirement.
2
Recommended subjects: 1.102 or 11.188.
3
2.10 may be accepted by petition as substitution for 1.00.
4
Schedules of students in Course I-A Option 2 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 Aquatic Chemistry and Biology Laboratory[1] (2-6-4)
1.11 Microcomputer Project Laboratory (3-2-7)
1.12 Computer Models of Engineering Systems[2] (3-0-9)
1.16J Ethics and Technocrats (4-0-8)
1.165 Introduction to Technology and Law (3-0-9)
1.20 Transportation Systems Analysis (4-0-8)
1.213 Introduction to Freight Transportation (4-0-8)
1.214 Public Transportation (4-0-8)
1.218 Case Study in Transportation Planning (3-3-9)
1.30 Soil Mechanics (3-1-8)
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 Building Construction I (3-3-6)
1.412J Building Construction II (2-4-3)
1.50 Introduction to Structural Engineering (3-2-7)
1.51 Structural Mechanics (4-1-7)
1.52 Structural Analysis and Design (3-1-8)
1.59J Materials of Construction[2] (3-0-9)
1.60 Fluid Dynamics (4-0-8)
1.62 Free Surface Hydraulics (3-1-8)
1.70 Analysis Methods in Water Resources and Environmental Engineering (3-3-6)
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.)

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.

1
Satisfies Institute Laboratory Requirement
2
Satisfies Institute Science Distribution Requirement.

Graduate Study

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. The Institute's general requirements for these degrees may be found in Chapter IV of this catalogue. Detailed information on the departmental requirements for each degree may be obtained from the Academic Programs Office, Room 1-281.

At the graduate level, research and education go hand-in-hand. Recognizing the continuing demand for pioneering technology while responding to the need to understand broad relationships, two basic tracks are provided. Students interested in physical processes or in the analysis and design of component facilities may work in a fundamental area such as soil, water, or structures. Others may study the planning, design, construction, and operation of large-scale systems of facilities in fields such as transportation, water resources, and other public and private systems.

The functional Divisions of the Department and the Center for Construction Research and Education have responsibility for graduate admissions; research assistant, teaching assistant, fellowship and traineeship awards and assignments; and the administration of the research and academic programs of the Department. Prospective graduate students indicate their preferred affiliation when applying for admission.

Fields of Advanced Study

Integrated programs of advanced study are available in the following areas: geotechnical engineering, structural engineering and mechanics, construction engineering and 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.

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 bring 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. All applicants are required to submit scores from the GRE Aptitude Test.

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 or Teaching Assistants. Most of these appointments fully cover tuition and reasonable living expenses in the Boston area.

In addition to financial support, these appointments provide valuable educational experience and, in the case of Research Assistantships, thesis opportunities.

A number of Fellowships are also available for graduate students.

Constructed Facilities

The academic and research programs are concerned with the broad field of development, design, analysis, and assessment of behavior of constructed facilities. Engineering programs in geotechnical engineering, and structural design and analysis build upon subjects in mechanical behavior of materials, engineering mechanics, applied probability and statistics, and computer-based analysis methods. Students may emphasize a particular engineering area or a combination thereof to prepare for professional practice or advanced study. Also, students may choose to focus on one of several disciplinary areas — including engineering risk assessment, computer-aided engineering, and analytic mechanics — and combine basic subjects in these areas with applications-oriented subjects from the engineering areas. The student can draw upon the subject offerings of the Department and the Institute to design a program that meets his or her particular needs and interests. The Department also offers academic and research programs in Construction Engineering and Management, which are described under the section on the Center for Construction Research and Education.

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 soils under cyclic loading; pile foundations; in-situ testing, especially for offshore exploration; and application of probability and decision theory to geotechnical problems.

Transportation

Many research projects are, and the individual student's academic program can be, of an interdisciplinary nature involving, for instance, structural engineering.

The Geotechnical Engineering Research Laboratory provides facilities for fundamental and applied research in the geotechnical area and is described later in this section of the catalogue.

Structural Design and Analysis. Society today has a great demand for constructed facilities. The problems associated with maintaining and rehabilitating the existing industrial, residential, and transportation structures are particularly critical. More efficient structural solutions which reduce the initial construction and long-term maintenance costs must be developed. For typical application areas such as buildings and bridges, reduction in cost is the critical issue. However, for facilities intended to meet the needs of new energy sources, the challenge is to devise new ways to provide functional and safe structures. 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.

A comprehensive treatment of the behavior of complex steel and concrete structures is the key element of the structural design and analysis program. The development of structural design concepts based on an understanding of behavior is stressed. Exposure to design procedures is provided by a set of laboratory subjects dealing with important design issues for buildings, bridges, and offshore structures. Additional study areas include structural analysis, analytical mechanics, structural dynamics, numerical modeling, structural loads, offshore structural engineering, structural mechanics for nuclear power facilities, and structural reliability.

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 this and other aspects of mechanics and materials may take advantage of subject offerings in all departments of the School.

The research program includes projects in the following areas: earthquake engineering including seismic risk analysis, nonlinear response of structures, soil-structure interaction, seismic resistance of buildings; statistically based loading and serviceability criteria for design; three-dimensional models for failure of concrete; computational strategies for complex concrete structures; offshore structures including dynamic response, system identification methods, behavior of segmented bridges.

Engineering Risk Assessment for a complex facility is one of the most important issues facing the profession. This is especially critical for civil engineering projects since the degree of uncertainty with respect to the site characterization, loading, and natural materials used in construction is high, and one has to resort to probabilistic characterizations of the system. The divisional academic program has been designed to provide an in-depth exposure to the fundamentals of probability theory, statistics, modeling of systems with emphasis on phenomena that require the use of random functions, and risk-based decision methods. Disciplinary subjects are complemented with application-oriented subjects dealing with structural reliability, uncertainties in geotechnical engineering, and risks in construction.

Computer-Aided Engineering is based upon the disciplinary areas of information processing and computational methods. Management information systems, the use of microcomputers for engineering computations, numerical modeling of physical systems, and finite element analysis methods for continuous media are the current subject offerings. Applications are integrated in various engineering subjects and existing software packages are utilized extensively.

Analytical Mechanics presents an in-depth treatment of the mechanics of solids and its extension to multiphase media. Emphasis is placed on the underlying physical principles the characterization of material behavior, and behavioral aspects of soil-structure systems. Students interested in engineering analysis can combine this program with additional geotechnical and structural mechanics subjects.

Transportation systems. The educational and research programs of the Transportation Systems Division are based on the philosophy that the **analysis, design,** and **implementation** of transportation improvements results from combining: 1) quantitative analysis of alternative solutions; 2) an in-depth understanding of specific problem areas spanning freight, passenger, urban, intercity and international transportation; and 3) knowledge of the economic and institutional setting in which solutions are implemented.

The academic programs of the Division reflect a multi-modal orientation, emphasizing basic methods of analysis and their applications to a range of problems. The approaches include a synthesis of economics, statistics, mathematical programming, as well as the tools of management and the social sciences. The subject offerings stress both the technical analysis of transportation systems as well as the understanding of the social and political factors which must be considered in transportation decisions. More specific, problem-centered subjects are offered in various applications areas, including freight transportation, public transit, operations planning, traffic engineering and urban transportation planning.

The research in the Division also reflects a wide range of methodological and substantive interests. Students are encouraged to participate in this research as an integral part of the educational process. This participation often includes financial support in the form of a research assistantship, but can also involve students engaged in separate, independent research with individual faculty.

The current major research activities include the following: railroad operations planning, both in the US and abroad; travel demand analysis; national equilibration; microcomputer applications in transportation operations; analysis of the U.S. automobile industry; freight and urban passenger transportation in developing countries; regulation in the common carrier industry; transit operations and planning; institutional and organization issues in transportation; and the relationship between transportation and downtown retail activity.

The faculty, students, and staff of the Transportation Systems Division actively participate in the MIT Center for Transportation Studies. At the Master's level, most students are enrolled in the interdepartmental Master of Science in Transportation degree program. The Division's ties to other departments involved in transportation include joint appointments between our faculty and the Departments of Economics, Aeronautics and Astronautics, and Urban Studies and Planning.

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 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 and hydrocarbons.

Research includes waste heat management, harbor and coastal modeling, local and regional water quality, resource and land use management and facility siting, microorganism/pollutant interaction, phytoplankton growth dynamics, inorganic and organic chemistry of surface and groundwater, and wetland geochemistry.

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.

Center for Construction Research and Education

The Center for Construction Research and Education was established in the Department to provide closer ties with the construction industry. The formation of the Center reflects a major commitment by the Department to the advancement of knowledge, methods, and technology which can help the industry meet the opportunities and challenges for the next several decades.

The Center provides a specific focus within the Department for students, faculty, and industry personnel to interact and collaborate on a wide range of educational programs and research projects on topics of particular relevance and interest to the construction industry. For the student preparing for a career in the construction industry, the Center offers advanced degree programs, internships and summer jobs in construction firms, and industry-sponsored thesis research opportunities.

The Center currently offers an integrated graduate degree program in **Construction Engineering and Management.** This program stems from the recognition that 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 control, more reliably than ever, time, cost, and quality, 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 construction projects have on public welfare is forcing closer 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.

In addressing this need, the program in Construction Engineering and Management 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 planned research activities of the Center are comprehensive and are designed to obtain active collaboration among students, faculty, and industry firms and personnel. These activities will focus on three broad sets of issues: management (at the industry, firm, and project levels); resources (labor, materials, equipment, and finance); and technology (innovation, productivity, adaptation, and transfer). Major re-

Laboratories, Facilities, and Special Programs

search programs are currently being developed in several areas of growing importance and concern to the industry such as the role of construction in energy; technology and productivity; rebuilding America's infrastructure; management of superprojects; computer applications for construction contractors; and US construction industry competitiveness in the world market.

The Center promotes and coordinates a number of liaison activities with the construction industry. These include an advisory board and policy committee in which industry representatives will provide their perspectives and guidance on the educational and research and development needs of the industry and on the nature and content of collaborative programs which the Center develops to meet those needs. Through appointments as adjunct faculty and research fellows, the Center plans to bring experienced and senior industry personnel to MIT to teach and conduct research in construction technology and management. The Center also helps to arrange summer and sabbatical leave work opportunities in the industry for MIT faculty. Other ongoing relationships between industry firms and the Department's faculty and students are provided by an industry affiliates program.

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, teaching and research 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 students in relating theoretical predictions to actual response and in visualizing the behavior of complex systems. The equipment is specifically designed for this purpose. It consists of several loading frames which enable students, working individually or in small groups, to conduct experiments on structural models of steel, reinforced concrete and other materials. Students also conceive, design, and construct models of structural systems which are then tested for verification of the design.

The **Materials Laboratory** is both an educational and a research facility. It assists students in relating the mechanical properties of construction materials to their composition. Current research includes studies of the mechanical behavior of concrete and asphaltic composites under various environmental conditions, and development of new composite materials for construction.

The **Civil Engineering Microcomputer Laboratory** provides facilities for students and faculty to use in pursuing academic and research interests in the use and application of microcomputers and microprocessor-based systems in civil engineering. The laboratory is concerned with the impact of new generations of microprocessors and microcomputers in civil engineering productivity as well as the development of new hardware and software designs and methodologies for improving productivity in civil engineering education, research, and practice. The laboratory has several microcomputer systems which are available for use in pursuing research interests in the above areas as well as for use by students in solving homework problems.

The **REMERGENCE Laboratory** is a joint effort of the Departments of Civil and Mechanical Engineering in the **R**esource **E**xtraction, **M**aterials, **E**nergy, **R**eservoir, **EN**vironmental, and **C**onstruction **E**ngineering areas. In addition to the participants in the Civil Engineering Geotechnical Engineering Research Laboratory and in the Mechanical Engineering Resource Extraction Laboratory, faculty and students from these departments and the Departments of Materials Science and Engineering, Ocean Engineering, and Earth, Atmospheric, and Planetary Sciences are involved. The Laboratory provides testing facilities for experimentation on geologic-geotechnical and construction materials both for teaching and research. Equipment includes high-pressure triaxial rock testing, test bins for large-scale soil tests, and physical data acquisition systems. The Laboratory is intended to provide a unique opportunity for interchange and stimulation among students, research staff, and faculty from many disciplines. The REMERGENCE Laboratory is directed by an interdepartmental faculty steering committee, currently chaired by Professor H. H. Einstein of the Department of Civil Engineering.

The **Joint Computer Facility** is maintained, in collaboration with several other Engineering departments, for use by students and faculty in the departments' academic and research programs. A 4MByte Digital Equipment Corporation dual process VAX 11/782 supports more than 50 on-line character and graphics terminals. The facility also provides a wide range of computer peripherals such as plotters and letter-quality printers, including analog and interactive graphics capabilities on separate DEC PDP 11/34 which is connected by a network to the VAX 11/782. Network access is also provided to other computer facilities around the campus. The Joint Computer Facility provides easy access to students and provides consultants for assistance in hardware and software use.

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, and engages the student in significant project work integrating technology and policy. 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. Details of the program and application procedures are described in Chapter V.

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 at the end of this chapter on MIT's Joint Program in Oceanography and Oceanographic Engineering with the Woods Hole Oceanographic Institution.

Master of Science in Transportation

The interdepartmental degree of Master of Science in Transportation is offered 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 under the Center for Transportation Studies.

Center for Transportation Studies

The Center for Transportation Studies (CTS) coordinates transportation research and educational activities at MIT. The Transportation Systems Division of the Department of Civil Engineering plays a major role in both the academic and research programs of the Center. 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 at MIT in the mineral resources field. The MMRRI and its various academic and research opportunities are described in Chapter V.

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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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 digital computers, their associated communication and switching networks, and software systems. Electrical engineers have developed conceptual models for estimation, communication, and control, and have applied them to physical and biological systems. 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 Accreditation Board for Engineering and Technology.

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.

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 listed for Program 1 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, arts, and social sciences 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]	120
6.001	Structure and Interpretation of Computer Programs 5 3 7	
6.002	Circuits and Electronics 4 2 9	
6.003	Signals and Systems 4 2 9	
6.004	Computation Structures[3] 4 3 8	
6.012	Electronic Devices and Circuits 4 0 8	
6.013	Electromagnetic Fields and Energy 4 0 8	
6.014	Electrodynamics 4 0 8	
18.03	Differential Equations 4 0 8	
	Thesis[4] 12	
	Restricted Electives	48
	1. One of the following subjects:	
2.40	Thermodynamics 4 0 8	
5.60	Chemical Thermodynamics 4 0 8	
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 4 0 8	
18.440	Probability and Random Variables 4 0 8	
	Group C. Advanced Mathematics	
18.04	Complex Variables with Applications 4 0 8	
	Restricted Electives (continued)	
18.063	Introduction to Algebraic Systems 4 0 8	
18.100	Analysis I 3 0 9	
	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 3 7 2	
6.141	Power Systems Project Laboratory 0 10 2	
6.142	Microcomputer Control of Energy Systems 2 7 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[5,6]	54
	Total Units Required for the S.B. Degree	366

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
6.004 will replace 6.032 no later than fall term 1984. A student who takes 6.032 before that time can use it to satisfy the 6.004 requirement, in which case the total number of units required for the S.B. degree will be 363.

4
A thesis of at least 12 units is required. Up to 18 additional units of thesis may be used as elective units.

5
Students are encouraged to consider elective subjects in the areas of science and public policy, engineering management, inventions, entrepreneurship, finance, or managerial economics.

6
Schedules of students in Course VI, Program 1 can always be arranged to leave available 12 units of Unrestricted Elective in the second year.

Bachelor of Science in Electrical Engineering
Course VI
Program 1: Bioelectrical Engineering Option

	General Institute Requirements			Total Units
	Specific science and humanities, arts, and social sciences 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			**156**
6.001	Structure and Interpretation of Computer Programs	5	3 7	
6.002	Circuits and Electronics	4	2 9	
6.003	Signals and Systems	4	2 9	
6.004	Computation Structures[1]	4	3 8	
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	
18.03	Differential Equations	4	0 8	
	Thesis[2]		12	
	Restricted Elective			**12**
6.041	Probabilistic Systems Analysis	4	0 8	
	or			
18.313	Probability	4	0 8	
	or			
18.440	Probability and Random Variables	4	0 8	
	Unrestricted Electives[3,4,5]			**42**
	Total Units Required for the S.B. Degree			**366**

1
6.004 will replace 6.032 no later than fall term 1984. A student who takes 6.032 before that time can use it to satisfy the 6.004 requirement, in which case the total number of units required for the S.B. degree will be 363.

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, inventions, entrepreneurship, finance, or managerial economics.

4
Schedules of students in Course VI, Program 1 can always be arranged to leave available 12 units of Unrestricted Elective in the second year.

5
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 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 on the next page. 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, arts, and social sciences 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]			144
6.001	Structure and Interpretation of Computer Programs	5	3 7	
6.002	Circuits and Electronics	4	2 9	
6.003	Signals and Systems	4	2 9	
6.004	Computation Structures[2]	4	3 8	
6.034	Artificial Intelligence	4	0 8	
6.035	Computer Language Engineering	4	4 4	
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[3]		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	
6.801	Machine Vision	3	0 9	
6.802	Robot Manipulation	3	0 9	
	Unrestricted Electives[4,5]			54
	Total Units Required for the S.B. Degree			366

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
6.004 will replace 6.032 no later than fall term 1984. A student who takes 6.032 before that time can use it to satisfy the 6.004 requirement, in which case the total number of units required for the S.B. degree will be 363.

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 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 Analog Devices, Inc., AVCO-Everett Research Laboratory, Bell Laboratories, Codex Corp., COMSAT Laboratory, C. S. Draper Laboratory, Digital Equipment Corporation, Fairchild Camera and Instrument Corporation, General Electric Company, Gen Rad, Inc., Hewlett-Packard Company, Honeywell, Inc., IBM Corporation, Lincoln Laboratory, Medtronic, Inc., Motorola, Inc., Naval Surface Weapons Center, Raytheon Company, RCA, Tektronix, Inc., Texas Instruments, Inc., and Xerox Corporation (Palo Alto Research Center).

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.

Graduate Study

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.

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.

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.

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-qualifed 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.

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.

Joint MIT-WHOI Program Course VI-W

A joint program with the Woods Hole Oceanographic Institution is intended for students whose primary career objectives 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 at the end of this chapter on MIT's Joint Program in Oceanography and Oceanographic Engineering with the Woods Hole Oceanographic Institution.

Other Degree Programs

Graduate students enrolled in the Department participate in several of the interdepartmental degree programs described in detail in Chapter V. Among those programs are: Biomedical Engineering, Management of Technology, Operations Research, and Technology and Policy.

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

Merton Corson Flemings, Sc.D.
Toyota Professor of Materials Processing
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
Ford Professor of Engineering
Faculty Coordinator, Energy Laboratory
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 Mineral Resources Research Institute
American Iron and Steel Institute Distinguished Professor

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

Thomas Burness King, Ph.D.
Professor of Metallurgy

William David Kingery, Sc.D.
Professor of Ceramics

Ronald Michael Latanision, Ph.D.
Shell Distinguished Professor of Materials Science
Director of the H.H. Uhlig Corrosion Laboratory

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

Walter Shepherd Owen, Ph.D.
Professor of Physical 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

Ioannis Vassiliou Yannas, Ph.D.
Professor of Polymer Science and Engineering

Associate Professors

Samuel Miller Allen, Ph.D.
ARCO Associate Professor of Physical Metallurgy

Joel Phillip Clark, Sc.D.
Associate Professor of Materials Systems

David Richard Clarke, Ph.D.
Associate Professor of Ceramics and Glass

Thomas Waddy Eagar, Sc.D.
Associate Professor of Materials Engineering

Linn Walker Hobbs, D.Phil.
Associate Professor of Ceramics

David Kaye Roylance, Ph.D.
Associate Professor of Materials Engineering

Donald Robert Sadoway, Ph.D.
Associate Professor of Materials Engineering

George S. Scherer, Ph.D.
Associate Professor in Ceramics (Visiting)

Harry Louis Tuller, D.Eng.Sc.
Associate Professor of Ceramics and Electronic Materials

Gregory John Yurek, Ph.D.
Associate Professor of Metallurgy

Assistant Professors

Ronald George Ballinger, Sc.D.
Assistant Professor of Nuclear and Materials Engineering

I-Wei Chen, Ph.D.
Assistant Professor of Nuclear Materials and Nuclear Engineering

Gretchen Kalonji, Ph.D.
Norton Assistant Professor of Materials Engineering

Terry Arthur Ring, Ph.D.
Assistant Professor of Minerals Engineering

Gary Edmund Wnek, Ph.D.
Du Pont 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)

Technical Instructors

Arthur Jeremiah Gregor
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Gregory Bruce Olson, Ph.D.

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Sponsored Research Staff

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Helena V. Goldfarb, Ph.D.

Department of Materials Science and Engineering

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Takoshi Aoyama, Ph.D.
Bernard Bendriem, Ph.D.
Xue Ling Cai
Masayuki Fujimoto, Ph.D.
Marie-Helene Gely, Ph.D.
Dorothy Hosler, M.A.
Masakazu Ito, Ph.D.
Tetsuya Kameyama, Ph.D.
Hirohiko Katayama, M.S.
Kazuo Kondo, Ph.D.
Genrich L. Krasko, Ph.D.
Yang-Quan Lei, Ph.D.
Ya-Yun Liu, Ph.D.
John W. McKelliget, Ph.D.
Richard Paul Messmer, Ph.D.
Ken-ichi Onisawa
Gregory Oreper, Ph.D.
Leighton Hartwell Peebles, Jr., Ph.D.
Ghanshyam Rai, Ph.D.
Wladyslaw Walukiewiez, Ph.D.
Mamoru Watanabe, Ph.D.
Huai-Zhi Yu
Zhang Yongchang, M.Eng.

Professors Emeriti

Michael Berliner Bever, Dr.Jur., M.B.A., Sc.D.
Professor of Materials Science and Engineering, 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, devices, 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 or other 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 grasp of the modern engineering sciences including heat and mass transfer and chemical kinetics. He or she must also have a proper concern for economic, social, and environmental factors.

Materials processing is a major part of materials engineering. We see today many examples where the processing of materials limits the properties of a component, device, or machine, and where improved performance depends directly on advances in materials processing. Examples include electronic devices, aircraft engine turbine components, and high-strength ceramic components. We also see many examples of challenging engineering problems in reducing the cost of processing of materials. Such cost reductions (productivity improvements) are vitally important to the strength of many industries today, such as the automotive industry. The Department has strong academic and research activities in all aspects of the processing of materials, as well as in other parts of materials engineering.

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, kinetics, and certain aspects of solid mechanics, physics, and chemistry. Suitable core subjects in these areas are provided at the undergraduate and graduate 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.

Undergraduate Study

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) 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, electronic materials, 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 and are in continuing high demand by industry for jobs in research, development, production, and management.

Examples of areas where the professional expertise of the materials scientist or engineer are required include: 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 wide variety of important 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 employment or graduate work in the engineering or science of materials. The decision to major in this field 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 sciences 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 Accreditation Board for Engineering and Technology. The degree programs in Course III-A are not accredited by the Accreditation Board for Engineering and Technology.

The elective program in materials is chosen, with the help of an advisor, to give depth in one or more specific materials areas (metallurgy, ceramics, polymers, electronic materials) while allowing for breadth through choice across these areas. The technical areas covered in the elective program include the extraction, preparation, and purification of materials; the processing and fabrication of materials by deformation, heat treatment and phase change; the study and control of structure-property relations in metallic, ceramic, polymeric, and electronic 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, and the Materials Processing Center, 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, arts, and social sciences 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]	**101**
3.00	Thermodynamics of Materials	4 0 8
3.01	Physical Chemistry of Materials	4 0 8
3.041	Thesis Seminar	Arr.
3.081	Materials Laboratory I	1 6 5
3.10	Chemical Physics of Materials	3 0 6
3.11	Mechanics of Materials I	4 0 8
3.13	Structure of Solids	4 0 8
3.185	Mass, Heat, and Fluid Transport	3 0 5
18.03	Differential Equations	4 0 8
	Thesis	9 to 15
	Restricted Electives[1]	**at least 54**
	Complete six subjects, three subjects from one specific materials area, and at least one laboratory.	
	Ceramics	
3.069	Introduction to Ceramics Processing	3 0 9
3.07	Introduction to Ceramics	3 0 9
3.075	Ceramics and Glass Laboratory	2 7 3
	Electronic Materials	
3.083J/ 3.084	Introduction to Microelectronic Technology/Semiconductor Devices Project Laboratory	1 9 2
3.146	Electronic Materials	2 0 6
3.147	Electronic Materials Processing	3 1 8
3.15	Electrical, Optical, and Magnetic Materials and Devices	3 0 5
	Metallurgy	
3.02	Phase Transformations and Structure Development	3 0 6
3.03	Chemical Metallurgy	3 0 6
3.082	Materials Laboratory II	1 6 5
3.14	Physical Metallurgy	3 0 6
	Polymers	
3.061J	Introduction to Polymer Science and Engineering	3 0 9
3.062	Introduction to Polymer Chemistry	3 0 6
3.064	Polymer Engineering	3 0 6
3.065	Polymer Laboratory	0 6 3
	Unrestricted Electives	**up to 61**
	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, polymers, and electronic materials 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, arts, and social sciences 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	**41 to 48**
3.00	Thermodynamics of Materials	4 0 8
3.01	Physical Chemistry of Materials	4 0 8
3.10	Chemical Physics of Materials	3 0 6
3.11	Mechanics of Materials I	4 0 8
3.13	Structure of Solids	4 0 8
3.185	Mass, Heat, and Fluid Transport	3 0 5
18.03	Differential Equations	4 0 8

[1] Substitution of similar subjects may be permitted by petition.

	Restricted Electives (continued)	
	B. Three of the following subjects	25 to 36
3.02	Phase Transformations and Structure Development	3 0 6
3.03	Chemical Metallurgy	3 0 6
3.061J	Introduction to Polymer Science and Engineering	3 0 9
3.062	Introduction to Polymer Chemistry	3 0 6
3.064	Polymer Engineering	3 0 6
3.069	Introduction to Ceramics Processing	3 0 9
3.07	Introduction to Ceramics	3 0 9
3.14	Physical Metallurgy	3 0 6
3.146	Electronic Matrials	2 0 6
3.147	Electronic Materials Processing	3 1 8
3.15	Electrical, Optical, and Magnetic Materials and Devices	3 0 5
	C. One of the following subjects	9 or 12
3.065	Polymer Laboratory	0 6 3
3.075	Ceramics and Glass Laboratory	2 7 3
3.081	Materials Laboratory I	1 6 5
3.082	Materials Laboratory II	1 6 5
3.083J/ 3.084	Introduction to Microelectronic Technology/Semiconductor Devices Project Laboratory	1 9 2
	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]	**33 to 12**
	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, 6.151 (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**

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.

Bachelor of Science in Materials Science and Engineering Course III-B

	General Institute Requirements	Total Units
	Specific science and humanities, arts, and social sciences 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]	**113**
3.00	Thermodynamics of Materials	4 0 8
3.01	Physical Chemistry of Materials	4 0 8
3.081	Materials Laboratory I	1 6 5
3.10	Chemical Physics of Materials	3 0 6
3.11	Mechanics of Materials I	4 0 8
3.13	Structure of Solids	4 0 8
3.185	Mass, Heat, and Fluid Transport	3 0 5
3.930	Industrial Practice	0 12 0
3.931	Industrial Practice[2]	0 12 0
18.03	Differential Equations	4 0 8
	Restricted Electives[1]	**at least 52**
	Complete six subjects with three subjects being from one specific materials area. For ceramics a substitution for subject 3.075 may be made.	
	Ceramics	
3.069	Introduction to Ceramics Processing	3 0 9
3.07	Introduction to Ceramics	3 0 9
3.075	Ceramics and Glass Laboratory	2 7 3
	Electronic Materials	
3.146	Electronic Materials	2 0 6
3.147	Electronic Materials Processing	3 1 8
3.15	Electrical, Optical, and Magnetic Materials and Devices	3 0 5
	Metallurgy	
3.02	Phase Transformations and Structure Development	3 0 6
3.03	Chemical Metallurgy	3 0 6
3.14	Physical Metallurgy	3 0 6

(Chart continues on next page)

1
Substitution of similar subjects may be permitted by petition.
2
Thesis, 12 units, may be substituted for 3.931.

Graduate Study

	Restricted Electives (continued)	
	Polymers	
3.061J	Introduction to Polymer Science and Engineering	3 0 9
3.062	Introduction to Polymer Chemistry	3 0 6
3.064	Polymer Engineering	3 0 6
	Unrestricted Electives	**up to 51**
	Total Units Required for the S.B. Degree	**360**

The Department offers the degrees of Doctor of Philosophy and Doctor of Science in Ceramics, Electronic Materials, Materials Engineering, Materials Science, Metallurgy, and in Polymers. It offers the degrees of Master of Science in Ceramics, Electronic Materials, Materials Engineering, Materials Science, Metallurgy, and Polymers; also the degrees of Materials Engineer and Metallurgical Engineer.

Ceramics. The field of ceramics is concerned with the science and engineering involved in the manufacturing, processing, and utilization of a wide rango 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.

	Core Subjects
3.20	Thermodynamics of Materials
3.21	Kinetic Processes in Materials
	or
3.205	Applied Thermo and Kinetics
	Elective Subjects
3.069	Introduction to Ceramics Processing
3.07	Introduction to Ceramics
3.22J	Solid-State Surface Science
3.27	Diffraction and Structure
3.271	Structure of Materials
3.32	Introduction to Electron Optical Instruments
3.33	Defects in Crystals
3.57	Particulate Technology
3.59	Research Proposals — Planning for Discovery
3.60	Thermal and Tensor Properties of Ceramics
3.601	Electrical, Optical, and Magnetic Properties of Ceramics
3.602	Mechanical 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	Ceramics Processes
3.631	Processing of Metals, Ceramics, and Glasses
3.64	Special Problems in Ceramics

Electronic Materials. The field of electronic materials is concerned with the science and technology of materials for semiconducting, magnetic, optical, and superconducting device applications. It is further concerned with the design and realization of useful materials through understanding and control of the interplay between electronic processes and structural aspects — atomic arrangments, defects, interfaces, and phase constitution and morphology. Research within this field includes electronic materials processing in bulk and thin-film form; characterization of the semiconducting, optical, and magnetic properties of crystalline and amorphous materials in relation to their microstructure and composition; and theoretical and experimental study of the electronic characteristics of solid-solid, -liquid, and -gas interfaces and their implications for devices.

	Core Subjects
3.20	Thermodynamics of Materials
3.21	Kinetic Processes in Materials
3.43	Physics and Chemistry of Materials
6.732J	Physics of Solids II
	Elective Subjects
3.46J	Electronic Materials
3.47	Electronic Materials Processing
3.601	Electrical, Optical, and Magnetic Properties of Ceramics
	Related Subjects
3.22J	Solid-State Surface Science
3.271	Structure of Materials
3.32	Introduction to Electron Optical Instruments
3.35	Solidification Processing
3.55	Macroscopic Transport in Materials Processing
3.60	Thermal and Tensor Properties of Ceramics
3.604	Problems in Nonstoichiometry
3.96	Spectroscopy and Electrical Properties of Polymers
6.741J	Theory of Solids I
6.742J	Theory of Solids II
6.751	Quantum Electronics
6.762	Dielectric and Optical Materials and Devices
6.771	Physics of Semiconductor Devices
6.774	Physics of Microelectronic Fabrication
6.781	Submicrometer Structures Technology
8.451	Physics of Optical and Infrared Lasers

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
3.46J Electronic Materials
3.51 Process Metallurgy
3.53 Electrochemical Processing of Materials
3.54 Corrosion—The Environmental Degradation of Materials
3.551J Gas-Solid Reactions
3.555 Principles of Materials Engineering
3.63 Ceramic Processes
3.71J Physical Metallurgy Principles for Engineers
3.91J Mechanical Behavior of Plastics
14.110J Applied Microeconomic Analysis

Materials Science. Materials Science is the study of common principles and fundamental phenomena which underlie the structure and properties of a wide range of materials: metals, ceramics, polymers, and electronic materials, which are frequently used in combination. The common principles involved are those associated with electronic structure and bonding, atomic arrangement, phase stability, and the role of imperfections and microstructure. Fundamental phenomena considered include structural and phase transformations; reactivity; mass and charge transport; interface behavior; and the optical, electronic, and mechanical responses to internal and external stimuli. In studying these principles and phenomena, materials science employs many characterization approaches, drawing heavily on diffraction and imaging methods, as well as microanalysis and computer modeling, to provide coherent descriptions of materials structure and structural imperfections to which particular materials properties can be ascribed.

Core Subjects

3.20 Thermodynamics of Materials
3.21 Kinetic Processes in Materials
3.271 Structure of Materials
3.31 Phase Transformations
3.33 Defects in Crystals
3.43 Physics and Chemistry of Materials

Suggested Elective Subjects

3.26J Physics of Deformation and Fracture of Solids II
3.27 Diffraction and Structure
3.30 Electron Microscopy: Image Interpretation
3.32 Introduction to Electron Optical Instruments
3.40 Physical Metallurgy
3.46J Electronic Materials
3.60 Thermal and Tensor Properties of Ceramics
3.601 Electrical, Optical, and Magnetic Properties of Ceramics
3.604 Problems in Nonstoichiometry
3.61 Glass Structure and Properties
3.721 Radiation Effects in Crystalline Solids
3.73 Special Problems in Advanced Computer Applications
3.96 Spectroscopy and Electrical 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; extracting and 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
3.40 Physical Metallurgy
3.50 Physical Chemistry of Metallurgical Processes

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
3.33 Defects in Crystals
3.34 Physical Metallurgy of Deformation
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
3.71J Physical Metallurgy Principles for Engineers

Polymers. Synthetic high polymers, "plastics," are man-made long molecules, the principal constituents of which are typically carbon, hydrogen, oxygen, chlorine, and a few other elements. Because of the unusual nature of carbon bonding, an infinite number of combinations can be conceived and produced, with virtually all exhibiting low specific gravity, ease of melt forming, and a wide range of properties, depending upon composition, structure, and processing history. Both the science and the engineering of materials have reached a high level of sophistication in this field: linear, cross-linked, crystalline, amorphous, oriented, glassy, rubbery, strong, stiff, homopolymers, copolymers, terpolymers, blends, transparent, opaque, filled, reinforced, alloys, composites, laminates, and adhesives are but a few of the descriptive aspects which can be controlled and manipulated to achieve a desired profile of properties.

Numerous opportunities exist for a student to concentrate on specific areas of polymer science or engineering: physical properties, mechanical behavior, chemical synthesis and modification, surface characteristics, environmental interactions, and 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
3.91J Mechanical Behavior of Plastics
3.93J Materials Science of Polymers

3.961	Polymer Synthesis and Properties
	or
10.691	Synthesis 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
3.26J	Physics of Deformation and Fracture of Solids II
3.27	Diffraction and Structure
3.30	Electron Microscopy: Image Interpretation
3.60	Thermal and Tensor Properties of Ceramics
3.92J	Composite Materials
3.95	Environmental Properties of Polymers
3.96	Spectroscopy and Electrical Properties of Polymers
10.641	Molecular and Morphological Engineering 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 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. Details of the program and application procedures are described in Chapter V.

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, and engages the student in significant project work integrating technology and policy. 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 in Mineral Resources Engineering and Management described in Chapter V.

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 at the end of this chapter on MIT's Joint Program in Oceanography and 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 Chapter IV. 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 procedure 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 Chapter IV. 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.

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. The manufacturing industry comprises a major element of the economy, and its 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. Mechanical 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.

Research Laboratories and Programs

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
- Computational mechanics, finite element methods
- 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
- 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
- Computational fluid dynamics
- 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
- Laser diagnostics

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 Biomechanics and Human 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. This interdepartmental center, which facilitates research and provides a focal point for educational programs Institute-wide in the area of transportation, is described in detail in Chapter V of this catalogue.

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. 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. The Energy Laboratory is described in detail in Chapter V.

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, cooling of electronic components, fusion reactor cooling systems, fluidized-bed combustors, thermal modeling of biological tissue, heat transfer in material processing, optimized heat exchanger design, moisture migration in building materials, and energy conservation.

Innovation Center. The Department provides logistic support for the MIT Innovation Center, a unit of the School of Engineering. The primary objective of the Center's program is to develop understanding of the technological innovation process through research and teaching, including direct involvement in authentic innovation processes. The Center is described in detail in Chapter V.

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. This interdepartmental laboratory was established in 1977 to provide a new focus for research and education in the area of manufacturing and productivity. The laboratory is described in detail in Chapter V.

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 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 Mineral Resources Research Institute. The MMRRI coordinates academic and research activities at MIT in the mineral resources field. The MMRRI and its various academic and research opportunities are described in detail in Chapter V.

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.

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 Accreditation Board for Engineering and Technology.[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, and automatic control 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 and medicine. 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, arts, and social sciences 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 Systems 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

(Chart continues on next page)

[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.

	Restricted Electives (continued)		
	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	The Mechanics of Fracture	3 0 9	
2.41J	Thermodynamics of Power Systems	3 0 9	
2.51	Heat and Mass Transfer	3 0 9	
	Group B		
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**

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	The Mechanics of Fracture
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.

1.107	Aquatic Chemistry and Biology Laboratory
2.14	Control System Principles
2.41J	Thermodynamics of Power Systems
2.51	Heat and Mass Transfer
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 course permits 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)

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	Probabilistic Modeling and Analysis of Engineering Systems
2.06J	Mechanical Vibration
2.14	Control System Principles
2.34J	The Mechanics of Fracture
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	Metals Processing
2.820J	Polymer Processing (A)
2.830	Control for Manufacturing Automation (A)
2.921	Polymer Deformation and Fracture (A)
2.922	Fiber Processing Mechanics (A)

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.

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.

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 Systems 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
2.900	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	Probabilistic Modeling and Analysis of Engineering Systems
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 subject is especially recommended:

CTS 100J	Transportation Systems Analysis

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 elective is suggested:

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:

2.092	Methods of Engineering Analysis (A)
2.093	Computer Methods in Dynamics (A)
2.094	Theory and Practice of Continuum Mechanics (A)

For students wishing to concentrate in automatic control, the following undergraduate electives are recommended:

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 Digital Control Systems (A)
2.181J	Models of 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 Accreditation Board for Engineering and Technology.

Bachelor of Science Course II-A

	General Institute Requirements	Total Units
	Specific science and humanities, arts, and social sciences 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 Systems 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	The Mechancis of Fracture	3 0 9
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
	Restricted Electives (continued)	
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 Accreditation Board for Engineering and Technology.

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.

Graduate Study

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.

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.

Some students may wish to combine a professional education in Mechanical Engineering with a liberal education which links the development and practice of engineering with its social, economic, historical, and cultural contexts. For them, the Department of Mechanical Engineering and the Department of Humanities in cooperation with the Program in Science, Technology, and Society offer a double degree program which combines majors in Course II and in Course XXI. A detailed description of that integrated program will be found later in this chapter.

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 IV. 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	Metals Processing

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 above requirements apply to students who have an S.B. degree in mechanical engineering. Other students may be required to take additional subjects to complete their background in mechanical engineering.

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, and engages the student in significant project work integrating technology and policy. General requirements and application procedures are described in Chapter V of this catalogue.

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 at the end of this chapter on MIT's Joint Program in Oceanography and 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 Warren M. Rohsenow, Graduate Officer, Room 3-156, (617) 253-2208.

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Professors Emeriti

Manson Benedict, Ph.D.
Institute Professor, Emeritus
Professor of Nuclear Engineering, Emeritus

Irving Kaplan, Ph.D.
Professor of Nuclear Engineering, Emeritus

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 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 charged particles, neutrons, and photon radiation. Included is a strong involvement in the broader problems of providing energy in socially acceptable ways and of energy policy alternatives in general. The Department is also involved in the medical applications of radiation.

Fission reactors are used to produce heat and electricity, to propel submarines and ships, 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 US it is 13 percent. Because of conservation and other reasons, the growth rate in electricity consumption 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 programs of many nations include 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 even better types of reactors.

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.

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.

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.

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,

Undergraduate Study

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 and radiation medicine.

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. Students in chemistry, biology, or physics are challenged by the Department's medically oriented Radiological Sciences program. 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.

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 the applied radiation industry including medical technology, or for graduate study in nuclear engineering and related disciplines. The field is very broad and the program is arranged to provide a variety of subject combinations appropriate for career preparation. Three specific optional tracks have been defined (fission, fusion, and radiological sciences) and other subject combinations may be selected to satisfy the needs of individual students.

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 and applied radiation physics. 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, radiological sciences, plasma physics, fusion reactor engineering, or engineering of nuclear systems.

The Departmental requirements under the Institute Science Distribution include 8.03, 18.03, and 22.02. Engineering 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, or 10.301. 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 10.302. 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 can substitute a subject in electricity and magnetism, such as 6.601 or 8.07, for computer modeling.

The introduction to the specialties of nuclear engineering requires a total of 60 units of restricted electives from Department XXII undergraduate (or, where appropriate, graduate) offerings. Of these 60 units, at least 36 should be for subjects covering engineering design and systems and 12 should be for an appropriate physics subject.

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. Three specific optional tracks through the departmental requirements have been defined: fission, fusion, and radiological sciences. The fission option includes design, analysis, and operations topics associated with light-water reactor plants and other fission reactor plant concepts. The fusion option is intended for students planning for graduate study and careers in areas of engineering research or development related to fusion reactors. The radiological sciences option is intended for students planning careers in medicine or biomedical engineering with particular emphasis on the applications of radiation in diagnostics and therapy. The information on each option includes specific choices of departmental requirements and recommendations for choice of unrestricted electives. The information is available from the student's departmental undergraduate advisor or from the departmental undergraduate records office (Room 24-207).

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.

Some students may wish to combine a professional education in nuclear engineering with a liberal education which links the development and practice of science and engineering with their social, economic, historical, and cultural contexts. For them, the Department of Nuclear Engineering and the Department of Humanities in cooperation with the Program in Science, Technology, and Society offer a double degree program which combines majors in Course XXII and in Course XXI. A detailed description of that integrated degree program will be found later in this chapter.

The degree programs in Course XXII and Course XXII-A are accredited by the Accreditation Board for Engineering and Technology.

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 an appropriate choice of subjects as approved by the advisor. 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.

Bachelor of Science in Nuclear Engineering Course XXII

	General Institute Requirements	Total Units
	Specific science and humanities, arts, and social sciences 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[1]	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	12
	Engineering Principles II	12
	Engineering Principles III	12
	Engineering Principles IV	12
	Engineering Principles V	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 22.061 Controlled Fusion Power, 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	48
	Total Units Required for the S.B. Degree	366

1
Suitable subjects for engineering principles are given in the text.

Bachelor of Science in Nuclear Engineering Course XXII-A

Most requirements 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. Each student must be selected by a participating company after application and an interview. The program consists of four work assignments at the same company. 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 in part by work assignments that are design-related. Otherwise, the requirement is to be satisfied by an appropriate selection of subjects, as approved by the registration officer.

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 a faculty advisor. Otherwise, the student must follow the same steps for satisfying the thesis requirement as those students in XXII.

Five-Year Degree Programs

Bachelor of Science in Nuclear Engineering
Course XXII-A

	General Institute Requirements	Total Units
	Specific science and humanities, arts, and social sciences 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[1]	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	12
	Engineering Principles II	12
	Engineering Principles III	12
	Engineering Principles IV	12
	Engineering Principles V	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 22.061 Controlled Fusion Power, 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	48
	Total Units Required for the S.B. Degree	366

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Suitable subjects for engineering principles are given in the text.

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.

Graduate Study

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 Energy Engineering Principles.

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 generally 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. Subject number 22.111 Nuclear Physics for Engineers I, or its equivalent is required for all master's degree candidates. Subjects recommended for all master's degree candidates include:

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 five alternative fields: fission reactor technology, applied plasma physics, applied radiation physics, nuclear materials engineering, or radiation health physics. 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 Engineering Economics of Energy Options
22.35 Nuclear Fuel Management
22.37 Environmental Impacts of Electricity
22.38 Reliability Analysis Methods
22.39 Nuclear Reactor Operations and Safety
22.42 Numerical Methods in Engineering 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
22.76 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 II
22.615J MHD Theory of Magnetic Fusion Systems I
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 the six courses just listed and from the following:

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
22.76 Introduction to Nuclear Chemical Engineering

Students specializing in **radiation health physics** should follow a special two-year curriculum in which courses in the following areas will form the core curriculum:

General Health Physics
Nuclear Measurements Laboratory
Introductory Applied Nuclear Physics
Radiobiology

An additional core course will be offered in conjunction with the MIT Nuclear Reactor Laboratory entitled Health Physics II — A Nuclear Reactor Emphasis. Students will be encouraged to register for courses covering these areas at the HSPH as well as at MIT.

Other subjects of interest to Master of Science candidates specializing in radiation health physics include:

HSPH Human Physiology A and B
22.55J Biological and Medical Applications of Radiation and Radioisotopes
22.51 Radiation Interactions and Applications
22.39 Nuclear Reactor Operations and Safety
22.37 Environmental Impacts of Electricity
22.57J Radiation Biophysics
Radiological Sciences Graduate Seminar

In addition to the aforementioned subject requirements, students in the radiation health physics program will complete a master's thesis.

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 and engages the student in significant project work integrating technology and policy. 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. Details of the program and application procedures are described in Chapter V.

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 Chapter IV, 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 or radiological sciences, 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 Philosophy unless he or she requests the Doctor of Science. 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.

The major program in **Radiological Sciences** has been developed to educate students in the diverse applications of radiation in medicine and to expand the research frontiers in this area. In addition to a central concern with ionizing radiation, Radiological Sciences encompasses more recent technologies employing other forms of radiation such as ultrasound and laser light, and other diagnostic techniques such as nuclear magnetic resonance. The curriculum in Radiological Sciences is a four- to five-year commitment leading to the Ph.D. or Sc.D. degree. Students in Radiological Sciences may pursue their academic and research objectives in any one of four specialty areas: medical therapy, imaging and diagnostic technology, radiation biophysics, and radiopharmaceutical chemistry. While most core Radiological Sciences subjects will be taken at MIT, student research will be conducted primarily at Harvard-affiliated hospitals, the Harvard School of Public Health, and MIT, depending upon the student's specialty area.

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; in energy systems and policy analysis — economics of energy production, electric power system model and planning environmental impacts of energy systems; 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, new technologies in cancer therapy, radiological diagnosis, health physics, 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; and in nuclear materials engineering — properties of nuclear fuels, effect of radiation on reactor materials, solvent extraction of metals, isotope separation, nuclear fuel reprocessing, treatment and disposal of radioactive wastes.

Research Facilities

The Department's educational program is supported by a number of outstanding experimental facilities for advanced research in nuclear engineering.

Nuclear Reactor Laboratory

The MIT Research Reactor operates at a power of 5,000 kw and is fueled with U-235 in a compact light-water cooled core surrounded by a heavy-water reflector. It is one of the finest university research reactors in the world. Details of the Laboratory's research programs and facilities are given in Chapter V.

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 high field Tokamak fusion device ALCATOR and in the design of the fusion magnetic mirror device TARA, both projects of the Plasma Fusion Center. 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 serve for many years as an important educational and research facility.

Most of the departmental research on plasmas and controlled fusion is done in the Plasma Fusion Center, which includes groups active in all aspects of plasma research. The Plasma Fusion Center is described in detail in Chapter V.

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. The Whitaker Laboratory of Microscopy is available for ultrastructural research in materials.

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 24-204, MIT, Cambridge, Massachusetts 02139, (617) 253-3801.

Department of Ocean Engineering

T. Francis Ogilvie, 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

David Valentine Burke, Jr., Ph.D.
Professor of Ocean Engineering

Alexander Douglas Carmichael, Ph.D.
Professor of Power Engineering

Chryssostomos Chryssostomidis, Ph.D.
Professor of Naval Architecture
Director, Sea Grant College Program

Ira Dyer, Ph.D.
Professor of Ocean Engineering

Ernst Gabriel Frankel, Mar. Mech.E.
Professor of Marine Systems
(On leave)

Justin Elliot Kerwin, Ph.D.
Professor of Naval Architecture

Patrick Leehey, Ph.D.
Professor of Ocean Engineering and Mechanical Engineering

Koichi Masubuchi, D.Eng.
Professor of Ocean Engineering and Materials Science

Jerome H. Milgram, Ph.D.
Professor of Naval Architecture
(On leave)

John Nicholas Newman, Sc.D.
Professor of Naval Architecture

J. D. Nyhart, J.D.
Professor of Ocean Engineering and Management

Tomasz Wierzbicki, Sc.D.
Professor of Ocean Engineering
(Visiting)

Associate Professors

Judith Tegger Kildow, Ph.D.
Associate Professor of Ocean Policy

Henry Stuart Marcus, D.B.A.
Associate Professor of Marine Systems

Harilaos Nicholas Psaraftis, Ph.D.
Associate Professor of Marine Systems

Terrence L. Tinkel, Ocean E.
Associate Professor of Ocean Engineering

Michael Stefanos Triantafyllou, Sc.D.
Associate Professor of Ocean Engineering

John Kim Vandiver, Ph.D.
Associate Professor of Ocean Engineering

Robert James Van Houten, Ph.D.
Associate Professor of Ocean Engineering

Paul Christos Xirouchakis, Ph.D.
Associate Professor of Ocean Engineering

Assistant Professors

Paul Demetre Sclavounos, Ph.D.
Assistant Professor of Naval Architecture

Dick Kau-Ping Yue, Sc.D.
Assistant Professor of Ocean Engineering

Adjunct Professor

Clark Graham, Ph.D.
Adjunct Professor of Naval Architecture

Senior Lecturers

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)

Paul F. Farrell, B.S.

Charalambos Ziogas, Ph.D.
(Visiting)

Administrative Officer

Patricia A. LeBlanc, B.S.

Visiting Research Scientist

Hiroshi Kagemoto, S.M.

Visiting Research Engineers

Mitsumasa Iwata, D.Eng.
Richard C. Kolf, Ph.D.
Eui-Pak Yoon, D.Eng.

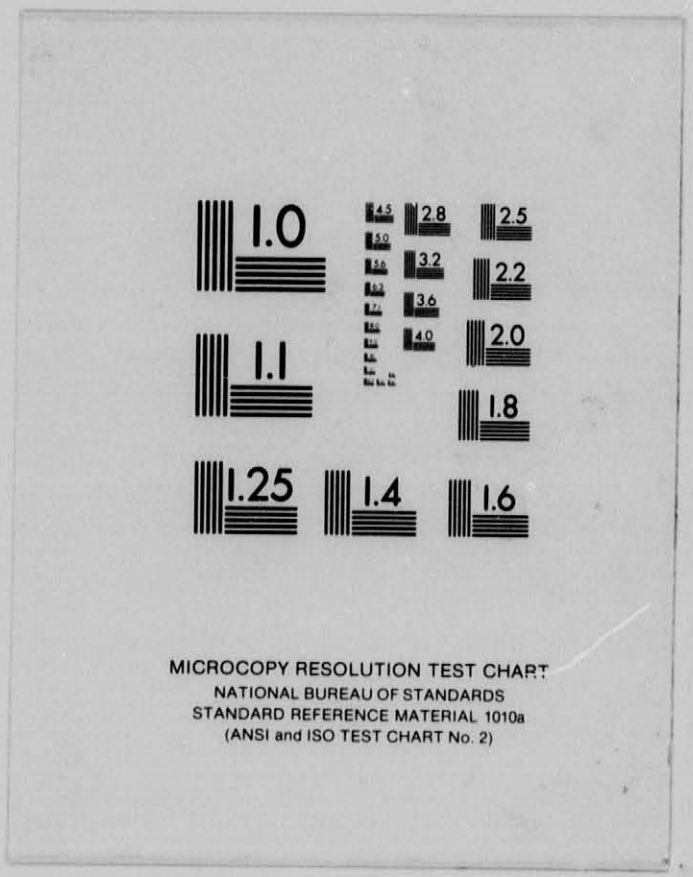
Professors Emeriti

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


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MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS
STANDARD REFERENCE MATERIAL 1010a
(ANSI and ISO TEST CHART No. 2)

24 : 1

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. 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.

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 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.

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.

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.

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. 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.

Undergraduate Study

Bachelor of Science in Ocean Engineering, in Naval Architecture and Marine Engineering, or without designation Course XIII

The basic program offered by the Department is designed for 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 Accreditation Board for Engineering and Technology, 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 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.

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, arts, and social sciences 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 Fluid Mechanics for Ocean Engineers	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
13.40	Elements of Ocean Engineering Design	3 3 6
13.73	A Survey of Ocean Engineering	1 1 1
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**

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. Students in the five-year program may substitute 9 units of 13.700-13.709 Special Problems in Ocean Engineering with an unrestricted elective.
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. Students in the five-year program may substitute 9 units of 13.700-13.709 Special Problems in Ocean Engineering with an unrestricted elective.
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 Accreditation Board for Engineering and Technology, while those leading to the Bachelor of Science without designation of field are not.

Graduate Study

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, arts, and social sciences 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 Fluid Mechanics for Ocean Engineers	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	
13.40	Elements of Ocean Engineering Design	3 3 6	
13.73	A Survey of Ocean Engineering	1 1 1	
18.03	Differential Equations	4 0 8	
13.771	Engineering Internship	12	
13.772	Industrial Practice in Ocean Engineering[5]	Arr.	
	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

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.

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 Electives 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.

Combined Bachelor's and Master's Degree Program

Programs leading to a joint Bachelor of Science (in aeronautics and astronautics, civil engineering, electrical engineering, mechanical engineering, or ocean engineering), and a Master of Science (in ocean engineering or naval architecture and marine engineering), are helpful to students who early in their undergraduate studies, decide to pursue a graduate degree in ocean engineering or naval architecture and marine engineering. Students desiring to enter such a program must meet the graduate admission requirements of the Department of Ocean 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 the Departmental Student Administration Office.

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.

Entrance Requirements for Graduate Study

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.

Ocean Engineering/
Naval Architecture and Marine Engineering
Course XIII

The Department's curriculum leading to a Master's degree in Ocean Engineering is based on a broad working knowledge of all the basic engineering skills. The intended product of this program is a person whose main interest is the development of the ocean for the good of humanity, and in following this ambition is prepared to use whatever engineering disciplines are needed to accomplish the problem at hand. As a part of the more general field of Ocean Engineering, Naval Architecture and Marine Engineering is concerned with all aspects of waterborne vehicles operating on, below, and just above the sea surface. The S.M. degree in Naval Architecture and Marine Engineering is intended to produce an individual who plans to concentrate in areas related to waterborne vehicles and/or their subsystems.

Major fields of study or specialization include (but are not limited to) the following:

Applied mechanics
Environmental engineering
Fluid mechanics
Hydrodynamics
Marine acoustics
Marine data systems engineering
Marine engineering
Marine materials and fabrication
Marine systems
Offshore engineering
Offshore platform design
Seafloor engineering
Ship design
Ship and offshore rig dynamics
Ship propulsion
Ship systems
Structural mechanics

Doctoral degrees are offered in the fields of Ocean Engineering and Naval Architecture and Marine Engineering. Students are admitted to the doctoral program after successful completion of the appropriate qualifying examinations. The student's program 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 on the examination process and other requirements, including the doctoral thesis, may be obtained from the Departmental Student Administration Office.

There are also a number of interdepartmental doctoral programs available to students in the Department. Details are given in Chapter V.

Naval Construction and Engineering
Course XIII-A

This Program 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.

The Program 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) offers both Master of Science and Doctor of Philosophy degrees.

The Master's program is intended for students with solid engineering backgrounds who are interested in the business and government management aspects of ocean engineering systems and activities, including ocean transportation, marine resource development, public policy and ocean use, ocean mining, and ports and fisheries. Technical background should consist of a S.B. degree in engineering or science. Background should include at least one undergraduate subject in differential equations, probability, and microeconomics. Any deficiency should be eliminated during the first term at MIT. Students not possessing a background in ocean engineering are required to take 13.40 Elements of Ocean Engineering Design.

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 a 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. Further information on the Master's program requirements can be obtained from the Departmental Student Administration Office.

A doctoral degree in Ocean Systems Management leads to the development of new knowledge that enhances the state of the art in this area. To achieve that goal, the student is expected to complete a program of study and write a dissertation that successfully integrates theory, methodology, and experience in the fundamental disciplines that constitute the Ocean Systems Management area, such as engineering, economics, business administration, operations research, public policy analysis, and law. Students are admitted to the doctoral program after passing the appropriate written and oral qualifying examinations. Further information on the doctoral program requirements and examination process may be obtained from the Departmental Student Administration Office.

Ocean Engineer

The objective of the program leading to the Ocean Engineer degree is of a higher level and significantly broader range of professional competence in engineering than that required for the S.M. degree. The program for an Engineer's degree ordinarily includes two subjects in the areas of economics, industrial management, and public policy or law, and at least 12 units of comprehensive design. Should the student be working toward the simultaneous award of the Engineer and Master's degrees, a single thesis is generally 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 degree of Ocean Engineer are available from the Departmental Student Administration Office.

Technology and Policy (S.M.)

The Department also offers a Master's degree in Technology and 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. 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.

Transportation (S.M.)

The interdepartmental degree of Master of Science in Transportation is offered in cooperation with the Center for Transportation Studies. Most ocean engineering students studying transportation at the Master's level are enrolled in this interdepartmental program. Requirements for the Master of Science in Transportation are described in Chapter V.

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. Details of the program and application procedures are described in Chapter V.

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 at the end of this chapter on MIT's Joint Program in Oceanography and Oceanographic Engineering with the Woods Hole Oceanographic Institution.

Assistantships and Graduate Scholarships

There are a limited number of 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. Fellowships are 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. Fellowships are also awarded each year by the Office of Naval Research (ONR) and the National Science Foundation (NSF).

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, and Office of Naval Research and National Science Foundation fellowships are made directly to the appropriate 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 and may be obtained by writing to the Department of Ocean Engineering, Room 5-225, MIT, Cambridge, Massachusetts 02139, (617) 253-1994.

Center for Advanced Engineering Study (CAES)

The primary objective of CAES is to improve the capabilities and effectiveness of practicing engineers. Engineers in private practice, in small companies, and in large corporations will be considered equally as our primary clients. Priority is given to advancing the arts and sciences of applications, rather than remedial instruction.

Both technical and managerial-technical subjects will be emphasized. Our strategy attempts to identify problems which are of great national or professonal interest and importance and to offer instruction and assistance to the profession in solving them. By conducting research on problems of practicing professional engineers and developing improved methods of continuing education, the Center will provide a number of ways for participants to acquire the knowledge and skills they need to resolve these problems.

Instructional techniques will be varied to meet the needs and circumstances of engineers in various settings (large vs small industries, advanced technologies vs professionally broadening topics). Schedules, methods of instruction, and learning materials will be prepared to provide a bridge between preprofessional education and patterns of continuous learning.

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 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.

Participants 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, the Advanced Study Program on Systems Reliability and Risk Analysis, or the Visiting Engineers 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 ongoing 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.

Advanced Study Program on Systems Reliability and Risk Analysis

The Advanced Study Program on Systems Reliability and Risk Analysis is offered during the spring term. Participants will acquire the skills they need to perform reliability analyses on engineering systems. They will learn to make quantitative estimates of reliability, maintainability, and availability for their designs; determine and develop strategies to avoid risk in the design and operation of systems; and develop operating strategies to minimize risk.

Visting Engineers Program

The Visiting Engineers 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 engineers and technologists 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 Programs. Participants have access to regular Institute facilities and services and may, if they wish, attend one regular academic subject each academic term.

Interested engineers may write to the Director, Advanced Study Programs, Center for Advanced Engineering Study, or to the head of 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. 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 $7,300 for the fall or spring term, $14,600 for the two-term school year, $4,500 for the regular 1983 summer terms, and $2,500 for Calculus Revisited (1983). 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 to the Advanced Study Programs, MIT, Center for Advanced Engineering Study, Room 9-435, 77 Massachusetts Avenue, 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.

Video-Based, Self-Study Subject Development Program

CAES has developed over 1,000 videotapes, video course manuals, and textbooks in engineering, science, mathematics and management. These video-based lectures and demonstrations are designed to meet the individual needs of engineers, scientists, and technical managers working in the field.

All of the videotapes are available separately for purchase or rental at any time. Also, each subject may be purchased or rented as a complete set, at generous discounts.

Most subjects include a comprehensive study guide and textbook which accompanies the videotapes. The video course manuals are detailed and permit learners to work through the course at their own rate.

For further information, write or call: Self-Study Program, MIT, Center for Advanced Engineering Study, Room 9-234, 77 Massachusetts Avenue, Cambridge, Massachusetts 02139, (617) 253-7444.

Subjects now available are:

Digital Speech Processing
Digital Electronics
Introduction to VLSI Design
Modern Control Theory
Probability and Random Processes
Microprocessors: Fundamental Concepts and Applications
Management of Microprocessor Technology
Electronic Feedback Systems
The Deming Videotapes: Quality, Productivity, and Competitive Position
Computer-Aided Manufacturing
Artificial Intelligence
Computer Languages
Corrosion Engineering
Colloid and Surface Chemistry
Electrochemistry
Mechanics of Polymer Processing
Tribology I
Advanced Tribology
Nonlinear Vibrations
Finite Element Methods in Engineering Mechanics
Decision Analysis
Systems Engineering and Systems Management
Introduction to Experimentation
Management of Technological Innovation

The Seminar Office

The Seminar Office is an MIT program which was designed with the approval of the Engineering and Academic councils in order to encourage nonaccredited continuing education programs. The emphasis is in the area of science and engineering, reflecting trends in the marketplace and their relationship to technology development.

Individual programs vary in length, lasting from one day to one month, and concentrate on technical and management applications. Depending on whether the meeting is a workshop, short course, seminar, or conference, the size of the group may range from 12 to 500 attendees. Programs are offered throughout the academic year and may be held at MIT or other locations around the country and overseas. The Seminar Office offers complete management and support for these meetings.

For more information contact: Conference and Seminar Program, MIT, Center for Advanced Engineering Study, Room 9-335, 77 Massachusetts Avenue, Cambridge, Massachusetts 02139, (617) 253-7406.

Research and Development in Continuing Education

The purpose of our research and development 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.

A 17-set series of modules on industrial energy conservation in print have been developed by this project.

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 Myron Tribus or John Newcomb at MIT, Center for Advanced Engineering Study, Building 9-221, 77 Massachusetts Avenue, Cambridge, Massachusetts 02139, (617) 253-7400.

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 Artificial Intelligence Laboratory, 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 cognitive science, and others involving political science and various branches of engineer-

ing. 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 acoustics and computers 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-E and XXI-S) 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 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 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.

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.

Office of the Dean

Harold John Hanham, Ph.D.
Professor of History and Political Science
Dean

Janet Romaine, B.A.
Assistant Dean for Administration

Travis Rhodes Merritt, Ph.D.
Associate Professor of Literature
Director, Humanities Undergraduate Office

Ruth V. Spear, B.A.
Coordinator, Humanities Undergraduate Office

School Faculty and Staff Without Departmental Affiliation

Martin Dyck, Ph.D.
Professor of German and Literature

Ruth Perry, Ph.D.
Senior Lecturer in Literature and Women's Studies
Director of Women's Studies

Robert N. Scanlan, Ph.D.
Lecturer in Drama and Theatre Arts

Beth Soll, B.S.
Lecturer in Dance

William Nash Locke, Ph.D.
Professor of Modern Languages, Emeritus
Director of Libraries, Emeritus

Department of Economics

Ann Fetter Friedlaender, Ph.D.
Professor of Economics and Civil Engineering
Head of the Department

Paul Lewis Joskow, Ph.D.
Professor of Economics
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

Edgar Cary Brown, Ph.D.
Professor of Economics

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
(On leave, fall)

Richard Samuel Eckaus, Ph.D.
Ford International Professor of Economics

Stanley Fischer, Ph.D.
Professor of Economics

Franklin Marvin Fisher, Ph.D.
Professor of Economics

Jerry Allen Hausman, D.Phil.
Professor of Economics
(On leave, spring)

Elhanan Helpman, Ph.D.
Professor of Economics
(Visiting)

Mervyn Allister King, M.A.
Professor of Economics
(Visiting)

Edwin Kuh, Ph.D.
Professor of Economics and Finance

Eric Stark Maskin, Ph.D.
Professor of Economics

Daniel Little McFadden, Ph.D.
Elizabeth and James R. Killian Class of 1926 Professor
Professor of Economics

Franco Modigliani, D.Jur., D.Soc.Sci., LL.D.
Institute Professor
Professor of Economics and Finance

Michael Joseph Piore, Ph.D.
Mitsui Professor in Problems of Contemporary Technology
Professor of Economics

Jerome Rothenberg, Ph.D.
Professor of Economics
(On leave)

Paul Anthony Samuelson, Ph.D., LL.D., D.Litt., Sc.D.
Institute Professor
Professor of Economics

Abraham J. 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
(On leave, spring)

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

Associate Professors

Ben Shalom Bernanke, Ph.D.
Associate Professor of Economics
(Visiting, fall)

Olivier Jean Blanchard, Ph.D.
Associate Professor of Economics

Henry Stuart Farber, Ph.D.
Associate Professor of Economics
(On leave)

Lars Peter Hansen, Ph.D.
Associate Professor of Economics
(Visiting, fall)

Jeffrey Earl Harris, M.D., Ph.D.
Associate Professor of Economics

Timothy Jerome Kehoe, Ph.D.
Associate Professor of Economics
(On leave)

William Cody Wheaton, Ph.D.
Associate Professor of Economics and Urban Studies

Assistant Professors

Joseph von Rosthorn Farrell, D.Phil.
Assistant Professor of Economics

James Michael Poterba, D.Phil.
Assistant Professor of Economics

James Leo Powell, Ph.D.
Assistant Professor of Economics

Garth Saloner, Ph.D.
Assistant Professor of Economics

Postdoctoral Associate

Ailsa Alexandra Röell, Ph.D.

Administrative Officer

Idella Lyman Tapley, A.B.

Administrator for Finance and Operations

Pamela Shepherd-Hart, B.A.

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 is the study of the choices that societies make with respect to the use of scarce resources — their production and the distribution of their consumption — and of the behavior of economic units, institutions, and systems. Such a study provides an understanding of the impact of broad socioeconomic developments and of policies on the economic environment of society, and of the impact of that environment on these developments and policies.

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, finance, 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, arts, and social sciences 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		81
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 4 5	
14.39	Undergraduate Thesis Seminar[3]	2 0 4	
	Thesis	9	
	Restricted Electives		45
	Elective subjects in economics	45	
	Unrestricted Electives		78
	Total Units Required for the S.B. Degree		360

1
No more than 27 units in Economics, excluding the required subjects, 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 (6) approved as to content may be substituted for 14.39.

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 IV 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, and financial aid 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

The Department of Humanities, unlike other departments at MIT, does not have a department head or a department headquarters. It consists of a number of autonomous sections and programs, each with its own headquarters. There are currently six such autonomous units: 1) Anthropology/Archaeology, 2) Foreign Languages and Literatures, 3) History, 4) Literature, 5) Music, and 6) Writing. In addition there are specialized programs in Drama and Dance, and interdisciplinary programs in American Studies, Film and Media Studies, Latin American Studies, Russian Studies, Women's Studies, Traditions and Texts, and Ancient and Medieval Studies.

As indicated in the descriptive summaries below, all the programs in the Humanities 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-E, XXI-S) or as full majors (XXI).

Anthropology/Archaeology

James Howe, Ph.D.
Associate Professor of Anthropology
Program Head

Heather Nan Lechtman, M.A.
Professor of Archaeology and Ancient Technology
Director, Center for Materials Research in Archaeology and Ethnology
(On leave, spring)

Martin Diskin, Ph.D.
Associate Professor of Anthropology
(On leave)

Jean Elizabeth Jackson, Ph.D.
Associate Professor of Anthropology

Arthur Steinberg, Ph.D.
Associate Professor of Archaeology
(On leave)

Suzanne DeAtley, Ph.D.
Assistant Professor of Anthropology

Sharon Traweek, Ph.D.
Assistant Professor of Anthropology and Science, Technology, and Society
(On leave, spring)

Michael Folsom, Ph.D.
Lecturer in Archaeology

Cyril Stanley Smith, Sc.D.
Institute Professor, Emeritus
Professor of the History of Science and Technology, Emeritus
Professor of Metallurgy, Emeritus

Anthropology/Archaeology

Distribution Subjects
Field of Concentration
Major Programs: XXI, XXI-E, XXI-S

Anthropology studies humankind from a comparative perspective that emphasizes the diversity of human behavior and the importance of culture in explaining that diversity. While the discipline encompasses the biological nature of our species and the material aspects of human adaptation, it takes as fundamental the idea that we respond to nature and natural forces in large part through culture. Anthropology, then, is the study of human beings as cultural animals. Archaeology, one of its principal branches, uses material remains to study cultures, often over long time periods. Cultural anthropology draws its data from the direct study of contemporary peoples living in a wide variety of circumstances, from peasant villagers and tropical forest hunters and gatherers, to urban populations in modern societies.

The Anthropology/Archaeology Program at MIT offers students a broad exposure to the discipline as well as an anthropological perspective on problems and issues relevant to other fields in the humanities, social sciences, and engineering. It also provides more intensive introductions to areas of faculty specialization, which include social and political organization, economics and human ecology, religion and symbolism, paleobotany, technology and materials science, and the anthropology of art and scientific research. Areal interests include ancient and modern cultures of the Americas, ancient civilizations of the Mediterranean and Near East, and modern Japan and the United States.

The scientific study of technologies and materials from ancient and contemporary nonwestern societies forms a special field of research and teaching for the Anthropology/Archaeology Program. MIT archaeologists, together with colleagues in the Department of Materials Science and Engineering and with anthropologists and archaeologists from six museums and universities in the Boston area, founded the Center for Materials Research in Archaeology and Ethnology (CMRAE). The center, which is directed by MIT Anthropology/Archaeology faculty, provides a focus for research, teaching, and graduate training in this field. Students may participate in research projects by arrangement with the appropriate faculty members.

The Anthropology/Archaeology curriculum is divided into two groups. Introductory subjects, whose numbers begin with 21.50, encompass broad topics such as human evolution and archaeological methods. Subjects with higher numbers focus somewhat more tightly on such topics as magic and witchcraft, the decline of empires, or sex roles. With the exception of special topics and subjects given through the CMRAE, most offerings do not have prerequisites. The curriculum includes subjects that may count as electives as well as Distribution subjects to satisfy the Institute requirements for the Humanities, Arts, and Social Sciences. Students taking a concentration in anthropology are advised to choose a mix of subjects in archaeology and cultural anthropology with help from the program's concentration advisor.

Anthropology subjects qualify for several interdisciplinary concentrations, including Women's Studies, Latin American Studies, and "Technology, Culture, and Development." Information on the latter concentration, which is based in the Anthropology/Archaeology Program, is available in the program office, Room 20B-131A, (617) 253-3065.

A major is also offered in XXI, XXI-E, and XXI-S (see Degree Program Requirements). Students interested in the major should consult an advisor and the Course XXI office, Room 14N-409, as early as possible.

Foreign Languages and Literatures

Edward Baron Turk, Ph.D.
Associate Professor of French
Section Head

James Wesley Harris, Ph.D.
Professor of Spanish and Linguistics

Robert Emmet Jones, Ph.D.
Professor of French and Humanities

Krystyna Pomorska, Ph.D.
Professor of Russian and Literature

Julia Alissandratos, Ph.D.
Associate Professor of Russian
(On leave, spring)

Catherine Vakar Chvany, Ph.D.
Associate Professor of Russian
(On leave)

Isabelle de Courtivron, Ph.D.
Associate Professor of French

Elizabeth Garrels, Ph.D.
Associate Professor of Spanish

Margery Resnick, Ph.D.
Associate Professor of Spanish

Jay Rosellini, Ph.D.
Associate Professor of German

Kathryn Crecelius, Ph.D.
Assistant Professor of French

Manuel Delgado, Ph.D.
Assistant Professor of Spanish

David Dollenmayer, Ph.D.
Assistant Professor of German
(On leave, fall)

Suzanne Flynn, Ph.D.
Assistant Professor of English
as a Second Language

Michael Geisler, Ph.D.
Assistant Professor of German
(On leave, spring)

Janie Vanpée, Ph.D.
Assistant Professor of French

Edith Waldstein, Ph.D.
Assistant Professor of German

Claire Jeanne Kramsch, M.A.
Senior Lecturer in German

Judith Davidson, Ph.D.
Lecturer in German

Kathy Irving, M.A.
Lecturer in English as a
Second Language

Gilberte Furstenberg, M.A.
Lecturer in French

Jacqueline Hill, M.Ed.
Lecturer in French

Brigitte Lane, M.A.
Lecturer in French

Evelyn Lilienfeld, B.A.
Lecturer in Spanish

Douglas Morgenstern, M.A.
Lecturer in Spanish

Christopher Sawyer-Laucanno, Ph.D.
Lecturer in English
as a Second Language

Ruth Trometer
Director of the Language
Laboratory

Margaret Zaroodny Freeman, S.M.
Associate Professor of Russian, Emerita

Richard Felix Koch, A.M.
Assistant Professor of Modern Languages, Emeritus

Foreign Languages and Literatures

Distribution Subjects
Field of Concentration
Major Programs: XXI, XXI-E, XXI-S

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 and critical awareness. If preserved through use, these skills constitute an intellectual and personal resource throughout a lifetime, and can be an important asset for those pursuing careers with international dimensions.

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/or literature. Programs should be arranged on an individual basis in consultation with a designated advisor.

Major programs are offered (XXI, XXI-E, XXI-S) 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

Pauline Maier, Ph.D.
Professor of History
Section Head

Richard Mateer Douglas, Ph.D.
Professor of History

Robert Michael Fogelson, Ph.D.
Professor of History and
Urban Studies

Loren Graham, Ph.D.
Professor of the History of
Science

Harold John Hanham, Ph.D.
Professor of History and
Political Science
Dean, School of Humanities
and Social Science

Robert Ellsworth MacMaster, Ph.D.
Professor of History and Literature

Thomas Henry Donald Mahoney,
Ph.D.
Professor of History

Bruce Mazlish, Ph.D.
Professor of History

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
(On leave, fall)

Peter Hopkinson Smith, Ph.D.
Professor of History and Political Science

John Dittmer, Ph.D.
Associate Professor of History

Arthur Daniel Kaledin, Ph.D.
Associate Professor of History and American Studies

David Bird Ralston, Ph.D.
Associate Professor of History
(On leave)

William Braasch Watson, Ph.D.
Associate Professor of History

Philip Khoury, Ph.D.
Assistant Professor of History
(On leave)

William Cushing Perdue, Ph.D.
Assistant Professor of History
(On leave)

Howard Russell Bartlett, B.S., A.M.
Professor of History, Emeritus

Lynwood Silvester Bryant, A.M.
Professor of History and American Studies, Emeritus

Edward Neal Hartley, A.M.
Professor of History, Emeritus
Institute Archivist, Emeritus

Cyril Stanley Smith, Sc.D.
Institute Professor, Emeritus
Professor of the History of Science and Technology, Emeritus
Professor of Metallurgy, Emeritus

Robert Smith Woodbury, S.B., A.M.
Professor of the History of Technology, Emeritus

History

Distribution Subjects
Field of Concentration
Major Programs: XXI, XXI-E, XXI-S

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

Alvin Charles Kibel, Ph.D.
Professor of Literature
Section Head

Albert Ramsdell Gurney, Jr., M.F.A.
Professor of Literature
(On leave, fall)

Louis Kampf, B.A.
Professor of Literature
(On leave, spring)

Barry Bernard Spacks, M.A.
Professor of Literature
(On leave, fall)

Irene Tayler, Ph.D.
Professor of Literature

Cynthia Griffin Wolff, Ph.D.
Professor of Literature
(On leave, fall)

Peter Samuel Donaldson, Ph.D.
Associate Professor of Literature

David Martin Halperin, Ph.D.
Associate Professor of Literature

Travis Rhodes Merritt, Ph.D.
Associate Professor of Literature
Director, Humanities Undergraduate Office

Stephen James Tapscott, Ph.D.
Associate Professor of Literature

David Thorburn, Ph.D.
Associate Professor of Literature
(On leave, spring)

Susan Dickman, Ph.D.
Assistant Professor of Literature

John Hildebidle, Ph.D.
Assistant Professor of Literature

Amy Lang, Ph.D.
Assistant Professor of Literature

Steven Mullaney, Ph.D.
Assistant Professor of Literature

William Paul, Ph.D.
Assistant Professor of Literature

Theodore Wood, Jr., A.M.
Professor of Literature and American Studies, Emeritus
Senior Lecturer in Literature

Howard Eiland, Ph.D.
Lecturer in Literature

Jane Roessner, Ph.D.
Lecturer in Literature

William Chace Greene, M.A.
Professor of Literature, Emeritus

Roy Lamson, Ph.D.
Class of 1922 Professor of Literature, Emeritus

Literature

Distribution Subjects
Field of Concentration
Major Programs: XXI, XXI-E, XXI-S

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.

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** (21.171-21.178), restricted to students who have taken at least two previous subjects in literature, encourage a greater degree of independent work, such as oral reports and other special projects. Enrollment in seminars is strictly limited to a maximum of 12 students.

Humanities Distribution Subjects. The Literature curriculum is notable for the range of its HUM-D offerings. The most broadly gauged of these, recommended especially for students seeking general introductions to literary study, are 21.001 **Foundations of Western Literature: Homer to Dante;** 21.002 **Classics of European Literature,** 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.

More specialized subjects carrying HUM-D credit are listed in the curriculum, and are open to all students. They include: Comedy; Tragedy; The Film Experience; Shakespeare; Modern Russian Literature; The American Novel; Literature, Ideology, and National Experience in the US.

Concentrations in Literature. The requirements for a Literature Concentration are three subjects that form a coherent group. 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, minority and ethnic studies, literary theory and 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 Literature Faculty Office, 14N-305, and the Humanities Undergraduate Office, 14N-409.

The Literature Major. The Literature Section offers a variety of major programs, including joint majors in combination with curricula in Engineering or Science (XXI-E and XXI-S) as well as a more intensive major program (XXI), 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

Marcus Aurelius Thompson, D.M.A.
Associate Professor of Music
Section Head

David Mayer Epstein, Ph.D.
Professor of Music
Conductor of the MIT Symphony Orchestra

Stephen Erdely, Ph.D.
Professor of Music

John Harbison, M.F.A.
Professor of Music
(On leave)

Jeanne Shapiro Bamberger, M.A.
Associate Professor of Music
(On leave, fall)

John La Boiteaux Buttrick, M.S.
Associate Professor of Music

Jane Coppock, Ph.D.
Associate Professor of Music
(On leave)

Lowell Edwin Lindgren, Ph.D.
Associate Professor of Music
(On leave, fall)

Barry Lloyd Vercoe, D.M.A.
Associate Professor of Music and Technology

Timothy Charles Aarset, D.M.A.
Assistant Professor of Music

Edward Cohen, M.A.
Senior Lecturer in Music

John Oliver, M.M.
Senior Lecturer in Music
Director, MIT Choral Society

John Cook, Mus.B.
Lecturer in Music
(On leave)

Steven Haflich, M.Phil.
Lecturer in Music

Mark Harvey, Ph.D.
Lecturer in Music

Melissa Howe, M.M.
Lecturer in Music

Martin Marks, M.A.
Lecturer in Music

Roland Vazquez, M.A.
Lecturer in Music

Claudia Von Canon, M.A.
Lecturer in Music

James David Christie, M.M.
Institute Organist

Klaus Liepmann
Professor of Music, Emeritus
Director of Music, Emeritus

Music

Distribution Subjects
Field of Concentration
Major Programs: XXI; XXI-E; XXI-S

The Music Section offers a broad range of opportunities to experience and explore the field of music. A great variety of subjects is given, ranging from early music performance to computer music composition. They are ordered into five categories: Introductory, History/Literature, Theory/Composition, Performance, and Seminars/Tutorials. Most students begin with introductory subjects, but anyone with musical training is encouraged to begin with history/literature or theory/composition subjects, which constitute the nucleus of the program. Graduate credit is available for nearly all of the seminars and tutorials.

A symphony orchestra, choral groups, concert and jazz bands, and chamber music groups are an integral part of MIT's cultural life and of any student's musical development, no matter what technical proficiency they possess. Academic credit is available for some performance activities at MIT. Auditions for groups are held at the beginning of each term.

The music faculty comprises professional composers, performers, historians, and theorists, whose individual interest in the confluence of history, theory, and performance is essential to our integrated music program.

A full major in music is available under Course XXI. For students interested in combining the study of engineering or science with humanities, joint majors in Course XXI-E and XXI-S 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.

Concentration in music requires four subjects. Students should file a plan of study with the advisor in the Music Section when they are enrolled in their first music subject. All subjects in the Section are applicable to the concentration requirement; but only one of the four may be a performance-related subject, and it must represent one year of performance.

For further information, students should contact the Music Section Office, Room 14N-434, 253-3210.

The Writing Program

James Paradis, Ph.D.
Associate Professor of Technical Communication
Program Head

Maxine Kumin, M.A.
Visiting Professor of Poetry

Elzbieta Ettinger Chodakowska, Ph.D.
Associate Professor of Writing

Rae Goodell, Ph.D.
Associate Professor of Science Writing
(On leave, spring)

Joe Haldeman, M.F.A.
Associate Professor of Science Fiction
(Visiting)

Bernard Avishai, Ph.D.
Assistant Professor of Writing

Ellen Chu, Ph.D.
Assistant Professor of Technical Writing

David Dobrin, Ph.D.
Assistant Professor of Technical Writing

Barbara Gastel, M.D.
Assistant Professor of Science Writing
(On leave)

Harriet Ritvo, Ph.D.
Assistant Professor of Writing

Joanne Yates, Ph.D.
Assistant Professor of Business Communication

Ilona Karmel, A.B.
Senior Lecturer in Writing
(On leave, fall)

Robin Becker, M.A.
Lecturer in Writing

Frank Conroy, B.A.
Lecturer in Writing

Fanny Howe
Lecturer in Writing

Marilyn Richardson, B.A.
Lecturer in Writing
(On leave, spring)

Charles Sides, Ph.D.
Lecturer in Writing

Steven Strang, Ph.D.
Lecturer in Writing

Robert Reynolds Rathbone, A.M.
Professor of Technical Communication, Emeritus

The Writing Program

Distribution Subjects
Field of Concentration
Major Programs: XXI; XXI-E; XXI-S

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.

Subjects in the Program's three categories — 1) Exposition and Rhetoric, 2) Creative Writing, and 3) Science and Technical Communication — are taught at basic, intermediate, and advanced levels. All subjects require repeated writing and revision. In addition, manuscripts are typically discussed in workshops and receive the written commentary of the instructor. Students are encouraged to schedule private conferences with their instructors.

Concentration. Many students elect to concentrate in Writing by selecting a program of four subjects in one or more of the Program's three categories. Concentrations establish a course of intensive study for prose, poetry, and fiction writers, or for engineers and scientists who expect writing to play a key role in their career development. For more information, consult the Writing Concentration advisor in the main Writing Program Office.

Writing Majors. Students with a strong interest in writing may pursue a Writing Major. The Course XXI-E and XXI-S Writing Major programs require a combination of subjects in science or engineering, writing, and a related field of humanities, arts, or social sciences.

The Course XXI major in Writing offers students the opportunity to focus on a single area of the writing curriculum — exposition and rhetoric, creative writing, or science and technical writing — in conjunction with the study of a related field in the humanities, arts, or social sciences. Students should contact the Course XXI Office (Room 14N-405, 253-4446) and the Writing Program Office (14E-310, 253-7894) for information. Since all requirements are guidelines, students work out individual programs with their advisors.

Special and Interdisciplinary Programs in Humanities

The Writing Requirement. In the spring of 1982, the MIT faculty passed an Institute writing requirement. Students may satisfy Phase One of the writing requirement by earning a passing grade in any of three introductory subjects, including 21.730 **Expository Writing,** 21.731 **Writing and Experience,** and 21.732 **Introduction to Technical Communication.** Additional inquiries should be directed to the Office of the Writing Requirement (253-3039).

Writing Center. The MIT Writing Center offers individual writing consultation on a drop-in basis to all MIT students. In addition, each semester the center gives mini-sessions on a variety of writing topics. For further information, contact The Writing Center (253-3090) or The Writing Program (253-7894).

Cooperative Writing Programs. The Science and Technical Communication staff of the Writing Program also supports an interdepartmental program of writing instruction jointly with the undergraduate and graduate departments in the School of Engineering, as well as the graduate sections of the Sloan School of Management and the Department of Urban Studies and Planning. For further information on these programs, contact the main Writing Program Office.

For subjects in Writing, see subjects 21.725-21.799 in Chapter VII.

American Studies

Distribution Subjects
Field of Concentration
Major Programs: XXI-E; XXI-S

American Studies at MIT offers students the opportunity to organize subjects from various fields (primarily History, Anthropology/Archaeology, Literature, Political Science, 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 a joint degree program (XXI-E or XXI-S). 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, and students may with permission include selected subjects from outside the core curriculum listed below.

For more information on American Studies subjects, see the appropriate listings in Chapter VII. Core subjects for American Studies are listed below.

Subjects in Literature

21.006 Introduction to American Literature (HUM-D)
21.030 Popular Narrative: Fantasy and Science Fiction
21.031 The Film Experience (HUM-D)
21.032J American Television: A Cultural History
21.087 Modernist Poetry
21.101 The American Novel (HUM-D)
21.103J Literature, Ideology and National Experience in the US (HUM-D)
21.105 American Voices
21.112 American Authors
21.120 American Themes: Inventing America
21.175 Major Authors

Subjects in History

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
21.409 American Ideas and Culture: From the Puritans to the Civil War (HUM-D)
21.410 American Ideas and Cultures: From the Civil War to World War I
21.411 American Ideas and Culture: the Modern Age, 1920-1980
21.412J American Urban History I (HUM-D)
21.413J America Urban History II
21.416 Women's History
21.418 The Civil Rights Movement
21.431 Thomas Jefferson and His Age
21.432 Religion in America
21.433J Industrialization and Cultural Change in 19th-Century America
21.435 The American Psyche
21.439 Fortress America: the Rise of the American Military, 1945-1975
21.449 Seminar in American Studies

Subjects in Anthropology/Archaeology

21.513 Religious Movements and Social Change (HUM-D)
21.546 The Archaeology of Industrial Revolutions
21.551 The First Americans
21.581 The Family in Contemporary Society (HUM-D)
21.585 American Communes and Utopias
21.586 Sex Roles: A Comparative Perspective
21.587 Organizing Modern Society
21.589J Anthropology of Industrial Society

Subjects in Music

21.635 American Music (HUM-D)
21.636 Jazz (HUM-D)
21.637 Traditional Music in America (HUM-D)

Subjects in Political Science

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
17.251 Congress and the American Political System
17.253 Executive Leadership: Presidents, Governors, and Mayors
17.255 Politics, TV, and the News
17.271 Evolution of American Politics

Latin American Studies

Distribution Subjects
Field of Concentration
Major Programs: XXI-E; XXI-S

The program in Latin American Studies offers MIT students the chance to explore interconnections between culture, society, and politics in a major "third-world" area. Its underlying purpose is to reveal the historical and contemporary forces that have shaped Latin American civilization and that delineate prospects and problems for future development, including the relationship to the United States and other parts of the "industrial world."

The concentration requirement consists of four subjects, no more than two of which should be from a single discipline; only one of the four can focus on the Iberian peninsula. Knowledge of Spanish and Portuguese is not absolutely necessary, but students are strongly encouraged to include at least one subject in the Spanish language.

The following list of subjects in Latin American Studies is drawn from various disciplines. Students are urged to consult with the program advisor about the possibility of counting selected collateral subjects toward partial fulfillment of the concentration.

Latin American Studies is also available as a major through Course XXI in Programs XXI-E and XXI-S. For the major, students must take at least one advanced subject conducted in Spanish (or Spanish III and IV). No more than four subjects can be from a single discipline; no more than two can focus on the Iberian peninsula. Interested students should consult the program advisor.

For more information on Latin American Studies subjects, see the appropriate listings in Chapter VII.

Subjects in Foreign Languages and Literatures

21.281 Intermediate Spanish Conversation and Composition
21.282 Spanish for Bilingual Students (HUM-D)
21.284 An Introduction to Latin American Culture (HUM-D)
21.285 Introduction to Spanish Culture (HUM-D)
21.286 Latin American Literature 1492-1898: Creation of a Continent (HUM-D)
21.287 Twentieth-Century Latin American Literature: The Alchemist's Laboratory (HUM-D)
21.288 The Modern Short Story in Spain and Latin America
21.290 Literature and Social Conflict: Perspectives on Modern Spain (HUM-D)
21.291 The Family in Spanish-American Literature
21.292 Cervantes and His Age
21.310 Masterpieces of the Hispanic Tradition (HUM-D)

Subjects in History

21.470 Latin American History
21.471 History of Mexico

Subjects in Anthropology/Archaeology

21.520 Mexican Society and Development
21.550 The Ancient Andean World
21.552 Origins of Civilization — The Aztecs, Maya, and their Ancestors

Subjects in Political Science

17.543 Comparative Politics of Latin America
17.544 Comparative Politics of Latin America

Russian Studies

Distribution Subjects
Field of Concentration
Major Programs: XXI-E; XXI-S

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. Russian Studies may be taken as a field of concentration or as a joint major in Programs XXI-E and XXI-S. 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.

Subjects in Russian Studies

17.490 Issues in Soviet Defense Planning
17.603 Continuity and Change in Soviet Politics
17.604 Soviet and Chinese Foreign Policy and the Communist World
17.608 Radical and Revolutionary Ideologies
17.609J Seminar in the Historical and Political Evolution of the Soviet Union
17.612 The Soviet Political System
21.080 Dostoevsky, Tolstoy, Solzhenitsyn
21.268 Russian Culture and Civilization (HUM-D)
21.302 Slavic Civilization: Magic, Vampires, and Witches (HUM-D)
21.313 Religious Trends in Soviet Thought and Literature
21.314 Tolstoy: An Approach to Biography and Creativity (HUM-D)
21.315 Seminar on Tolstoy's *War and Peace*
21.316 The Roots of Russian Literature (HUM-D)
21.317 Russian Novel of the 19th Century (HUM-D)
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
21.378J Seminar in the Historical and Political Evolution of the Soviet Union
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.

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 Dramatic Literature

21.005 Introduction to Drama (HUM-D)
21.009 Shakespeare (HUM-D)
21.021 Comedy (HUM-D)
21.022 Tragedy (HUM-D)
21.086 Twentieth-Century Drama
21.173 Advanced Studies in Drama
21.223 Modern French Drama
21.250 Introduction to German Drama (HUM-D)

Subjects in Theatre Arts and Dance

21.236 German Drama Workshop
21.700 Acting I
21.701 Acting II
21.702 Theatre Arts: Elementary Stagecraft and Production Studies
21.703 Performance Workshop in Drama
21.704 Performance Workshop in Dance
21.768 Plays and Playwriting

Traditions and Texts

Distribution Subjects
Field of Concentration

This program provides a series of humanistic subjects, listed below, which are designed to introduce undergraduates to some of the major traditions of the world as expressed in texts and works of art. Although most of these subjects are drawn from the West, the program includes options concerned with other civilizations. These subjects cut across various forms of thought and expression — religion, philosophy, history, literature, and the arts — and are taught by members of different faculties. "Tradition" refers to the changing network of agreements which links a society's present with its past and future, and to the processes of transmission and rebuilding which occur within it.

Any one of these subjects may be used for Distribution. The program may also be designated as a four-subject Field of Concentration, in which either 21.708 or 21.709 is required.

Subjects in Traditions and Texts

21.708 The Bible (HUM-D)
21.709 The Greeks (HUM-D)
21.710 The East Asian Tradition: Past and Present (HUM-D)
21.711 The Islamic Tradition: Past and Present (HUM-D)
21.712 The Romans (HUM-D)
21.713 Major Medieval Texts (HUM-D)
21.714 The 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)
21.718 The Americans (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 advisors.

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
21.256 Classical Greek II (HUM-D)
21.302 Slavic Civilization: Magic, Vampires, and Witches (HUM-D)
21.316 The Roots of Russian Literature (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)
21.553 Origins of Civilization — Middle East
21.554 Origins of Civilization — Egypt
21.559 The Decline of Empires
21.584 Agrarian Society (HUM-D)
21.708 The Bible (HUM-D)
21.709 The Greeks (HUM-D)
21.713 Major Medieval Texts (HUM-D)

Degree Program Requirements

Women's Studies

Distribution Subjects
Field of Concentration

Women's Studies is concerned with the social, historical, and cultural experience and contributions of women. This includes an examination of sex roles and gender identity at the individual level, at different times and in different societies, and whether or not we can discover cultural universals with respect to what it means to be a man or woman. A Women's Studies perspective can add an important and long-neglected dimension to traditional humanistic, scientific, and social scientific disciplines by providing significant reassessments of what is adequate theory and methodology, in fields as diverse as biology, psychology, or literature. A student's program may consist of three subjects in a single discipline (e.g., literature), or it may be interdisciplinary if a coherent theme is clearly apparent (e.g., a concern with sex roles and the family). Subjects listed below qualify for inclusion in the concentration. Other subjects may be included if approved by the Committee on Women's Studies Concentration. One subject of the three may be taken at Wellesley or Harvard.

	Subjects in Women's Studies
21.003	Introduction to Fiction (HUM-D)(Perry's section)
21.291	The Family in Spanish-American Literature
21.297	Sex Roles in Fiction: Europe and Latin America (HUM-D)
21.298	The Don Juan Legend (HUM-D)
21.416	Women's History
21.581	The Family in Contemporary Society (HUM-D)
21.586	Sex Roles: A Comparative Perspective

Film and Media Studies

Distribution Subjects
Field of Concentration

The program in film and media offers MIT undergraduates an opportunity for interdisciplinary study of film, television, and other media of mass communications. The goal of the program is to develop an understanding of the historical, cultural, and artistic signficance of film and other modern media.

Many of the subjects that comprise the core curriculum make extensive use of such special resources as the MIT Cable Television system, which regularly telecasts films and specially prepared video tapes in conjunction with particular subjects; the University Film Study Center, an archive containing primary film and video materials as well as books and periodicals devoted to film and media; the Research Program on Communications Policy, which conducts seminars and research on the mass media; and the News Study Group, which archives and analyzes public affairs and news broadcasting.

Faculty drawn from the following fields regularly teach subjects in the core curriculum: art and architecture, foreign languages and literatures, literature, and political science.

The concentration requirement consists of four subjects, no more than three of which may be from a single discipline.Each student designs his or her own plan of study in consultation with a field advisor. Field advisors for 1983-84 are Professors Russell Neuman (Political Science), David Thorburn (Literature), and Edward Turk (Foreign Languages and Literatures).

	Subjects in Film and Media Studies
4.991	Introduction to the History of Film
17.217	Media and Public Policy
17.255	Politics, TV, and the News
17.705	The Social Effects of Communications Technologies
17.707	Mass Communication and American Culture (HUM-D)
21.010	Literature and Film (HUM-D)
21.031	The Film Experience (HUM-D)
21.032J/ STS 625J	American Television: A Cultural History
21.033	Major Film Directors
21.228	French Film Classics
21.229	The French New Wave Cinema
21.304	The German Cinema

Students may also fulfill the concentration requirement by choosing a subject drawn from a list of collateral subjects in a variety of disciplines. For further information, consult field advisors.

Full, Joint, and Double-Degree Majoring

For students who wish to carry on their humanistic studies extensively and at an advanced level, two basic types of degree programs are available. The first, Course XXI, constitutes a **full** major in any one of seven fields of the humanities. The second, Course XXI-E or XXI-S, is a **joint** major which combines work in humanities with work in engineering, science, or psychology. Further, a student pursuing either a **full** or **joint** major in XXI may obtain interdisciplinary competence on a larger scale by adding a separate major in a discipline of engineering or science, as part of a **double-degree** arrangement. In fact, one version of the full major, that in STS/Humanities, may be taken only in conjunction with another degree program in Engineering or Science. Descriptions and specifications for full and joint major programs in Course XXI follow.

Bachelor of Science in Humanities
Course XXI

This program provides a **full** major in any of the following fields: Anthropology/Archaeology; Foreign Languages and Literatures; History; Literature; Music; Writing; STS/Humanities. The required curriculum consists of eight to eleven subjects in the chosen discipline plus four subjects from a related field of humanities, arts, or social sciences. Depending on the field of specialization, the course of study may include special introductory or advanced seminars and a senior thesis or general examination. Faculty advisors in each of the disciplines help students to arrange programs suited to both their main lines of interest and professional objectives.

Bachelor of Science in Humanities Course XXI

General Institute Requirements	Total Units
Specific science and humanities, arts, and social sciences subjects[1]	132
Science Distribution Requirement	36
Laboratory Requirement	12
Departmental Programs	

Restricted Electives	122 to 149
One of the following	

Anthropology/Archaeology

Thesis (21.ThU)	18
Eight elective subjects in Anthropology/Archaeology including 21.501, 21.502, and 21.503 or 21.504 (21.50 is also strongly recommended, as a preliminary subject, in addition to the required program)	at least 72
Four elective subjects in a second discipline of humanities, arts, or social sciences	at least 36

Foreign Languages and Literatures

Thesis (21.ThU)	18
Eight elective subjects in one of the following languages: French, German, Russian, or Spanish (with permission of advisor one subject not conducted in the foreign language may be counted; for a student whose program is in cultural area-study rather than strictly in language and literature, additional subjects not conducted in the foreign language may be counted)	at least 72
Four elective subjects in one second discipline of the humanities, arts, or social sciences, or four subjects from various disciplines that form a coherent grouping	at least 36

Restricted Electives (continued)

History

Thesis (21.ThU)	14
Nine elective subjects in History	at least 81
Four elective subjects in a second discipline of humanities, arts, or social sciences	at least 36

Literature

Three advanced-level Literature seminars	36
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 (with the permission of the Literature faculty, a student may substitute a 14-unit Thesis [21.Thu] for one elective)	at least 27
Four elective subjects in a second discipline of humanities, arts, or social sciences	at least 36

Music[2]

General Examination (21.Ex) or Thesis (21.ThU)	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, arts, or social sciences	at least 36
[Four semesters of ensemble performance are also required; these may be taken for credit as performance subjects in addition to the regular requirements.]	

Writing

Thesis (21.ThU)	14
Five subjects in Writing of which three must be in one of the following areas: creative writing, exposition and rhetoric, science and technical writing. One of these three subjects 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 student's educational goals in writing	at least 36
Four elective subjects in another discipline of humanities, arts, or social sciences	at least 36

Restricted Electives (continued)

STS/Humanities*

Thesis (21.ThU)	14
Reading Seminar in Humanities, Science and Technology I and II (21.901J/STS 130J and 21.902J/STS 131J)	18
Project Seminar (21.903J/STS 132J)	9
A coherent group of five elective subjects, drawn from the curricula of the Program in Science, Technology, and Society, the Department of Humanities, and other departments where appropriate. Three of these subjects must be in one of the following areas, and one must be in each of the other two: a) Social and Historical Studies of Science and Technology b) Technology and the Organization of Industrial Societies c) Cultural Dimensions of Science and Technology	at least 45
Four elective subjects in a second discipline of humanities, arts, or social sciences	at least 36

*[The full major in STS/Humanities may be pursued only as a second degree program in conjunction with another degree program in a field of engineering or science.]

Students who wish to integrate studies in STS, Humanities and Science/Engineering on the smaller scale of a single degree program should see the description of STS/Humanities as an option in the joint major, XXI-E/XXI-S.

Unrestricted Electives[1]	58 to 31
Total Units Required for the S.B. Degree	360

1
Since the major program normally contains five of the eight subjects which satisfy the Institute Requirement in Humanities, Arts, and Social Sciences (i.e., those not being used to meet the Distribution Requirement), the number of units of Unrestricted Electives is effectively increased by 45, to a total of 103 to 76. Note, however, that as a matter of general Course XXI policy, subjects used to meet other elements of the General Institute Requirements (including the freshman requirements in Physics, Mathematics, and Chemistry/Biology, the Science Distribution Requirement, the Laboratory Requirement, and the Humanities, Arts, and Social Sciences Distribution Requirement) may not be counted toward any component of the major program requirement.

2
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 on an analytical or historical topic or an original composition.

Bachelor of Science in Humanities and Engineering Course XXI-E

Bachelor of Science in Humanities and Science Course XXI-S

These **joint** major programs combine humanities with scientific/engineering studies, creating an educational experience of unusual scope and balance. Groups of subjects from the humanistic and technical areas are conjoined to yield a substantial "dual literacy," a basic command of each mode of inquiry. One part is a selection from the undergraduate degree curriculum of a science or engineering department, or the Department of Psychology, approved by a faculty member in the field. The other part consists of subjects in some field of the humanities, chosen by the student in consultation with an advisor from the appropriate humanistic faculty. In most cases a senior thesis, general examination, or sequence of advanced seminars is also required.

This arrangement yields a humanities program of considerable depth while allowing for continued serious commitment to a scientific or engineering interest. Available humanities fields include: Anthropology/Archaeology; Foreign Languages and Literatures (in French, German, Russian, or Spanish); History; Literature; Music; Writing; American Studies; Latin American Studies; Russian Studies; and STS/Humanities.

Any one of these fields may be joined with any Science or Engineering field to form a major. Some combinations naturally lend themselves not only to an understanding of each field but also to an integrative and comparative view of the relationship between the two. In fact one field — STS/Humanities — is designed expressly for this purpose. It includes a group of specially designated relational subjects offered by the faculties in Humanities and the Program in Science, Technology, and Society, which provide a focus for interdisciplinary work. Central to this core is a year-long reading seminar, jointly taught by faculty members from Humanities and STS, which examines interactions of science, technology, and culture through critical discussion of major works.

Studies in Humanities, STS, and Science/Engineering can also be integrated on the larger scale of a double-degree program. See the description of the full Course XXI major in STS/Humanities.

Bachelor of Science in Humanities and Engineering Course XXI-E

Bachelor of Science in Humanities and Science Course XXI-S

General Institute Requirements	Total Units
Specific science and humanities, arts, and social sciences subjects[1]	132
Science Distribution Requirement	36
Laboratory Requirement	12
Departmental Program	
Restricted Electives	129 to 140
For the Humanities Component, **one** of the following	
Anthropology/Archaeology	
Thesis (21.ThU)	18
Seven elective subjects in Anthropology/Archaeology, including 21.501,21.502. and 21.503 or 21.504 (21.50 is also strongly recommended, as a preliminary subject, in addition to the required program)	at least 63
Foreign Languages and Literatures	
Thesis (21.ThU)	18
Seven elective subjects in one of the following languages: French, German, Russian, or Spanish (with permission of advisor one subject not conducted in the foreign language may be counted; for a student whose program is in cultural area-study rather than strictly in language and literature, additional subjects not conducted in the foreign language may be counted)	at least 63
Restricted Electives (continued)	
History	
Thesis (21.ThU)	14
Seven elective subjects in History	at least 63
Literature	
Eight elective subjects in Literature including three which are substantially involved in three of the following periods: 1) Ancient and Classical; 2) Medieval; 3) Renaissance; 4) 17th Century and Enlightenment; 5) 19th Century. At least two of these eight electives must be seminars from the advanced tier of the curriculum. With the permission of the Literature faculty, a student may substitute a 14-unit Thesis (21.ThU) for one elective.	at least 78
Music	
Advanced Music Seminar approved by advisor[2]	9
Two subjects in composition (21.641, and 21.642)	21
Two subjects in history and literature of music (21.621 and 21.622)	18
Three additional elective subjects in Music (excluding 21.60 and performance subjects)	at least 27
[Two subjects of ensemble performance are also required; these may be taken for credit as performance subjects in addition to the regular requirements.]	
Writing	
Thesis (21.ThU)	14
Four elective subjects in Writing, three of which must be from one of the following areas: creative writing, exposition and rhetoric, science and technical writing. One of these three must be from the advanced tier of the curriculum.	at least 36
Three subjects in a field of humanities, arts, or social sciences pertinent to the student's educational goals in writing.	at least 27
American Studies[3]	
Thesis (21.ThU)	14
Seven elective subjects from the list of American Studies subjects, including at least two subjects in American history and at least two subjects in American literature	at least 63

1
Since the major program normally contains five of the eight 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 96 to 85. Note, however, that as a matter of general Course XXI policy, subjects used to meet other elements of the General Institute Requirements (including the freshman requirements in Physics, Mathematics, and Chemistry/Biology, the Science Distribution Requirement, the Laboratory Requirement, and the Humanities, Arts, and Social Sciences Distribution Requirement) may not be counted toward any component of the major program requirement.

2
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 seminar approved by the major advisor. Especially qualified students may be permitted to substitute a thesis on an analytical or historical topic or an original composition.

3
American Studies, Latin American Studies, and Russian Studies are also available as full majors by special arrangement with the Course XXI Office.

Restricted Electives (continued)

Latin American Studies[3]

Thesis (21.ThU) 14

Seven elective subjects from the list of Latin American Studies subjects: the program may not include more than four subjects from any single discipline; no more than two subjects may focus on the Iberian Peninsula. Program must include either Spanish III and IV or one advanced elective subject conducted in Spanish. **at least 63**

Russian Studies[3]

Thesis (21.ThU) 14

Seven elective subjects from the list of Russian Studies subjects, including at least two on Russian society (e.g., history, political science) and at least two on Russian culture (e.g., literature) **at least 63**

STS/Humanities

Thesis (21.ThU) 14

Reading Seminars in Humanities, Science and Technology I and II (21.901J/STS 130J and 21.902J/STS 131J) 18

Six subjects from the curricula of Humanities, STS, and other departments where appropriate, which form a coherent grouping that includes at least one basic subject in the history of science or technology and one subject treating the cultural dimensions of science and technology, and that has clear relevance to the scientific/technical field forming the other component of the program **at least 54**

Students who wish to integrate studies in STS/Humanities, and Science/Engineering on the larger scale of a double-degree program should see the description of STS/Humanities as an option in the full major, XXI.

And, for the Engineering/Science component, **one** of the following

For **XXI-E**

Six elective subjects restricted to one of the Engineering curricula and approved by a faculty member in the field **at least 54**

[When possible, the subject satisfying the Institute Laboratory Requirement and one of the subjects satisfying the Science Distribution Requirement should be selected from this same curriculum, in addition to the regular requirement.]

Restricted Electives (continued)

For **XXI-S**

Six elective subjects restricted to one of the Science curricula and approved by a faculty member in the field **at least 54**

[When possible, the subject satisfying the Institute Laboratory Requirement and one of the subjects satisfying the Science Distribution Requirement should be selected from this same curriculum, in addition to the regular requirement.]

or

The following program in Psychology:

Introduction to Psychology (9.00) 9

Five intermediate-level subjects distributed across no fewer than three of the following four categories:

a) The Neurosciences (9.01, 9.02, 9.50, 9.91, 9.92)
b) Perception and Natural Computation (9.35, 9.36, 9.50, 9.91, 9.92)
c) Cognitive Science (9.62J, 9.65, 9.59, 9.50, 9.91, 9.92)
d) Comparative, Developmental and Social Psychology (9.05, 9.30, 9.68, 9.70, 9.88, 9.90, 9.50, 9.91, 9.92) **at least 45**

Unrestricted Electives[1] **40 to 51**

Total Units Required for the S.B. Degree 360

1
Since the major program normally contains five of the eight 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 96 to 85. Note, however, that as a matter of general Course XXI policy, subjects used to meet other elements of the General Institute Requirements (including the freshman requirements in Physics, Mathematics, and Chemistry/Biology, the Science Distribution Requirement, the Laboratory Requirement, and the Humanities, Arts, and Social Sciences Distribution Requirement) may not be counted toward any component of the major program requirement.

3
American Studies, Latin American Studies, and Russian Studies are also available as full majors by special arrangement with the Course XXI Office.

Inquiries

Additional information concerning degree programs in Course XXI may be obtained from Professor Travis R. Merritt, Director of the Humanities Undergraduate Office, Room 14N-405, MIT, Cambridge, Massachusetts 02139, (617) 253-4446.

Department of Linguistics and Philosophy

Undergraduate Study

Samuel Jay Keyser, Ph.D.
Professor of Linguistics
Director, Center for Cognitive Science
Head of the Department

Professors

Ned Block, Ph.D.
Professor of Philosophy

George Stephen Boolos, Ph.D.
Professor of Philosophy
(On leave, spring)

Sylvain Bromberger, Ph.D.
Professor of Philosophy

Richard Lee Cartwright, Ph.D.
Professor of Philosophy

Noam Avram Chomsky, Ph.D.
Institute Professor
Professor of Linguistics

Hartry Field, Ph.D.
Professor of Philosophy
(Visiting, spring)

Jerry Alan Fodor, Ph.D.
Professor of Philosophy
and Psycholinguistics

Kenneth Locke Hale, Ph.D.
Ferrari P. Ward Professor of
Modern Languages and Linguistics
(On leave)

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
(On leave)

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

James Higginbotham, Ph.D.
Associate Professor of Philosophy

Paul Horwich, Ph.D.
Associate Professor of Philosophy
(On leave)

James McCloskey, Ph.D.
Associate Professor of Linguistics
(Visiting, fall)

Luigi Rizzi, D.Lit.
Associate Professor of Linguistics
(Visiting)

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

Administrative Officer

Marilyn Matthes Silva, A.B.

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, arts, and social sciences subjects		132
	Science Distribution Requirement		36
	Laboratory Requirement		12
	Departmental Program		
	Required Subjects[1]		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	Logic I	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

Bachelor of Science in Philosophy
Course XXIV
Program 2: Language and Mind

	General Institute Requirements		Total Units
	Specific science and humanities, arts, and social sciences subjects[2]		132
	Science Distribution Requirement		36
	Laboratory Requirement		12
	Departmental Program		
	Required Subjects[1]		69
24.119	Minds and Machines	3 0 9	
24.151	Introduction to Philosophy of Language	3 0 6	
24.241	Logic I	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 three subjects		
9.59	Psychology of Language and Communication	3 0 6	
9.65	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

24.200	Ancient Philosophy
24.202	Modern Philosophy: Descartes to Kant
24.211	Theory of Knowledge
24.221	Metaphysics
24.242	Logic II
24.251	Philosophy of Science
24.521	Topics in Philosophy of Mind
24.801	Philosophy of Mathematics

Group II: Linguistics

24.951	Introduction to Linguistics I: Syntax
24.952	Introduction to Linguistics III: Theory of Grammar
24.956	Introduction to Linguistics IV: Universal Grammar

Group II: Linguistics (continued)

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	Sensation and Perception
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
9.65	Cognitive Processes
9.651	Cognitive Processes
9.652	Seminar in Cognitive Development
9.88	Development of Behavior
9.92	Topics in Psychology

Group IV: Artificial Intelligence

6.034	Artificial Intelligence
6.036	Problem-Solving Paradigms
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

1
Any student taking the required subjects for either Program 1 or Program 2 automatically satisfies the requirements for Concentration in Philosophy.

2
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.

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:

24.941 Topics in the Grammar of a Non-Indo-European Language
or
24.942 Topics in the Grammar of a Non-Indo-European Language
24.951 Introduction to Linguistics I: Syntax
24.961 Introduction to Linguistics II: Phonology
24.952 Introduction to Linguistics III: Theory of Grammar
24.956 Introduction to Linguistics IV: Universal Grammar
24.957 Introduction to Linguistic Theory at an Advanced Level
24.958 Linguistic Structure
24.959 Workshop in Syntax
24.962 Advanced Phonology
24.969 Workshop in Phonology
24.972 Formal Foundations of Linguistic Theory
24.973 Topics in Logic and Semantics
24.982 Linguistic Change
24.992 Survey of General Linguistics I

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 including a proseminar in contemporary philosophy which all students must complete in their first year of graduate study. Students are also required to pass general examinations and demonstrate competence in the following areas; value theory, logic, and the history of philosophy.

Interdisciplinary study is encouraged, and candidates for the doctorate may take a minor in a field other than philosophy. Options for minors include psychology, linguistics, and logic. Students who elect one of these options will be expected to complete three approved graduate subjects in their minor field. There is no general language requirement for the doctorate, except in those cases in which competence in one or more foreign languages 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-213, MIT, Cambridge, Massachusetts 02139, (617) 253-4141.

Department of Political Science

Donald Laurence Morton Blackmer, Ph.D.
Professor of Political Science
Head of the Department

Professors

Hayward Rose Alker, Jr., Ph.D.
Professor of Political Science

Alan Anthony Altshuler, Ph.D.
Professor of Political Science
and Urban Studies and Planning
(On leave)

Suzanne Berger, Ph.D.
Professor of Political Science

Lincoln Palmer Bloomfield, Ph.D.
Professor of Political Science

Walter Dean Burnham, Ph.D., Lit.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
(On leave)

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., L.L.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
(On leave)

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

Myron Weiner, Ph.D.
Ford Professor of Political Science

Associate Professors

Stephen Michael Meyer, Ph.D.
Associate Professor of Political
Science

Brian Henry Smith, Ph.D.
Associate Professor of Political
Science
(On leave)

Deborah Anne Stone, Ph.D.
Associate Professor of Political
Science

Martha Wagner Weinberg, Ph.D.
Associate Professor of Political
Science
(On leave)

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

Daniel Metlay, 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
(On leave)

Senior Lecturers

Edwin Diamond, M.A.
Louis Menand III, Ph.D.
(On leave, spring)

Lecturers

Ted Ronald Ivan Greenwood, Ph.D.
Charles M. Jonscher, Ph.D.

Visiting Lecturer

Richard Greene, Ph.D.

Administrative Officer

Anne M. Grazewski

Administrative Staff

Frances F. Powell

Professors Emeriti

Everett Hagen, Ph.D.
Professor of Economics and
Political Science, Emeritus

Harold Robert Isaacs, A.B.
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 selected other subjects with faculty permission. 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, arts, and social sciences subjects[1]		132
	Science Distribution Requirement[2]		36
	Laboratory Requirement		12
	Departmental Program		
	Required Subjects		18
17.913	Pre-thesis Reading Seminar	3 0 6	
17.ThU	Undergraduate Political Science Thesis	Arr.	
	Restricted Electives	**at least**	81
	Normally 9 subjects divided as follows:		
	a. At least one subject 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 subjects, majors take at least 5 additional political science subjects.		
	Specific subjects 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

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 nonpolitical 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), 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 prethesis and thesis subjects.

Bachelor of Science in Political Science: Public Policy Course XVII-A

	General Institute Requirements		Total Units
	Specific science and humanities, arts, and social sciences 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	Undergraduate Political Science Thesis	Arr.	
	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. This may be done through 17.351J or a supervised summer internship. Other course or non-course alternatives may be substituted 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 Introduction to Computers and 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

There are no absolute prerequisites for admission to the graduate program, but students are expected to have taken at least six term subjects in English, history, and other fields of the humanities and social sciences. It is recommended that candidates for the doctoral program take at least one upper-level subject on the history of political thought and one term of statistics. Candidates for master's and doctoral programs are advised to take undergraduate subjects in areas relevant to their special fields of interest, for example, introductory economics for work in public policy; languages for area studies; science or engineering subjects for study in science, technology, and public policy; and mathematics for work in defense and arms control.

Master of Science in Political Science and Public Policy

This program is intended both for mid-career professionals and for recent college graduates interested in career-oriented training for positions in government, the media, business, banking, research institutes, and nonprofit institutions. The program may also be suitable for students who think of working toward a Ph.D.

Four public policy fields are offered within this program: 1) Defense and Arms Control; 2) Science, Technology, and Public Policy; 3) Communications Policy; 4) International Development. Each specialty is structured so that each student takes one or more subjects on the policy process, methods of policy analysis, and substantive policy issues.

Students from a wide variety of disciplinary backgrounds and professional experience are welcomed. For mid-career professionals, at least eight courses are required for the S.M. degree, plus a thesis. Students without professional experience are ordinarily required to take 12 courses, plus a thesis. Students are expected to enter with or acquire an intermediate-level competence in both micro- and macroeconomics. The department places great importance on tailoring programs to meet the particular competencies and needs of students. Interested students are encouraged to write about their interests or personally visit the department. The general requirements for the S.M. are described in Chapter IV.

Master of Science in Political Science

The Master of Science is intended for students who are concerned with developing skills in applied research and who are seeking careers in public service. The master's program emphasizes intensive preparation in a single field of study. Students wishing to concentrate in any of the specialized fields offered in the S.M. program in Political Science and Public Policy (described above) should apply to that program. Students interested in other fields offered by the Department should apply for the S.M. in Political Science. Applications should describe the field in which students wish to specialize.

Subjects need not be restricted to those offered within the Department, but the entire program must meet with the approval of the student's advisor. A thesis is required. See Chapter IV of this catalogue for the general requirements for the S.M.

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 Food and Nutrition 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.

Department of Psychology

Richard Marx Held, Ph.D.
Professor of Experimental Psychology
Head of the Department

Professors

Emilio Bizzi, M.D.
Eugene McDermott Professor in the Brain Sciences and Human Behavior
Director, Whitaker College of Health Sciences, Technology, and Management

Stephan Lewis Chorover, Ph.D.
Professor of Psychology

Jerry Alan Fodor, Ph.D.
Professor of Philosophy and Psycholinguistics

Merrill Frederick Garrett, Ph.D.
Professor of Psychology

Norman Geschwind, M.D.
Professor, Harvard-MIT Division of Health Sciences and Technology
Professor of Psychology

Ann Martin Graybiel, Ph.D.
Professor of Neuroanatomy

Alan Hein, Ph.D.
Professor of Psychology

Walle Jetze Harinx Nauta, M.D., Ph.D.
Professor of Neuroanatomy
Institute Professor

Mary Crawford Potter, Ph.D.
Professor of Psychology
(On leave, fall)

Whitman Albin Richards, Ph.D.
Professor of Psychophysics

Peter Harkai Schiller, Ph.D.
Professor of Psychology

Gerald Edward Schneider, Ph.D.
Professor of Psychology and Brain Science

Associate Professors

Susan E. Carey, Ph.D.
Associate Professor of Psychology

Suzanne Hammond Corkin, Ph.D.
Associate Professor of Psychology

Daniel Nathan Osherson, Ph.D.
Associate Professor of Education and Psychology
(On leave)

Tomaso Armando Poggio, Ph.D.
Associate Professor of Psychology

Shimon Ullman, Ph.D.
Associate Professor of Psychology

Assistant Professors

John Hollerbach, Ph.D.
Assistant Professor of Psychology

Steven Pinker, Ph.D.
Assistant Professor of Psychology

Jeremy Michael Wolfe, Ph.D.
Assistant Professor of Psychology

Visiting Scholars/Scientists

Ferdinando Mussa Ivaldi, Ph.D.
Hanspeter Lipp, Ph.D.
Indra Mohindra, O.D.
Suzanne R. Tarlov, Ph.D.
Frank Thorn, O.D., Ph.D.

Technical Instructors

Henry Hall, S.B.
Diane Major
John Bruce Swan, A.E.

Research Associates/Scientists

Joseph Aloysius Bauer, Jr., M.S.
Benjamin Morgan Dawson, Ph.D.
Rhea Diamond Gendzier, Ph.D.
Harris R. Lieberman, Ph.D.
David Owen Pettijohn, M.S.
Edith V. Sullivan, Ph.D.

Postdoctoral Associates/Fellows

William Abend, M.D., Ph.D.
Marie F. Chesselet, M.D., Ph.D.
Neal J. Cohen, Ph.D.
Jane E. Gwiazda, Ph.D.
Paul E. Haenny, M.D.
F. Jacob Huff, M.D.
Robert B. Illing, Ph.D.
Judith L. Klavans, Ph.D.
Christof Koch, Ph.D.
Kathy A. Lawler, Ph.D.
Rafael Malach, Ph.D.
John H. Maunsell, Ph.D.
Brian B. McKeon, Ph.D.
Kenneth R. K. Nielsen, M.D., Ph.D.
Marilee P. Ogren, Ph.D.
Harvey J. Sagar, D.M., Ph.D.

Administrative Officer

Diane E. McLaughlin, M.B.A.

Administrator for Academic Programs

Janice Nagle

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

Undergraduate Offerings

Psychology subjects at the undergraduate level normally begin with 9.00 Introduction to Psychology, 9.62J Introduction to Cognitive Science, or 9.90 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. For all undergraduates, many psychology subjects may be taken to fulfill the Institute Requirement in the Humanities, Arts, and Social Sciences. Students interested in developing strong backgrounds in psychology should consider the Bachelor of Science in Cognitive Science or the options listed under the Master of Science program.

Bachelor of Science in Cognitive Science Course IX

Cognitive Science is an evolving field of study concerned with the psychology of human intellect. Central issues in the discipline include the structure, acquisition, use, and internal representation of human language, the interpretation of sensory experience, the development of formal and informal reasoning skills, the manipulation and storage of information within the nervous system, and the planning and execution of motor activity.

The Bachelor of Science in Cognitive Science prepares students for graduate training in psychology, linguistics, philosophy, or aspects of artificial intelligence (particularly those aspects concerned with vision) as well as for further work in the area of efficient human-machine interaction.

Methods of inquiry in Cognitive Science are drawn from Computer Science and Artificial Intelligence, Linguistics, Cognitive and Perceptual Psychology, Philosophy of Language and of Mind, Neurophysiology, and relevant parts of Mathematics. The undergraduate program is designed to provide instruction in the relevant aspects of these various disciplines. The program is administered by a committee made up of faculty members from these disciplines who also serve as advisors to majors. Each major works with a member of the committee to select a coherent set of subjects within the requirements listed below. These include an independent research project. Members of the committee are available to guide that research.

The committee supervising the program consists of the following faculty members: Emilio Bizzi, Shimon Ullman, Mary Potter, Susan Carey, Merrill Garrett, and Daniel Osherson, all from Psychology; and Wayne O'Neill, James Harris, Morris Halle, James Higginbotham, Ned Block, and Sylvain Bromberger, all from Linguistics and Philosophy.

Bachelor of Science in Cognitive Science Course IX

	General Institute Requirements	Total Units
	Specific science and humanities, arts, and social sciences subjects	132
	Science Distribution Requirement	36
	Laboratory Requirement	12
	Departmental Program	
	Required Subjects	**72-81**
9.62J	Introduction to Cognitive Science	3 0 9
	Either	
24.971	Formal Foundations of Linguistic Theory	3 0 9
	or	
6.045J	Computability, Automata, and Formal Languages	3 0 9
	Four of the following six subjects	
24.900J	The Study of Language	3 0 6
9.65	Cognitive Processes	3 0 6
6.001	Structure and Interpretation of Computer Programs	5 3 7
9.01	Neuroscience and Behavior	3 0 6
9.35	Sensation and Perception	3 0 6
24.119	Minds and Machines	3 0 9
	Twelve units of independent research (either 9.91, 9.92, 24.292, or 24.293)	
	Restricted Electives	**48**
	A total of 48 additional units, to be chosen from the following list with approval of the student's faculty advisor. Normally, the choice will be constrained by the subjects chosen under Required Subjects, above.	
	Unrestricted Electives	**51-60**
	Total Units Required for the S.B. Degree	**360**

	Experimental Cognitive Psychology
9.65	Cognitive Processes (U)
9.651	Cognitive Processes (G)
9.59	Psychology of Language and Communication (U)
9.591	Seminar in Psychology of Language and Communication I (G)
9.592	Seminar in Psychology of Language and Communication II (G)
9.90	Human Development: Individual and Social Perspectives (U)
9.88	Development of Behavior (U)
9.652	Seminar in Cognitive Development (G)
	Aspects of Natural Language
24.900J	The Study of Language (U)
24.901J	Language and Its Structure (U)
24.151	Introduction to Philosophy of Language (U)
24.727	Logic and Language (G)
24.915	Elements of Linguistics Theory (G)
24.951	Introduction to Linguistics I: Syntax (G)
24.964	Theory of Phonology (G)
24.968J	Speech Communication (G)
24.973	Topics in Logic and Semantics (G)
9.59	Psychology of Language and Communication (U)
9.591	Seminar in Psychology of Language and Communication I (G)
9.592	Seminar in Psychology of Language and Communication II (G)
6.543	Natural Language Processing (G)
6.542J	Laboratory on the Physiology, Acoustics, and Perception of Speech (G)
	Neurological Foundations of Cognition
9.01	Neuroscience and Behavior (U)
9.02	Nature, Nurture, and the Individual Brain (U)
9.014J	The Human Nervous System: The Neurosciences I (G)
9.019	Topics in Neuropsychology (G)
9.021	Topics in Brain and Behavior (G)

Graduate Study

	Perception
9.036	The Visual System (G)
9.35	Sensation and Perception (U)
9.36	Natural Computation and Control (U)
6.501	Sound, Speech, Hearing (U)
9.351	Advanced Seminar on Sensation and Perception (G)
9.380	Vision Algorithms and Psychophysics (G)
6.542J	Laboratory on the Physiology, Acoustics, and Perception of Speech (G)
	Natural Computation
6.001	Structure and Interpretation of Computer Programs (U)
6.045J	Computability, Automata, and Formal Languages (U)
6.034	Artificial Intelligence (U)
6.036	Problem-Solving Paradigms (U)
6.543	Natural Language Processing (G)
6.801	Machine Vision (U)
6.802	Robot Manipulation (U)
9.36	Natural Computation and Control (U)
9.370	Control of Movement in Biological and Robotic Systems (G)
9.380	Vision Algorithms and Psychophysics (G)
	Philosophy of Mind
24.119	Minds and Machines (U)
24.518	Problems of Mental Representation (G)
24.521	Topics in Philosophy of Mind (G)

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

Only 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 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	4 0 5
9.01	Neuroscience and Behavior	3 0 6
9.35	Sensation and Perception	3 0 6
9.921	Research in Psychology	Arr.
18.03	Differential Equations	4 0 8
	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
9.014J	The Human Nervous System: The Neurosciences I	6 3 6
9.02	Nature, Nurture and the Individual Brain	3 0 6
9.021	Topics in Brain and Behavior	3 0 6
9.036	The Visual System	3 0 6
9.015J	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	3 2 4
9.370	Control of Movement in Biological and Robotic Systems	3 0 6
9.36	Natural Computation and Control	3 0 6
9.036	The Visual System	3 0 6
24.968J	Speech Communication	3 0 9
	Area III: Cognitive Systems	**66**
1.00	Introduction to Computers and 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
	or	
9.90	Human Development: Individual and Social Perspectives	3 0 6
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 E10-145, MIT, Cambridge, Massachusetts 02139, (617) 253-5741.

Program in Science, Technology, and Society

Carl Kaysen, Ph.D.
David W. Skinner Professor of Political Economy
Director

Kenneth Rogers Manning, Ph.D.
Associate Professor of the History of Science
Academic Officer

Professors

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Professor of Political Science
Head, Department of Political Science

Loren R. Graham, Ph.D.
Professor of the History of Science

Gerald Holton, Ph.D.
Professor of the Social Study of Science
(Visiting)

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
(On leave, fall)

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
Provost, Emeritus

Merritt Roe Smith, Ph.D.
Professor of the History of Technology
(On leave, fall)

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
President, Emeritus

Associate Professors

Louis Lawrence Bucciarelli, Ph.D.
Associate Professor of Engineering and Technology Studies

Peter Buck, Ph.D.
Associate Professor of the Social Study of Science
(On leave, spring)

David Franklin Noble, Ph.D.
Associate Professor of the History of Technology
(On leave)

Emma Rothschild, M.A.
Associate Professor of Technology, Society, and Rhetoric
(On leave, spring)

Charles Frederic Sabel, Ph.D.
Ford International Associate Professor of Social Science
(On leave, spring)

Sherry Roxanne Turkle, Ph.D.
Associate Professor of Sociology

Assistant Professor

Sharon Traweek, Ph.D.
Assistant Professor of Anthropology and Science, Technology, and Society
(On leave, spring)

Senior Lecturer

Irving Kaplan, Ph.D.
Professor of Nuclear Engineering, Emeritus

Lecturers

Martin Krieger, Ph.D.
John P. Terry, Ph.D.

Senior Research Scientist

Joel Yellin, Ph.D.

Principal Research Associate

Victor McElheny, B.A.

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Karen L. Birchard, B.A.
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S. Catherine Foster, M.S.
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Russ Mitchell, B.S.
Mitchel J. Resnick, B.A.
Richard C. Saltus, B.A.
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Dennis Sebian, M.E.
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Visiting Scholar

Marcel Evelyn Chotkowski LaFollette, Ph.D.

Professor Emeritus

Elting Elmore Morison, A.M.
Elizabeth and James Killian Class of 1926 Professor, Emeritus

Administrative Officer

Carla Welch Kirmani

Program in Science, Technology, and Society

Undergraduate Study

The Program in Science, Technology, and Society (STS) 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 cultural considerations in shaping developments in science and technology.

The STS Program brings together humanists, social scientists, engineers, and natural scientists, all committed to transcending the narrow boundaries of their disciplines in a joint search for new insights and new ways of reaching science and engineering students. The goal of the Program is to set up a forum for the Institute's wider concerns with the interactions between what scientists and engineers do and the constraints, needs, and responses of society.

Engineering and science students seek to understand the social and historical contexts in which they will work and the social consequences of what they will do in their professional careers. STS subjects help them think realistically and creatively about the intellectual, moral, and social issues raised by the rapid growth of science and technology in the 20th century.

STS contributes to undergraduate education at MIT in several ways. It offers general subjects to introduce science and engineering students to broad social and intellectual perspectives on their fields. It offers other subjects in three areas: the social and historical study of science and technology; technology and the organization of industrial societies; and cultural dimensions of science and technology. Within each of these categories, students can choose both introductory and more advanced subjects.

All STS undergraduate subjects can be counted toward the Institute Requirement in the Humanities, Arts, and Social Sciences. The Program also offers a number of Humanities Distribution subjects as well as a Field of Concentration.

Double Degree Program

For those students who wish to integrate their professional study of engineering or science with a rigorous treatment of its relation to social and historical forces, STS offers a double degree program through Course XXI in cooperation with the Department of Humanities and several departments in the Schools of Engineering and Science. The object of this degree program is to give such students the full technical and scientific education provided by a science or engineering major, and to enrich it with complementary studies of the historical and social contexts in which science and technology function.

Students in this double degree program must complete all the requirements of their technical majors as well as the Course XXI requirements described as follows. Altogether they must complete 450 units of study to receive the two S.B. degrees.

The Course XXI degree requirements in STS include the following:

Two Reading Seminars (STS 130J/21.901J and STS 131J/21.902J) designed to provide a basic grounding in the study of science, technology, and society.

A coherent sequence of five subjects arranged to provide an understanding in depth of one of the following fields that comprise STS and some familiarity with the other two:
a) Social and Historical Studies of Science and Technology
b) Technology and the Organization of Industrial Societies
c) Cultural Dimensions of Science and Technology

Four additional elective subjects in humanities, social sciences, and visual arts related to STS.

A Project Seminar (STS 132J/21.903J), to be taken in the third or fourth year, in which students reexamine from an STS perspective a laboratory project, or summer job experience in the sciences or engineering. The Project Seminar provides training for work in STS in much the same way as laboratory subjects do for engineering or science.

A Thesis or Design Project (21.ThU) in which students expand their senior technical thesis or design project to include the social effects and historical contexts of their work. In cases where an integrated study is not feasible, two separate but related projects may be considered.

Students must submit to the Registrar a petition which indicates the desire to work for this double degree and which has been approved by a faculty advisor in the two appropriate departments before the end of the entire program. Students who take a normal course load will require five years to complete this program, but the majority of double degree candidates finish their work in four years.

Double Degree Program Requirements Course XXI

General Institute Requirements	Total Units
Specific science and humanities, arts, and social sciences subjects	132
Science Distribution Requirement	36
Laboratory Requirement	12
Departmental Program	
Science, Technology, and Society	
Thesis (21.ThU)	14
Reading Seminar in Humanities, Science, and Technology I and II (STS 130J/21.901J and STS 131J/21.902J)	18
Project Seminar (STS 132J/21.903J)	9
A coherent group of five elective subjects, drawn from the curricula of STS, the Department of Humanities, and other departments where appropriate. Three of these subjects must be in one of the following areas, and one must be in each of the other two:	
a) Social and Historical Studies of Science and Technology	
b) Technology and the Organization of Industrial Societies	
c) Cultural Dimensions of Science and Technology **at least**	45
Four elective subjects in a second discipline of humanities, social sciences, or visual arts **at least**	36
Unrestricted Electives	58
Total Units Required for the S.B.Degree in Course XXI	360
Total Units Required for Two Bachelor's Degrees	450

Joint Degree Program

Students who wish to integrate studies in STS, Humanities, and Science/Engineering on the smaller scale of a single degree program should consider this option. The program includes a group of specially designated subjects offered by STS and the Department of Humanities which provides a focus for interdisciplinary work. Central to this core is a year-long reading seminar, jointly taught by faculty members from STS and Humanities, which examines interaction of science, technology, and culture through critical discussion of major works.

Joint Program Requirements Course XXI-E and XXI-S STS/Humanities

General Institute Requirements	Total Units
Specific science and humanities, arts, and social sciences subjects[1]	132
Science Distribution Requirement	36
Laboratory Requirement	12
Departmental Program	
Thesis (21.ThU)	14
Reading Seminars in Humanities, Science, and Technology I and II (STS 130J/21.901J and STS 131J/21.902J)	18
Six subjects from the curricula of Humanities, STS, and other departments where appropriate, which form a coherent grouping that includes at least one basic subject in the history of science or technology and one subject treating the cultural dimensions of science and technology, and that has clear relevance to the scientific/technical field forming the other component of the program **at least**	54
Students who wish to integrate studies in Humanities, STS, and Science/Engineering on the larger scale of a double degree program should see the description of STS/Humanities as an option in the full major, XXI.	
And, for the Engineering/Science component, **one** of the following	
For **XXI-E**	
Six elective subjects restricted to one of the Engineering curricula and approved by a faculty member in the field **at least**	54
[When possible, the subject satisfying the Institute Laboratory Requirement and one of the subjects satisfying the Science Distribution Requirement should be selected from this same curriculum, in addition to the regular requirement.]	
For **XXI-S**	
Six elective subjects restricted to one of the Science curricula and approved by a faculty member in the field **at least**	54
[When possible, the subject satisfying the Institute Laboratory Requirement and one of the subjects satisfying the Science Distribution Requirement should be selected from this same curriculum, in addition to the regular requirement.]	
or	
The following program in Psychology:	
Introduction to Psychology (9.00)	9
Five intermediate-level subjects distributed across no fewer than three of the following four categories:	
a) The Neurosciences (9.01, 9.02, 9.50, 9.91, 9.92)	
b) Perception and Natural Computation (9.35, 9.36, 9.50, 9.91, 9.92)	
c) Cognitive Science (9.62J, 9.65, 9.59, 9.50, 9.91, 9.92)	
d) Comparative, Developmental and Social Psychology (9.05, 9.30, 9.68, 9.70, 9.88, 9.90, 9.50, 9.91, 9.92) **at least**	45
Unrestricted Electives[1]	45 to 51
Total Units Required for the S.B. Degree	360

1
Since the major program normally contains five of the eight 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 96 to 85. Note, however, that as a matter of general Course XXI policy, subjects used to meet other elements of the General Institute Requirements (including the freshman requirements in Physics, Mathematics, and Chemistry/Biology, the Science Distribution Requirement, the Laboratory Requirement, and the Humanities, Arts, and Social Sciences Distribution Requirement) may not be counted toward any component of the major program requirement.

Graduate Study

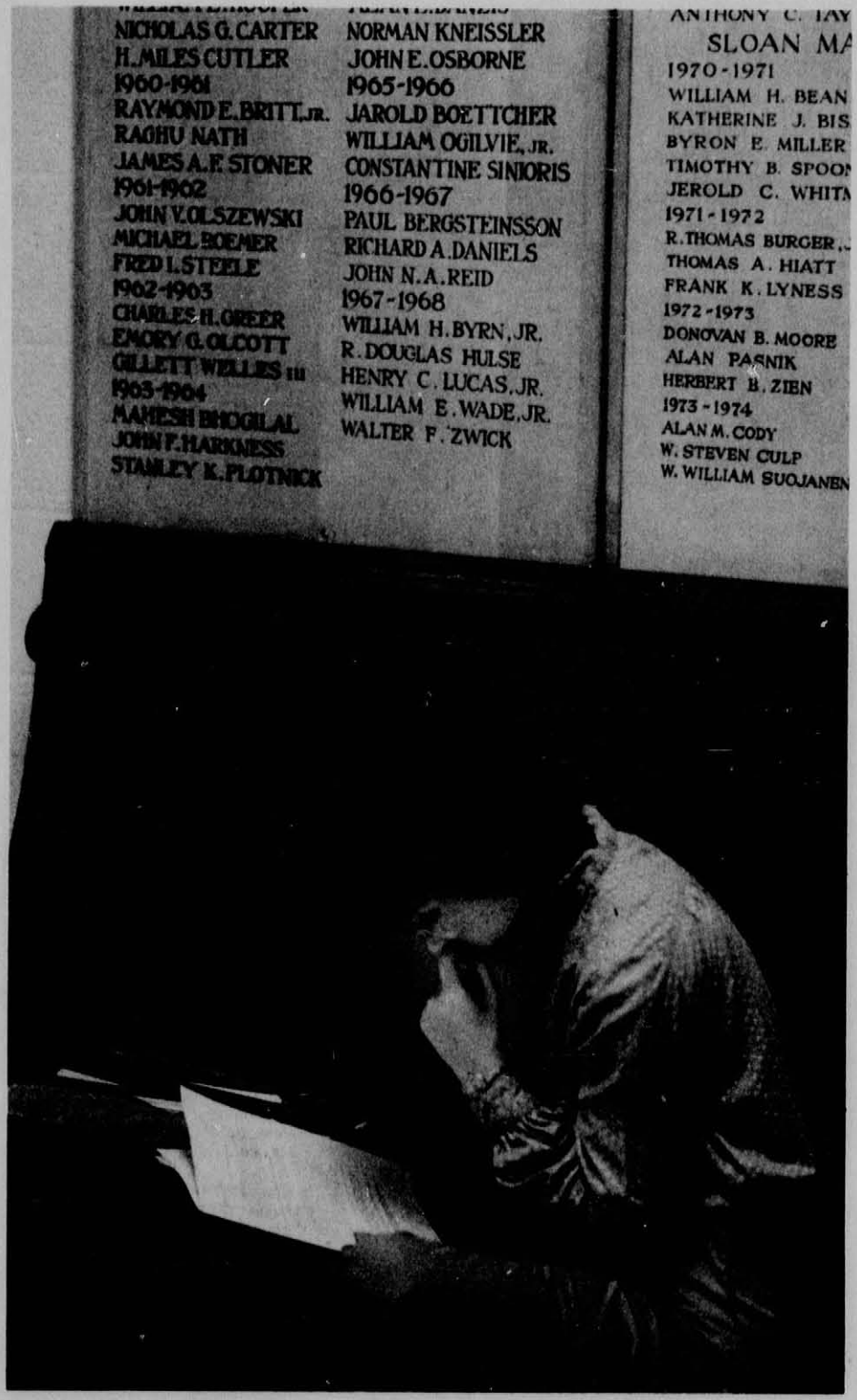
STS offers several graduate level subjects in addition to reading and research seminars. Graduate students are encouraged to participate in faculty research projects. With departmental permission, they can structure special concentrations or minor fields in STS as part of their degree programs. Such arrangements have been made with students in the Departments of Political Science and Economics interested in the history of science and technology, science and public policy, or the comparative study of advanced industrial societies. STS has provided financial assistance for some of these students. We expect these interdepartmental arrangements to expand. Interested students may also take advantage of the opportunity MIT offers to arrange doctoral programs supervised by an ad hoc committee of faculty members from STS and one or more other departments.

Inquiries

Additional information on the Program may be obtained from Kenneth R. Manning, Room E51-116, MIT, Cambridge, Massachusetts 02139, (617) 253-4066.

For subjects in Science, Technology, and Society, see STS 100-633 in Chapter VII of this catalogue.

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. However, the gift of Alfred P. Sloan, Jr., in 1952 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 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.

Sloan School of Management

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.

Office of the Dean

Abraham J. Siegel, Ph.D.
Professor of Industrial Relations
Dean

Alvin J. Silk, Ph.D.
Professor of Management Science
Associate Dean

Professors

Sidney Stuart Alexander, Ph.D.
Professor of Management and Economics
(On leave)

Thomas John Allen, Jr., Ph.D.
Professor of Organizational Psychology and Management

Lotte Lazarsfeld Bailyn, Ph.D.
Professor of Organizational Psychology and Management

Ernst R. Berndt, Ph.D.
Professor of Applied Economics

Fischer Black, Ph.D.
Professor of Finance

Jay Wright Forrester, D.Eng.
Germeshausen Professor of Management.

Arnoldo Cubillos Hax, Ph.D.
Professor of Management

Daniel Mark Holland, Ph.D.
Professor of Finance

Henry Donnan Jacoby, Ph.D.
Professor of Management
(On leave)

Howard Wesley Johnson, L.L.D.
Special Faculty Professor of Management

Gordon Mayer Kaufman, D.B.A.
Professor of Operations Research and Management

Thomas Anton Kochan, Ph.D.
Professor of Industrial Relations

Edwin Kuh, Ph.D.
Professor of Finance and Economics
Director, Center for Computational Research in Economics and Management Science

John Dutton Conant Little, Ph.D.
George Maverick Bunker Professor of Operations Research and Management

Thomas Lee Magnanti, Ph.D.
Professor of Operations Research and Management

Shlomo Maital, Ph.D.
Professor of Management
(Visiting, spring)

Robert Bruce McKersie, D.B.A.
Professor of Industrial Relations

Robert Cox Merton, Ph.D.
J.C. Penney Professor of Management

Franco Modigliani, D.Jur., D.Soc.Sci., LL.D.
Institute Professor
Professor of Finance and Economics

Stewart Clay Myers, Ph.D.
Professor of Finance

J. D. Nyhart, J.D.
Professor of Management and Ocean Engineering

Robert Stephen Pindyck, Ph.D.
Professor of Applied Economics

William Frank Pounds, Ph.D.
Professor of Management

Edward Baer Roberts, Ph.D.
David Sarnoff Professor of Management of Technology

Richard Dunlop Robinson, Ph.D.
Professor of Management
(On leave)

Edgar Henry Schein, Ph.D.
Sloan Fellows Professor of Management

Richard Lee Schmalensee, Ph.D.
Professor of Applied Economics

Michael Stewart Scott Morton, D.B.A.
Professor of Management

Eli Shapiro, Ph.D.
Alfred P. Sloan Professor of Management
(On leave)

Jeremy Frank Shapiro, Ph.D.
Professor of Operations Research and Management
Co-Director, Operations Research Center

Abraham J. Siegel, Ph.D.
Professor of Industrial Relations
Dean, Sloan School of Management

Alvin John Silk, Ph.D.
Professor of Management Science
Associate Dean

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(Visiting)

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Professor of Management and Economics

Glen Lee Urban, Ph.D.
Professor of Management Science

John Eastin Van Maanen, Ph.D.
Professor of Organizational Psychology and Management
(On leave)

Phyllis Ann Wallace, Ph.D.
Professor of Management

Roy Elmer Welsch, Ph.D.
Professor of Management Science and Statistics

Zenon Soteriou Zannetos, Ph.D.
Professor of Management

Associate Professors

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Associate Professor of Operations Research and Management

Gabriel Richard Bitran, Ph.D.
Associate Professor of Management

John Stephen Carroll, Ph.D.
Associate Professor of Management

John Joseph Donovan, Ph.D.
Associate Professor of Management Science

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Stephen C. Graves, Ph.D.
Associate Professor of Management Science

John R. Hauser, Sc.D.
Associate Professor of Management Science

John C. Henderson, Ph.D.
Associate Professor of Management Science

Mel Horwitch, Ph.D.
Associate Professor of Management

Harry Charles Katz, Ph.D.
Associate Professor of Management and Economics
(On leave, fall)

Ralph Katz, Ph.D.
Associate Professor of Management
(Visiting)

Paul Robin Krugman, Ph.D.
Associate Professor of Management

Kenneth Lange, Ph.D.
Associate Professor of Health Sciences, Technology, and Management
(Visiting)

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Associate Professor of Management

Stuart Elliot Madnick, Ph.D.
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Scott Andrew Neslin, Ph.D.
Associate Professor of Management Science
(Visiting, spring)

James Berger Orlin, Ph.D.
Associate Professor of Management Science

Eric Arthur von Hippel, Ph.D.
Associate Professor of Management

Paul Rod Warshaw, Ph.D.
Associate Professor of Management Science
(Visiting, spring)

Manchek Anthony Wong, Ph.D.
Associate Professor of Management Science

Assistant Professors

Katharine Gail Abraham, Ph.D.
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Assistant Professor of Management
(Spring)

Terry Alan Marsh, Ph.D.
Assistant Professor of Management

Leigh McAlister, Ph.D.
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John Douglas William Morecroft, Ph.D.
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Assistant Professor of Management
(Spring)

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Assistant Professor of Applied Economics

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Mitsubishi Career Development Assistant Professor in International Management

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Adjunct Professor of Management

Richard Beckhard, A.B.
Adjunct Professor of Management

James Suren Hekimian, Ph.D.
Adjunct Professor of Management

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Harlan C. Meal, Ph.D.

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Director, Center for Information Systems Research

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Albert Andrew Marcotte, Ph.D.
Irwin Tepper, Ph.D.
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E. David Wanger, L.L.M.

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Coordinator for the Master's Program

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Operations Coordinator

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Assistant Managing Editor, *Sloan Management Review*

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Administrative Assistant, Executive Education Programs

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Director, Center for Energy Policy Research
and Lecturer

Paula Budlong Cronin, S.M.
Director of Alumni/ae Relations and Information and Lecturer

Josephine Marie DiCicco
Fiscal Office Manager

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and Lecturer

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Coordinator for the Master's Program

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Data Base Coordinator

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Director of Master's Placement

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Managing Editor,
Sloan Management Review

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Director of Executive
Education Programs
and Lecturer

Postdoctoral Associate

Amar Gupta, Ph.D.

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Professor of Management and Humanities, Emeritus
Senior Lecturer

Edward Lindley Bowles, D.Sc.
Professor of Industrial Management, Emeritus

Edward Pennell Brooks, D.C.S.
Professor of Industrial Management, Emeritus
Dean, Emeritus

Douglass Vincent Brown, Ph.D.
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Billy Earl Goetz, Ph.D.
Professor of Management, Emeritus

Mason Haire, Ph.D.
Alfred P. Sloan Professor of Management, Emeritus

Leo Benjamin Moore, S.M.
Professor of Management, Emeritus

Charles Andrew Myers, Ph.D.
Professor of Industrial Relations
Sloan Fellows Professor of Management, Emeritus

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, arts, and social sciences subjects	132
	The Science Distribution Requirement can be satisfied by 14.30, which is required in the Departmental Program, plus appropriate subjects totaling[1]	24
	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	**90**
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	
15.561	Introduction to Computers, Programming, and Information Systems 0 6 0	
15.761	Operations Management 3 0 6	
15.812	Marketing Management 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	**60 to 51**
	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, arts, and social sciences subjects	132
	The Science Distribution Requirement can be satisfied by 18.05, which is required in the Departmental Program, plus appropriate subjects totaling	24
	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	**147**
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	
15.561	Introduction to Computers, Programming, and Information Systems 0 6 0	
15.761	Operations Management 3 0 6	
15.812	Marketing Management 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]	**45**
	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, arts, and social sciences 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	**129**
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	Applied Statistics	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	4 0 8
15.761	Operations Management	3 0 6
15.812	Marketing Management	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 Nonprofit Organizations	3 0 6
15.565	Management Information Technology II	3 0 6
15.571	Advanced Computer Systems	3 0 6
15.874	System Dynamics for Business Policy	3 0 9
	A minimum of 9 units of additional electives in management or economics	
	Unrestricted Electives[3]	**81**
	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 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 E52-119, MIT, Cambridge, Massachusetts 02139, (617) 253-2931.

Program 4
Dynamics of Management Systems

	General Institute Requirements	Total Units
	Specific science and humanities, arts, and social sciences 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
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 Systems 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	System Dynamics for Business Policy	3 0 9
15.875	Applications of System Dynamics	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

Applications are welcome from college graduates in all areas of concentration — the humanities, the social sciences, the physical sciences, and engineering — but applicants must have completed formal courses in differential and integral calculus and in economic theory, both macro- and microeconomics. The minimum level of preparation is normally a one-year course in economic theory and a one-year course in calculus. If these subjects have not been taken in a previous academic program, they may be covered by formal courses prior to enrollment in anticipation of diagnostic examinations given at the Sloan School at the commencement of the first term.

All applicants, including those from foreign countries, must take the Graduate Management Admission Test (GMAT). Information about the locations and dates at which this test may be taken is available from the Graduate Management Admission Council, Educational Testing Service, Princeton, New Jersey 08541. The January test is the latest one appropriate for admission the following September. GRE scores are not required and may not be substituted.

Master of Science in Management

Degree candidates are admitted in September to a program of study extending over two academic years.

The two-year Sloan Master's Program offers students with or without previous work experience a comprehensive education in management, as well as the opportunity to develop competence in a particular area of interest that may lead to positions of either general executive responsibility or technical leadership.

The program follows 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 relationships that characterize the changing world in which managers must operate. The principal fields covered by these studies are economics, behavioral science, and quantitative methods of analysis. The Sloan School was a pioneer in fitting these rigorous disciplinary subjects into the curriculum of a graduate business school. Although

by now many comparable schools have followed this lead, the School continues to be distinguished from most of its counterparts by the importance it attaches to developing the student's basic powers of analysis and by the emphasis it places on understanding the economic and social environment in which organizations operate. This inclusion of rigorous work in the basic disciplines of management has served the graduates of the School well in dealing with newly emerging and increasingly complex professional challenges.

Applied studies, which occupy the bulk of the master's student's time, link the theoretical studies to the practical problems faced by managers. The Sloan School offers an unusually wide range of applied fields, the principal ones being Accounting, Planning, and Control; Applied Economics; Corporate Strategy, Policy, and Planning; Finance; Health Care Management; Industrial Relations; International Management; Management Information Systems; Management of Technological Innovation; Marketing; Operations Management; Operations Research, and Statistics; Organization Studies; and System Dynamics. Many subjects are taught in each of these fields, and the curriculum allows students considerable choice. This flexibility enables students to construct either a general program that introduces them to many of the applied fields, or a specialized program that enables them to study one or two of the applied fields in depth. Students are thus able to design broad programs if they are interested in immediate entry into general management careers, or ones more specialized if they seek expertise as a means to higher level management responsibility. In either case, students acquire basic knowledge and skills essential to general management.

Practical exposure to management takes place in the Sloan School through a variety of activities. Students in the master's program are expected to spend the intervening summer working in some activity that will contribute to their understanding of and effectiveness in dealing with management problems. During the academic year, more than 15 percent of the master's candidates work as paid research assistants for members of the faculty, or become involved with them in the consulting activities that they carry on for government, firms, and other public and private organizations. In addition, many students choose topics for their master's theses that involve research into the practice of management in particular organizations, industries, or sectors.

The thesis, an MIT requirement for the Master of Science degree, is a major component of the Sloan Master's Program. It offers students, under the supervision of their faculty advisors, the opportunity to practice newly acquired management skills in the exploration of a single topic of particular interest. Each thesis normally represents the original contribution of a single student, although in the case of collaborative research, joint theses are also encouraged. A third dimension to the thesis concept is the "project" thesis, in which faculty members engaged in research activities that lend themselves to teamwork may offer groups of students the opportunity to explore portions of the overall study, with each student reporting on a specific phase.

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.

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 needy 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 E52-112, Sloan School of Management, MIT, Cambridge, Massachusetts 02139, (617) 253-3730.

Programs for Executive Education in Management

Alfred P. Sloan Fellows Program

Each year the Alfred P. Sloan Fellows Program admits approximately 50 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). Approximately one-third of the participants 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 health professionals who are admitted each year participate fully in all aspects of the Sloan Fellows Program.

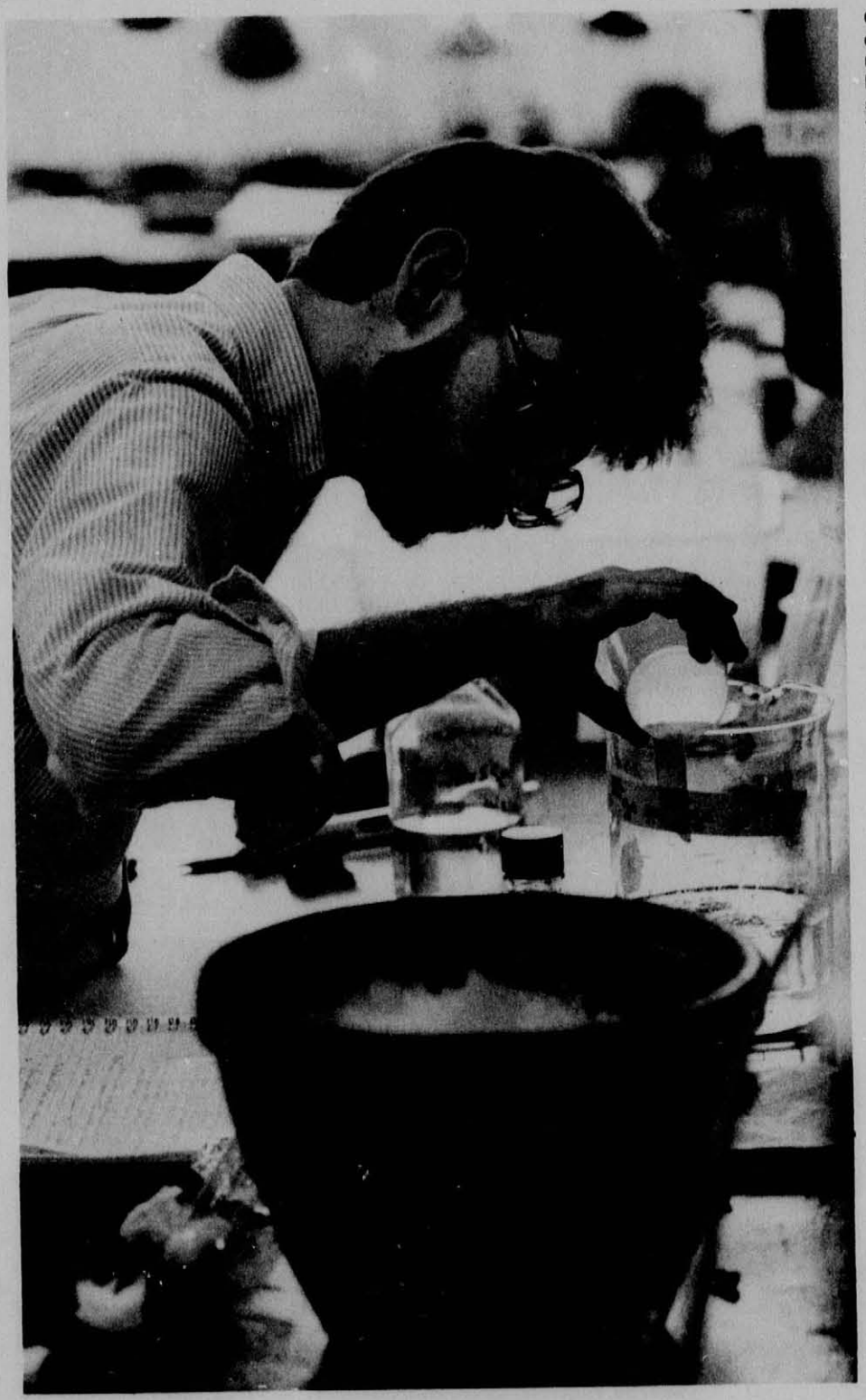
MIT Program for Senior Executives

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 the MIT executive conference center in Dedham, Massachusetts, taking their course work on campus at the Sloan School, and at the center. A one week trip to Washington, DC to visit policy makers of the Federal government is an integral part of the Program.

Inquiries

Detailed information about these programs may be obtained from the Executive Education Programs Office, Room E52-126, 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 Science. 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 interde-

partmental laboratories listed here. 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 firsthand 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.

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

George Russell Harrison Spectroscopy Laboratory

Haystack Observatory

Laboratory for Computer Science

Laboratory for Nuclear Science

Lincoln Laboratory

Research Laboratory of Electronics

Detailed descriptions of these laboratories and centers may be found in Chapter V of this catalogue.

Office of the Dean

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Arthur C. Cope Professor of Chemistry
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Department of Biology

Gene Monte Brown, Ph.D.
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Professors

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Robert Daniel Rosenberg, M.D., Ph.D.
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Paul Reinhard Schimmel, Ph.D.
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Phillip Allen Sharp, Ph.D.
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David Henri Raulet, Ph.D.
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S. Catherine Hubbard, Ph.D.
Parmjit S. Jat, Ph.D.
Judy H. Krueger, Ph.D.
Ihor R. Lemischka, Ph.D.
Robert G. Levenson, Ph.D.
Yen Li, Ph.D.
Dennis Y. Loh, Ph.D.
Douglas N. Ludtke, Ph.D.
Carole A. Mikoryak, Ph.D.
Masataka Nakamura, Ph.D.
Yoshimitsu Onodera, Ph.D.
Duncan R. Paton, Ph.D.
Narnakaje N. Rao, Ph.D.
Regina M. Reilly, Ph.D.
Lawrence J. Reitzer, Ph.D.
Jean E. Schwarzbauer, Ph.D.
Nancy A. Speck, Ph.D.
Koichi Tamoto, Ph.D.
Martha M. Teeter, Ph.D.
Judith L. Toffenetti, Ph.D.
Suh-der Tsen, Ph.D.
David S. Ucker, Ph.D.
Shizue Ueno-Nishio, Ph.D.
Joseph R. Votano, Ph.D.
Philip A. Wendler, Ph.D.
Charles Wood, Ph.D.
Jing-lun Wu, Ph.D.

Department of Biology

Undergraduate Study

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

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 S.B., 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, it 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 56-511, MIT, Cambridge, Massachusetts 02139, (617) 253-4701.

Bachelor of Science in Life Sciences Course VII

	General Institute Requirements	Total Units
	Specific science and humanities, arts, and social sciences 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	
7.54J	Human Physiology 3 0 9	
	One of the following subjects:	
7.031	Experimental Microbial Genetics 2 16 6	
7.041	Experimental Cell Biology 2 16 6	
7.051	Experimental Biochemistry 2 16 6	
7.15	Experimental Molecular Biology: Biotechnology I 2 16 6	
7.16	Experimental Molecular Biology: Biotechnology II 2 16 6	
	Acceptable research experience[6]	
	Unrestricted Electives[7]	**70**
	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, 7.75J, 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.

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, arts, and social sciences 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	
	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 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 and Oceanographic Engineering with the Woods Hole Oceanographic Institution, at the end of this chapter.

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, and assistantships may be obtained from Biology Headquarters, Room 56-511, MIT, Cambridge, Massachusetts 02139, (617) 253-4701.

Department of Chemistry

Christopher Thomas Walsh, Ph.D.
Professor of Chemistry and Biology
Uncas and Helen Whitaker Professor in the Whitaker College
Head of the Department

Professors

Robert Arnold Alberty, Ph.D., Sc.D.
Professor of Chemistry

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
Dean of the School of Science

Robert Warren Field, Ph.D.
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

James Lloyd Kinsey, Ph.D.
Professor of Chemistry

Stephen James Lippard, Ph.D.
Professor of 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.
Robert T. Haslam and Bradley Dewey Professor of Chemistry

K. Barry Sharpless, Ph.D.
Professor of Chemistry

Robert James Silbey, Ph.D.
Professor of Chemistry

Jeffrey Irwin Steinfeld, Ph.D.
Professor of Chemistry,

Charles Gardner Swain, Ph.D.
Professor of Chemistry

John Stewart Waugh, Ph.D.
Arthur Amos Noyes Professor of Chemistry

Mark Stephen Wrighton, Ph.D.
Frederick G. Keyes Professor of Chemistry

Associate Professors

Rick Lane Danheiser, Ph.D.
Associate Professor of Chemistry

Gregory Anthony Petsko, D.Phil.
Associate Professor of Chemistry

Mary Fedarko Roberts, Ph.D.
Associate Professor of Chemistry

William Richard Roush, Ph.D.
Rogers and Georges Firmenich Career Development
Associate Professor of Natural Products Chemistry

Assistant Professors

Sylvia Teresse Ceyer, Ph.D.
Assistant Professor of Chemistry

Keith Adam Nelson, Ph.D.
Assistant Professor of Chemistry

Lecturer

Dagmar Ringe, Ph.D.

Principal Research Scientist

Catherine Elizabeth Costello, Ph.D.

Technical Instructors

John Robert Linzi
James Alexander Simms

Executive Associate

Lawrence William Ryan, Jr.

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

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, arts, and social sciences 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:	
5.04	Principles of Inorganic Chemistry II (3 0 6)	
5.43	Organic Chemistry (4 0 8)	
5.62	Physical Chemistry (4 0 8)	
	Unrestricted Electives[2]	**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, Atmospheric, and Planetary Sciences

William Francis Brace, Ph.D.
Cecil and Ida Green Professor of Geology
Head of the Department

Professors

Keiiti Aki, Ph.D.
Robert R. Shrock Professor of Earth and Planetary Sciences

Burrell Clark Burchfiel, Ph.D.
Professor of Geology

Roger George Burns, Ph.D.
Professor of Geochemistry
(On leave)

Charles Claude Counselman III, Ph.D.
Professor of Planetary Sciences

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

Richard Siegmund Lindzen, Ph.D.
Professor of Meteorology

Edward Norton Lorenz, Sc.D.
Professor of Meteorology

Theodore Richard Madden, Ph.D.
Professor of Geophysics

Erik L. Mollo-Christensen, Sc.D.
Professor of Oceanography

Peter Molnar, Ph.D.
Professor of Earth Sciences
(On leave)

Reginald Edward Newell, Sc.D.
Professor of Meteorology

Gordon Hemenway Pettengill, Ph.D.
Professor of Planetary Physics

Ronald George Prinn, Sc.D.
Professor of Meteorology

Frederick Sanders, Sc.D.
Professor of Meteorology

Irwin Ira Shapiro, Ph.D.
Schlumberger Professor of Geophysics and Physics
(On leave)

M. Gene Simmons, Ph.D.
Professor of Geophysics

Sean Carl Solomon, Ph.D.
Professor of Geophysics

Peter Hunter Stone, Ph.D.
Professor of Meteorology
Director, Center for Meteorology and Physical Oceanography

M. Nafi Toksöz, Ph.D.
Professor of Geophysics
Director, Earth Resources Laboratory
Director, George R. Wallace, Jr. Geophysical Observatory

Carl Isaac Wunsch, Ph.D.
Cecil and Ida Green Professor of Physical Oceanography

Associate Professors

Edward Allen Boyle, Ph.D.
Associate Professor of Chemical Oceanography

Mark Alan Cane, Ph.D.
Associate Professor of Oceanography

James Ludlow Elliot, Ph.D.
Associate Professor of Astronomy and Physics
Director, George R. Wallace, Jr. Astrophysical Observatory

Charles Curtiss Eriksen, Ph.D.
Associate Professor of Physical Oceanography

Glenn Richard Flierl, Ph.D.
Associate Professor of Oceanography

Barry Eaton Parsons, Ph.D.
Associate Professor of Geophysics

William Hamet Pinson, Jr., Ph.D.
Associate Professor of Geology

John Brelsford Southard, Ph.D.
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Frank S. Spear, Ph.D.
Associate Professor of Geology

Assistant Professors

Randall M. Dole, Ph.D.
Assistant Professor of Meteorology

Kerry Andrew Emanuel, Ph.D.
Assistant Professor of Meteorology

J. Brian Evans, Ph.D.
Assistant Professor of Geophysics

Timothy L. Grove, Ph.D.
Assistant Professor of Petrology

David C. Jewitt, Ph.D.
Assistant Professor of Planetary Science

Marcia K. McNutt, Ph.D.
Assistant Professor of Marine Geophysics

Richard Eugene Passarelli, Jr., Sc.D.
Assistant Professor of Meteorology

Paola Malanotte Rizzoli, Ph.D.
Assistant Professor of Oceanography

Instructor

Linda M. French, Ph.D.

Senior Lecturer

John Carl Foster, Ph.D.

Lecturers

John M. Holt, Ph.D.
William L. Oliver, Ph.D.

Honorary Lecturer

Cecil H. Green, S.M., D.S.C., LL.D.

Administrative Officer

Douglas Pfeiffer

Administrative Staff

Jane Sinnott McNabb, B.A.
Carol Ann Ramey
Deborah G. Roecker

Senior Research Scientists

Nobumichi Shimizu, D.Sc.
Director, Ion Probe Facility

Joseph Broughton Walsh, Ph.D.

Principal Research Scientist

Chuen Hon Cheng, Ph.D.

Research Associates

Richard Abbott, Ph.D.
Richard Baron, Ph.D.
Vernon Cormier, Ph.D.
Stephen Daly, Ph.D.
Edward Dunham, Ph.D.
Peter Ford, Ph.D.
Richard French, Ph.D.
Sergei Gourevitch, Ph.D.
Robert Heinmiller, Ph.D.
Pillalamarri Ila, Ph.D.
Robert King, Ph.D.
Christopher Measures, Ph.D.
Alfredo Rene Navato, Ph.D.
Jay J. Pulli, Ph.D.
Roger Turpening, Ph.D.

Postdoctoral Associates

Rosemary L. Hickey, Ph.D.
Karen Kimball, Ph.D.
Dong Soo Lee, Ph.D.
Robert McCaffrey, Ph.D.
Roger Morin, Ph.D.
Gilles Pierre Reverdin, Ph.D.
Steven Roecker, Ph.D.
Leigh Royden, Ph.D.
Jens G. Schröter, Ph.D.
Alan Shiller, Ph.D.
Roy Wilkens, Ph.D.
Earle Williams, Ph.D.
Victor Zlotnicki, Ph.D.

Visiting Professors

Claude J. Allegre, Ph.D.
Professor of Geochemistry

Ari Ben-Menahem, Ph.D.
Professor of Geophysics

Claude J. Frankignoul, Ph.D.
Professor of Oceanography

Don Edmunds Harrison, Ph.D.
Assistant Professor of Oceanography

Sandro Rambaldi, Ph.D.
Assistant Professor of Meteorology

Visiting Scientists

Anas Abo-Zena, Ph.D.
Yehuda Bock, Ph.D.
Christopher Brooks, Ph.D.
Frederick L. Paillet, Ph.D.
Jiadong Qian
Dazhang Tang, B.S.
Qiming Wang
Jinzhong Zhang
Xiachen Zhi

Undergraduate Study

Professors Emeriti

James Murdoch Austin, Sc.D.
Professor of Meteorology, Emeritus

Martin Julian Buerger, Ph.D.
Institute Professor, Emeritus
Professor of Mineralogy and Crystallography, Emeritus

Harold Williams Fairbairn, Ph.D.
Professor of Geology, Emeritus

Henry Garrett Houghton, Sc.D.
Professor of Meteorology, Emeritus

Patrick Mason Hurley, Ph.D.
Professor of Geology, Emeritus

Robert Rakes Shrock, Ph.D.
Professor of Geology, Emeritus

Hurd Curtis Willett, Ph.D.
Professor of Meteorology, 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, special emphasis is placed on mineralogy-crystallography, petrology, rock mechanics, geochemistry, geochronology, tectonics, seismology, planetary magnetism and electricity, heat flow, high pressure geophysics, geophysical fluid dynamics, optical and radar astronomy, meteorology and dynamical astronomy, planetary atmospheres and surfaces, planetary rings, physical and chemical oceanography, and marine geology and geophysics.

Modern problems in these fields 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.

Bachelor of Science in Earth and Planetary Sciences
Course XII

The Department offers undergraduate preparation for professional careers in the earth, atmospheric, 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. Lists of undergraduate research and employment opportunities are also available. Some sample programs are shown under Restricted Elective Requirements on the next page. 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, Atmospheric, 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 arrange conferences with advisors.

Bachelor of Science in Earth and Planetary Sciences
Course XII

	General Institute Requirements	Total Units
	Specific science and humanities, arts, and social sciences 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	
	or	
3.00	Thermodynamics of Materials 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[2] Arr.	
	or	
12.UR	Undergraduate Research[2] Arr.	
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 following description.	
	Unrestricted Electives[3]	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
Each student must register for at least 12 units of research in one of these subjects, or by approval of the advisor, in an equivalent subject or Undergraduate Thesis in another department.

3
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, physical oceanography and meteorology, planetary physics and observational astronomy are given below.

Earth Sciences

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, 12.502 Plate Tectonics and Marine Geophysics, 12.521 Elements of Seismology.

Physical Oceanography and Meteorology: Physics and mathematics subjects similar to the program in geophysics, plus 12.21 Physics of the Ocean, or 19.83 Modeling Oceanic Systems, and one subject in fluid mechanics. For further detail see description of Undergraduate Study in the Center for Meteorology and Physical Oceanography.

Planetary Sciences

Planetary Physics: Physics and mathematics subjects similar to the program in geophysics, plus 12.131J Physics of the Solar System and 12.121 Exploration of the Solar System. Physics subjects can be experimental or theoretical or both, according to individual interests.

Observational Astronomy: This program is intended for those students who seek preparation for graduate school in radio or optical astronomy, but find neither the Planetary Physics Program in Course XII nor the Astrophysics Program in Course VIII compatible with their needs. In addition to the departmental requirements, the course requirements for this program are: 1) Physics: 8.03, 8.04, and 8.06; 2) Mathematics: 18.075; 3) Dynamical Astronomy: 12.115J; 4) Astronomy: Stars and Galaxies: 12.113 or 8.282 or 8.284; 5) Solar System Astronomy (2 of the following): 12.114, 12.121, 12.131J; 6) Advanced Radio and Optical: 12.117J or 12.620J. The special problems course 12.091-4, or its alternative 12.UR (a departmental requirement), would normally be completed during the senior year, after the student has a firm background in astronomy and could be expected to complete a substantial project.

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.

Graduate Study

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, Atmospheric, 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, Atmospheric, and Planetary Sciences, Room 54-912, MIT, Cambridge, Massachusetts 02139, (617) 253-3381.

The Department of Earth, Atmospheric, 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 and Oceanographic Engineering 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 and Oceanographic Engineering with the Woods Hole Oceanographic Institution, at the end of this chapter.

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 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, atmospheric, and planetary sciences, admission requirements, assistantship appointments, and financial aid may be obtained by writing to the Department of Earth, Atmospheric, and Planetary Sciences, Room 54-912, MIT, Cambridge, Massachusetts 02139, (617) 253-3381. The Department annually publishes a booklet describing current research activities.

Center for Meteorology and Physical Oceanography*

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 Center'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 Center 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.

* Formerly Department of Meteorology and Physical Oceanography

Undergraduate Study

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. A selection of undergraduate electives offered includes 19.05J Environmental Chemistry of the Ocean-Atmosphere System, 19.83 Modeling Oceanic Systems, and 19.10 Past and Present Climate.

Certain introductory graduate level subjects, such as 19.69 Fluid Dynamics of the Atmosphere and Ocean, 19.70J Steady Circulation of the Atmosphere and Ocean, 19.71J Wave Motions in the Atmosphere and Oceans, and 19.43-19.44 Synoptic Meteorology I and II, 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 or oceanography, and for students who wish to supplement their basic undergraduate program with an exposure to interesting environmental problems. Offerings in the Undergraduate Seminar Program and the Undergraduate Research Opportunities Program are listed in advance of each term in the appropriate announcement booklet.

Adequate preparation is also provided by other MIT undergraduate curricula, particularly in the Departments of Mathematics and Physics.

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 Center 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 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.

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:

19.05J	Environmental Chemistry of the Ocean-Atmosphere System
19.10	Past and Present Climate
19.43	Synoptic Meteorology I
19.44	Synoptic Meteorology II
19.46	Numerical Modeling in Meteorology and Oceanography
19.50	Physical Meteorology
19.63	Diagnostic Studies of the General Circulation
19.64	Atmospheric Modeling
19.65J	Turbulence and Random Processes in Fluid Mechanics
19.66	Atmospheric Convection
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

19.70J	Steady Circulation of the Atmosphere and Ocean
19.71J	Wave Motions in the Atmosphere and Oceans
19.73	Chemistry and Dynamics of Upper Atmospheres
19.74	Cloud and Precipitation Physics
19.75	Radar Meteorology
19.76	Dynamical Oceanography

As this list suggests, there are research and educational activities in all the principal areas of meteorology. There is a Doppler 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 Center 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 Center also has access to the high-speed computing facilities of the MIT Information Processing Center.

Laboratory facilities include the Doppler weather radar and a small fluid mechanics laboratory, and an electronics shop used for the assembly and maintenance of measuring equipment.

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

The Center for Meteorology and Physical Oceanography is an active participant in the joint MIT-Woods Hole Oceanographic Institution graduate program in oceanography and oceanographic engineering. Except in special circumstances, all students in the Department of Earth, Atmospheric, and Planetary Sciences 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 Earth, Atmospheric, 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 Center for 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 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

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 Center offers a considerable number of Research and Teaching Assistantships each year. Research Assistants work on one of the many research projects in the Center. Teaching Assistants assist in laboratory instruction or in the preparation of teaching materials and the grading of papers.

The Center also offers the Jule G. Charney Awards for graduate study. These awards will be available to a few students to supplement the normal support from research assistantships or other fellowships. Selection of individuals will be based on the excellence of the applicant's record, as evidenced by academic performance, letters of recommendation, professional accomplishments, and other awards such as National Science Foundation Fellowships.

Inquiries

Further information on degree programs, research activities, admission requirements, assistantship appointments, and financial aid may be obtained from the Department of Earth, Atmospheric, and Planetary Sciences, Room 54-912, MIT, Cambridge, Massachusetts 02139, (617) 253-3381.

Department of Mathematics

Daniel J. Kleitman, Ph.D.
Professor of Applied Mathematics
Head of the Department

Victor William Guillemin, Ph.D.
Professor of Mathematics
Chairman, Committee on Pure Mathematics

(To be announced)
Professor of Mathematics
Chairman, Committee on Applied Mathematics

Professors

Warren Ambrose, Ph.D.
Professor of Mathematics

Nesmith Cornett Ankeny, Ph.D.
Professor of Mathematics

Michael Artin, Ph.D.
Professor of Mathematics
(On leave)

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
(On leave)

Richard Mansfield Dudley, Ph.D.
Professor of Mathematics

Daniel Z. Freedman, Ph.D.
Professor of Applied Mathematics

Harvey Philip Greenspan, Ph.D.
Professor of Applied Mathematics
(On leave, spring)

Sigurdur Helgason, Ph.D.
Professor of Mathematics
(On leave, fall)

Francis Begnaud Hildebrand, Ph.D.
Professor of Mathematics

Kenneth Myron Hoffman, Ph.D.
Professor of Mathematics

Louis Norberg Howard, Ph.D.
Professor of Mathematics
(On leave)

Victor Kač, Ph.D.
Professor of Mathematics
(On leave)

Daniel Marinus Kan, Ph.D.
Professor of Mathematics

Steven Kleiman, Ph.D.
Professor of Mathematics

Bertram Kostant, Ph.D.
Professor of Mathematics
(On leave, spring)

Chia-Chiao Lin, Ph.D.
Institute Professor
Professor of Applied Mathematics
(On leave, fall)

George Lusztig, Ph.D.
Professor of Mathematics
(On leave, fall)

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 and Education

Franklin Paul Peterson, Ph.D.
Professor of Mathematics

Daniel Gray Quillen, Ph.D.
Norbert Wiener Professor of Mathematics

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
(On leave)

Richard Donald Schafer, Ph.D.
Professor of Mathematics

Irving Ezra Segal, Ph.D.
Professor of Mathematics

Isadore Manual Singer, Ph.D.
John D. MacArthur Professor of Mathematics
(On leave)

Richard Peter Stanley, Ph.D.
Professor of Applied Mathematics

Harold Mead Stark, Ph.D.
Professor of Mathematics
(On leave, spring)

William Gilbert Strang, Ph.D.
Professor of Mathematics

Alar Toomre, Ph.D.
Professor of Applied Mathematics

Michèle Françoise Vergne, Ph.D.
Professor of Mathematics
(On leave)

George William Whitehead, Ph.D.
Professor of Mathematics

Associate Professors

William Hermas DuMouchel, Ph.D.
Associate Professor of Applied Mathematics

Sy David Friedman, Ph.D.
Associate Professor of Mathematics

Ravindran Kannan, Ph.D.
Associate Professor of Applied Mathematics

Gary Lee Miller, Ph.D.
Associate Professor of Applied Mathematics

Michael Sipser, Ph.D.
Associate Professor of Applied Mathematics

Audrey Terras, Ph.D.
Associate Professor of Mathematics
(Visiting, fall)

David Alexander Vogan, Jr., Ph.D.
Associate Professor of Mathematics

Assistant Professors

David Jay Anick, Ph.D.
Assistant Professor of Mathematics

Andrew Cadle Fowler, Ph.D.
Assistant Professor of Applied Mathematics

Ira Martin Gessel, Ph.D.
Assistant Professor of Applied Mathematics

William Mark Goldman, Ph.D.
Assistant Professor of Mathematics

David S. Jerison, Ph.D.
Assistant Professor of Mathematics

Jeffry Kahn, Ph.D.
Assistant Professor of Applied Mathematics

Frank Thomson Leighton, Ph.D.
Assistant Professor of Applied Mathematics

Philip Marcus, Ph.D.
Assistant Professor of Applied Mathematics

Frank Morgan, Ph.D.
Assistant Professor of Mathematics

Stephen M. Paneitz, Ph.D.
Assistant Professor of Mathematics

Rodolfo Ruben Rosales, 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

C. L. E. Moore Instructors

Patricia Bauman, Ph.D.
Hari Bercovici, Ph.D.
Thomas Daniel Cochran, Ph.D.
Isaac Y. Efrat, Ph.D.
Lawrence Ein, Ph.D.
Matthew A. Grayson, Ph.D.
John D. McCarthy, Ph.D.
Troels Petersen, Ph.D.
Antonio Sanchez, Ph.D.
Joseph Hillel Silverman, Ph.D.
Maurice Collins Stanley, Ph.D.
Kari Kaleva Vilonen, Ph.D.
David James Wright, Ph.D.

Instructors in Pure Mathematics

Paul Baird, Ph.D.
Devra Garfinkle, Ph.D.
Andrew Philpott, Ph.D.

Instructors in Applied Mathematics

Jon Christopher Haass, Ph.D.
Stephan Morgenthaler, Ph.D.
William Alfredo Nazaret, Ph.D.
David Ross Richman, Ph.D.
Deborah Lee Sulsky, Ph.D.
M. Grae Worster, Ph.D.

Lecturers

Deborah Faye Allinger, h.D.
Patrizio Aviles, Ph.D.
Steven Ellis, Ph.D.

Postdoctoral Associates

Julian A. Domaradzki, Ph.D.
Christopher M. Hull, Ph.D.
Richard Pelz, Ph.D.

Research Associates

F. Ann Carr, M.S.
Yi-Ching Yao, Ph.D.

Department of Mathematics

Undergraduate Study

Administrative Officer

James Edward Dalton

Administrative Assistants

Martha L. Fox, A.B.
Joanne E. Murray
Phyllis Ruby, A.B.

Professors Emeriti

Prescott Durand Crout, Ph.D.
Professor of Mathematics, Emeritus

William Ted Martin, Ph.D.
Professor of Education and Mathematics, Emeritus

Claude Elwood Shannon, Ph.D.
Donner Professor of Science and Professor of Mathematics and Electrical Engineering, 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 toward 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, arts, and social sciences 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.

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.

[1] Advanced standing credit does not fulfill any part of this requirement, but is accepted as Unrestricted Elective.

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
Applied Mathematics Option

	General Institute Requirements	Total Units
	Specific science and humanities, arts, and social sciences 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 4 0 8	
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	
18.07	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
Theoretical Mathematics Option

	General Institute Requirements		Total Units
	Specific science and humanities, arts, and social sciences 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	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, 18.504, 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 or 18.710 Abstract 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 18.710 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 topics 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 a joint weekly mathematics colloquium sponsored alternately by MIT, Brandeis University, and Harvard University, supplement the subject offerings.

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, Lie theory, 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 explained in a set of notes available from the Department. The first stage is to take subjects (normally totaling 132 hours of graduate credits) and to prepare for the general qualifying examination. Doctoral candidates are required to have a reading knowledge of mathematical French, German, Italian, 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. One of the three areas is examined in greater depth and normally becomes the field of specialization. The examiner in this area normally becomes the thesis advisor. The examination 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 the core curriculum, which assures 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 specific requirements set in the general examination, the student may officially begin thesis research under the supervision of a thesis advisor. The thesis must represent original research of high quality, done while a student at MIT, 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 and teaching and research assistantships are available. Normally, entering students who are offered financial aid are offered teaching assistantships and the assistantships are renewed so that students are supported for a total of four years. Entering students who have not been offered aid should not expect aid later.

Inquiries

Any additional information regarding academic or research programs in mathematics, admissions, or financial aid, may be obtained from Phyllis Ruby, Graduate Mathematics Office, Room 2-233, MIT, Cambridge, Massachusetts 02139, (617) 253-2689.

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

Professors

John Francis Burke, M.D.
Professor of Experimental Surgery
(Visiting)

Charles Leland Cooney, Ph.D.
Professor of Chemical and Biochemical Engineering

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

Robert Spencer Lees, M.D.
Professor of Cardiovascular Disease

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

Steven Robert Tannenbaum, Ph.D.
Professor of Toxicology and Food Chemistry
Registration and Admissions Officer

Lance Jerome Taylor, Ph.D.
Professor of Nutritional Economics

Daniel I.C. Wang, Ph.D.
Professor of Chemical and Biochemical Engineering

George Wolf, D.Phil.
Professor of Physiological Chemistry

Richard Jay Wurtman, M.D.
Professor of Neuroendocrine Regulation

Vernon Robert Young, Ph.D.
Professor of Nutritional Biochemistry

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Associate Professor of Behavioral Endocrinology

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Alexander M. Klibanov, Ph.D.
Associate Professor of Applied Biochemistry

Robert Samuel Langer, Sc.D.
Dorothy W. Poitras Associate Professor in Medical Engineering
Associate Professor of Biochemical Engineering

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Cho Kyun Rha, Sc.D.
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Assistant Professor of Toxicology

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Assistant Professor of Toxicology

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Assistant Professor of Comparative Pathology

Marsha Rich Rosner, Sc.D.
Assistant Professor of Toxicology

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Charles S. Davidson, M.D.
John Everett Gordon, Ph.D., M.D.
Edward S. Josephson, Ph.D.
John Burton Stanbury, M.D.

Lecturers

Bruce Bistrian, M.D., Ph.D.
George Blackburn, M.D., Ph.D.
Ari Brynjolfsson, Ph.D.
James Carpenter, D.V.M. (Visiting)
John H. Growdon, M.D.
Gerald Keusch, M.D.
William Medden Rand, Ph.D.
Christophe Riboud, Ph.D.
Israel A. Saguy, Ph.D. (Visiting)
Andrew Sivak, Ph.D.
Barbara Underwood, Ph.D.
Mitchell B. Wallerstein, Ph.D.
Bernard Yon, Ph.D.
Steven Zeisel, Ph.D.

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.
Enrico Cherubini, M.D.
William Dietz, M.D., Ph.D.
Mary Erskine, Ph.D.
Harry Lynch, Ph.D.
John Sherman Wishnok, Ph.D.
John Williams, Ph.D.
Judith Hirschhorn Wurtman, Ph.D.

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Sally Holick, Ph.D.
Ahmed Kamarei, Ph.D.
Hua-Fuan Lam, Ph.D.
James Murphy, Ph.D.
Kathleen M. Nauss, Ph.D.
Paul Skipper, Ph.D.
Nadine Solomons, B.A.
Leona Zacharias, Ph.D.

Postdoctoral Associates

Tim Ahern, Ph.D.
John Babson, Ph.D.
Carl Batt, Ph.D.
Michael Connor, D.V.M.
Bernhard Gmeiner, Ph.D.
Viktor Gol'dmakher, Ph.D.
Calvert Green, Ph.D.
Laura Green, Ph.D.
Pegram Johnson, Ph.D.
Joseph Kost, Ph.D.
Roland Kurth, Ph.D.
Kam Leong, Ph.D.
Howard Liber, Ph.D.
Patricia Miller, Ph.D.
Rahul Ray, Ph.D.
Joanne Recchia, Ph.D.
William Shanabruch, Ph.D.
Lisa Weymouth, Ph.D.
Margaret Wheatley, Ph.D.
Michael Wildschutte, Ph.D.
Victor Yang, Ph.D.
Gerold Zerlauth, Ph.D.

Professor Emeritus

Robert Samuel Harris, Ph.D.
Professor of Nutritional Biochemistry, 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; food and nutrition policy planning; and mechanisms of action of neurotransmitters and hormones.

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 biotechnology, nutritional biochemistry and metabolism, food science, toxicology, pathology, medicine, 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, arts, and social sciences 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.[1,3]	
	Departmental Program	
	Required Subjects	**86**
5.41	Introduction to Structure, Bonding and Mechanism	5 0 7
5.42	Organic Chemistry	5 0 7
5.60	Chemical Thermodynamics	4 0 8
7.03	Genetics	4 0 8
7.05	General Biochemistry	5 0 7
20.002	Laboratory in Applied Biology[1,3]	2 8 4
20.021	Nutrition and Metabolism	4 0 8
	Restricted Electives	**69-72**
	Any *two* of the following subjects:[2]	
7.06	Metazoan Cell Biology	3 0 9
7.21	Microbial Physiology	4 0 8
20.022J	Human Physiology	3 0 9
	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
	One of the following:	
5.310	Laboratory Chemistry	2 8 2
5.311	Introductory Chemical Experimentation	2 8 2
10.26	Chemical Engineering Laboratory	2 8 2
	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	**73-70**
	Total Units Required for the S.B. Degree	**360**

1
It should be noted that either 20.002 or 5.311 satisfy the Institute Laboratory Requirement and medical school entrance requirements.

2
Graduate courses that may be substituted for *one* course include:

20.211	Regulation of Intermediary Metabolism	5 2 8
20.212	Basic and Human Nutrition	4 0 8
20.213	Endocrinology	4 0 8
20.511J	The Human Nervous System: The Neurosciences I	0 0 9
20.611	General Toxicology	2 0 6

3
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 — Nutritional Biochemistry and Metabolism, Biochemical Engineering, Food Science and Technology, 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.

Nutritional Biochemistry and Metabolism. This program leads to the Master of Science and doctoral degrees. It trains graduate students in biochemistry and physiological chemistry as these apply to metabolic and nutritional problems in normal and pathological states. Research projects in this track include: regulation of protein synthesis and turnover; mechanism of action of vitamin A on glycoprotein synthesis; regulation of fatty acid and cholesterol synthesis in isolated organs; validation of tracer techniques using radioactive and stable isotopes for metabolic and nutritional studies; ketone bodies and alcohol metabolism; photobiology of vitamin D; dietary and hormonal factors influencing carcinogenesis; biochemical, morphological, and physiological effects of malnutrition in animal models; effects of aging, cancer, physical trauma, and other systemic and metabolic disease conditions on nutrient metabolism and requirements; biochemical and clinical evaluation of new food sources; the regulation of body protein and energy metabolism; nutrition and immunocompetence; nutrition and drug treatment of hyperlipoproteinemia.

Biotechnology. The Biotechnology program in the Department of Nutrition and Food Science has two degree options, one in Biochemical Engineering and the other in Food Science and Technology. The program in Biotechnology prepares students for careers in research involving the application of modern biology, biochemistry, and engineering to problems in the production of foods, chemicals, and medicinal agents.

The objective of the Biotechnology program is to provide broad training in microbiology, biology, biochemistry, and engineering. The program combines course instruction in these subjects with practice in experimental applications of this knowledge to research problems.

The formal course work for the doctoral degree centers on the core Biotechnology courses with appropriate supporting course work from the Departments of Nutrition and Food Science, Chemical Engineering, Biology, and Chemistry.

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; mammalian tissue cultures; use of molecular genetics to improve industrial microorganisms; performance characterization of polymers and biomaterials and studies on utilizing their particular physical, chemical, and biological properties; and drug delivery techniques.

Food Science and Technology. The program in Food Science and Technology leads to both the Master of Science and Ph.D. degrees. Academic and research programs are offered in three broad areas in Food Science and Technology: applied chemistry, applied microbiology, and engineering.

These programs stress fundamental principles. Research projects in Food Science and Technology include: formation, occurrence, and analysis of chemical substances in biological materials; physical, biochemical, and engineering properties of proteins; mechanisms of enzyme denaturation; reactivation of inactivated enzymes; changes in food composition and nutrient values due to food processing, control of undesirable microorganisms as well as utilization of beneficial ones.

Toxicology. A program is offered leading to the Master of Science and doctoral degrees. The multidisciplinary training program consists of fundamental course work in biology and chemistry followed by courses in toxicology at molecular and cellular levels. Typical research areas include: chemical carcinogenesis; tumor promotion; metabolism of drugs, chemical carcinogens and other toxins; studies on the entry and mode of action of toxic agents; development of approaches to the direct measurement of exposure to toxic agents in humans; and structural elucidation of chemically modified DNA and its relationship to control of gene expression and genetic change in bacteria and human cells.

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. The Graduate Record Examination is strongly recommended. 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 — Nutritional Biochemistry and Metabolism, 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 course study together with an original thesis. A limited number of required subjects are supplemented 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

Jerome Isaac Friedman, Ph.D.
Professor of Physics
Head of the Department

Professors

Michel Baranger, Ph.D.
Professor of Physics
(On leave, fall)

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

John Winston Belcher, Ph.D.
Professor of Physics

George Bernard Benedek, Ph.D.
Alfred H. Caspary Professor
of Physics and Biological Physics

Aron Myron Bernstein, Ph.D.
Professor of Physics

William Bertozzi, Ph.D.
Professor of Physics

Robert Joseph Birgeneau, Ph.D.
Cecil and Ida Green Professor
of Physics
Associate Director, Research
Laboratory of Electronics

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

Min Chen, Ph.D.
Professor of Physics

George Whipple Clark, Ph.D.
Professor of Physics

Bruno Coppi, Ph.D.
Professor of Physics
(On leave, spring)

Eric Richard Cosman, Ph.D.
Professor of Physics

Ronald Crosby Davidson, Ph.D.
Professor of Physics
Director, Plasma Fusion Center

Peter Theodore Demos, Ph.D.
Professor of Physics

Martin Deutsch, Ph.D., Sc.D.
Professor of Physics

Mildred Spiewak Dresselhaus, Ph.D.
Professor of Physics and Abby
Rockefeller Mauzé Professor of
Electrical Engineering

Thomas Henderson Dupree, Ph.D.
Professor of Physics
and Nuclear Engineering

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

Herman Feshbach, Ph.D.
Institute Professor
Professor of Physics

Anthony Philip French, Ph.D.
Professor of Physics

David Henry Frisch, Ph.D.
Professor of Physics
(On leave, fall)

Jeffrey Goldstone, Ph.D.
Professor of Physics
Director, Center for Theoretical
Physics
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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

Roman Wladimir Jackiw, Ph.D.
Professor of Physics

Robert Loren Jaffe, Ph.D.
Professor of Physics

Ali Javan, Ph.D.
Francis Wright Davis
Professor of Physics

John Dimitris Joannopoulos, Ph.D.
Professor of Physics

Kenneth Alan Johnson, Ph.D.
Professor of Physics

Paul Christopher Joss, Ph.D.
Professor of Physics

Marc Aaron Kastner, Ph.D.
Professor of Physics
(On leave, spring)

Henry Way Kendall, Ph.D.
Professor of Physics

Arthur Kent Kerman, Ph.D.
Professor of Physics
Director, Laboratory for Nuclear
Science

John Gordon King, Ph.D.
Francis Friedman Professor
of Physics

Vera Kistiakowsky, Ph.D.
Professor of Physics

Daniel Kleppner, Ph.D.
Professor of Physics
(On leave)

George Fred Koster, Ph.D.
Professor of Physics

Benjamin Lax, Ph.D.
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Patrick A. Lee, Ph.D.
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Walter Hendrik Gustav Lewin,
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James David Litster, Ph.D.
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Director, Center for Materials
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Earle Leonard Lomon, Ph.D.
Professor of Physics

Francis Eugene Low, Ph.D.
Karl Taylor Compton Professor
of Physics
Provost

Margaret Love Agnes MacVicar,
Sc.D.
Professor of Physical Science
and Cecil and Ida Green
Professor of Education
Director, Undergraduate Research
Opportunities Program
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June Lorraine Matthews, Ph.D.
Professor of Physics
(On leave, fall)

Ernest Moniz, Ph.D.
Professor of Physics
Director, Bates Linear Accelerator

Philip Morrison, Ph.D.
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Professor of Physics

John William Negele, Ph.D.
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Stanislaw Olbert, Ph.D.
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Louis Shreve Osborne, Ph.D.
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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.
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Irwin Ira Shapiro, Ph.D.
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(On leave)

Clifford Glenwood Shull, Ph.D.
Professor of Physics

Malcom Woodrow Pershing
Strandberg, Ph.D.
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Toyoichi Tanaka, D.Sc.
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.
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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
(On leave)

Associate Professors

Charles Alcock, Ph.D.
Associate Professor of Physics

Ahmet Nihat Berker, Ph.D.
Associate Professor of Physics

James Gordon Branson, Ph.D.
Associate Professor of Physics

Claude Roger Canizares, Ph.D.
Associate Professor of Physics

Richard Jonathan Cohen, Ph.D., M.D.
Associate Professor of Physics
Hermann von Helmholtz
Associate Professor of Health
Sciences and Technology

Lennox L. Cowie, Ph.D.
Associate Professor of Physics
(On leave)

James Ludlow Elliot, Ph.D.
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Robert Page Redwine, Ph.D.
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(On leave, fall)

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Assistant Professors

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Alan Jay Lazarus, Ph.D.

Paul David Luckey, Jr., Ph.D.

Charles Philip Sargent, Ph.D.

Stephen Geoffrey Steadman, Ph.D.

Edwin Floriman Taylor, Ph.D.
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Professor of Physics, Emeritus

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Professor of Physics, Emeritus

Department of Physics

Undergraduate Study

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 following research areas.

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 the section entitled Astronomy and Astrophysics in Chapter V.

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 characteristic of 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, the Francis Bitter National Magnet Laboratory, and the Program on Sciences and Technology and International Security. 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.

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 8.05 Quantum Physics 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.

Graduate Study

Bachelor of Science in Physics Course VIII

	General Institute Requirements			Total Units
	Specific science and humanities, arts, and social sciences 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[3]	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[4]		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[5]		12	
	Unrestricted Electives[6]			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
8.211 may substitute for 8.04.

4
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.

5
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 and 8.07.

6
Schedules of students in Course VIII may always be arranged to leave available 12 units of Unrestricted Electives in the second year.

In the fourth year, the theoretical sequence can be continued with 8.07 Electromagnetism II and 8.08 Statistical and Quantum Physics. 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 required to submit a thesis proposal prior to registering for 8.ThU. 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 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 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 Chapter V).

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 information on 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.

Joint Program in Oceanography and 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, marine geochemistry, 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. All decisions, from admission to the conferring of the degree are made by consensus of joint MIT/WHOI committees.

Research at WHOI encompasses the basic sciences as they apply to the marine environment: physics, chemistry, geology, geophysics, and biology, as well as ocean engineering and marine policy. Some 200 scientists and technicians and a support staff of about 600 work in four large laboratories and smaller facilities located in Woods Hole and on the nearby Quisset Campus. Another 75 people operate three research vessels ranging from 177 to 245 feet in length, the deep-diving submersible ALVIN and mother ship, and a small coastal vessel. Computer services are provided within the Institution and with links to other institutions. The library facilities are shared with the Marine Biological Laboratory and supplemented by collections of the Northeast Fisheries Center of the National Marine Fisheries Service and the US Geological Survey, all located in Woods Hole. The village is located on the southwest corner of Cape Cod, about 80 miles from Boston. A marine facility is maintained by MIT in Boston Harbor and consists 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.

1.165	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
1.82	Problems in Aquatic Biology and Chemistry (A)
2.065J	Flow Noise (A)
2.071J	Introduction to Structural Mechanics
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)
6.341	Digital Processing of Signals (A)
6.455J	Marine Data Systems (A)
7.03	Genetics
7.05	General Biochemistry
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	Benthic Ecology
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)
12.011	Sedimentary Processes: Rivers
12.014	Sedimentary Processes: Coastlines
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)
12.58	Geodynamics (A)
12.70J	Steady Circulation in the Atmosphere and Ocean (A)
12.71J	Wave Motions in the Atmosphere and Oceans (A)
12.72	Oceanic Volcanology and Petrology (A)
12.73	Marine Geology (A)
12.732	Internal Structure of Ophiolites and Oceanic Lithosphere (A)
12.74	Marine Micropaleontology (A)
12.742	Cenozoic Foraminifera (A)
12.75	Marine Sediments (A)
12.77	Marine Geophysics I (A)
12.78	Marine Geophysics II (A)
12.781	Special Problems in Chemical Oceanography at Woods Hole (A)
12.783	Topics in Geophysical Time Series Analysis (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)
12.822	Paleoceanography (A)
12.83	Marine Geochemistry (A)
12.85	Oceanographic Time Series (A)
12.87J	Equatorial Physical Oceanography (A)
12.88	Topics in Modern Observational Physical Oceanography (A)
12.891-12.899	Special Problems in Oceanography at MIT (A)
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)
13.74J	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)
13.861	Ocean and Seabed Acoustics I (A)
13.862	Ocean and Seabed Acoustics II (A)
13.87	Wave Propagation in Random Media (A)
13.92	Marine Policy (A)
13.94	Law for Ocean Systems

13.961J Ocean Resources 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)
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 Past and Present Climate
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)
19.70J Steady Circulation of the Atmosphere and Ocean (A)
19.71J Wave Motions in the Atmosphere and Oceans (A)
19.78 Dynamics of Shelf Circulation (A)
19.83 Modeling Oceanic Systems
19.84J Equatorial Physical Oceanography (A)
19.842 Dynamics of Eddies and Circulation (A)
19.86 The General Circulation of the Oceans (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)
20.811J 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 between institutions. 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.

The Joint Program involves several departments at MIT — Biology, and Earth, Atmospheric, and Planetary Sciences 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. Upon admission, students register in the appropriate MIT department and are assigned academic advisors at each institution. Because the Joint Program is not affiliated with any one particular department, it is important that students who wish to be considered for the Joint Program indicate this on the front of their applications.

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 Oceanography and Oceanographic Engineering.

Chemical Oceanography, Marine Geology, Marine Geophysics, Marine Geochemistry, and Physical Oceanography

The Department of Earth, Atmospheric, and Planetary Sciences offers programs with WHOI in chemical oceanography, marine geology, marine geochemistry, marine geophysics, and physical oceanography. The programs 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.

Inquiries

Application for admission to the Joint Program 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, (617) 548-1400, x2200; or to the MIT Joint Program Office, Room 26-167, Cambridge, Massachusetts 02139, (617) 253-7544.

The Whitaker College of Health Sciences, Technology, and Management

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 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 biological and health 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 concept of Whitaker College derives from MIT's belief that biomedical and health-related problems are complex in nature and require the combined efforts of a wide range of disciplines for their ultimate solution. These disciplines include not only biology and chemistry, but also physics, mathematics, various branches of engineering, computer science, economics, and management. Faculty members involved in the educational and research programs of Whitaker College hold joint appointments in the College and in other Schools, departments, and interdisciplinary laboratories at MIT.

The director of Whitaker College is Dr. Emilio Bizzi, Eugene McDermott Professor in the Brain Sciences and Human Behavior.

In defining the programmatic objectives of Whitaker College, MIT has sought to identify the fields in which the College can play an especially effective role by developing new activities, fortifying existing programs, and amplifying opportunities for faculty members and students. Initially, the College has identified four intellectual foci, which now serve as the basis for its divisions: neurosciences (including neurobiology, systems neuroscience, and communication sciences); biomedical engineering and biophysics (including biological imaging, under way in the College's Electron Microscopy Laboratory); human biology and experimental medicine; and health policy and management. Several graduate programs are being developed in the College. The Ph.D. program in health policy and management (described here) admitted its first class in September 1983. The interdepartmental Ph.D. program in Biomedical Engineering also operates under the auspices of the College. (See the program description in Chapter V of this catalogue.)

The Doctoral Program in Health Policy and Management

The goal of this unique, multidisciplinary program is to generate an understanding of scientific and technological issues in medicine, as well as the managerial/institutional context that determines the allocation of health-care resources. The program draws on faculty from the Departments of Economics and Political Science and the Sloan School of Management, as well as other departments and Schools throughout the Institute. In addition, doctoral candidates benefit from the rich university environment and special strengths in academic medicine in the greater Boston area.

The program offers a three- to four-year doctoral curriculum for new entrants into the health policy and management field. The program may be completed in a shorter time by matriculants with advanced preparation.

The core curriculum of the program provides the scientific methodology and tools needed to understand health policy and management, and offers alternative perspectives on ways to resolve policy and management issues in the field. Degree candidates are required to specialize in a related underlying discipline. Each Ph.D. candidate develops an advanced track of disciplinary study, such as economics, political science, or management. Students may design alternative courses, subject to faculty approval. In addition, each doctoral student is expected to carry out an independent research project, preferably in a clinical setting. The doctoral dissertation generally requires one year of field study and/or analysis, after completion of the qualifying examinations.

Applications are encouraged from physicians, medical students, and others who have completed two years of basic medical sciences or who demonstrate equivalent knowledge or preparation. All successful candidates will receive stipends to defray tuition and living expenses from funds granted to MIT by the Henry J. Kaiser Family Foundation. Those who wish to apply to the program may request an application by contacting Stan N. Finkelstein, M.D., Director, Laboratory for Health Care Studies, MIT, 77 Massachusetts Ave., Cambridge, MA 02139, (617) 253-5285.

Harvard-MIT Division of Health Sciences and Technology

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Director, Harvard-MIT Division of Health Sciences and Technology
Professor of Medicine at Harvard University and MIT
Grover M. Hermann Professor of Health Sciences and Technology
Professor of Biology
MIT

Ernest G. Cravalho, Ph.D.
Associate Director, Harvard-MIT Division of Health Sciences and Technology
Matsushita Professor of Mechanical Engineering in Medicine
MIT Department of Mechanical Engineering

Professors

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Harvard Medical School

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Professor of Electrical Engineering
MIT Department of Electrical Engineering and Computer Science

Ronald A. Arky, M.D.
Charles S. Davidson
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Lecturer, MIT Department of Electrical Engineering and Computer Science

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George Fabyan Professor of Comparative Pathology
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J. David Litster, Ph.D.
Professor of Physics
MIT
Lecturer on Physics in the Faculty of Medicine
Harvard Medical School

Boris Magasanik, Ph.D.
Jacques Monod Professor of Microbiology
MIT Department of Biology

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.
Professor of Electrical and Bioengineering
MIT Department of Electrical Engineering and Computer Science

John T. Potts, Jr., M.D.
Jackson Professor of Clinical Medicine
Harvard Medical School

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.
Professor of Electrical Engineering
MIT Department of Electrical Engineering and Computer Science

Clement B. Sledge, M.D.
John B. and Buckminster Brown Professor of Orthopedic Surgery
Harvard Medical School

Thomas W. Smith, M.D.
Professor of Medicine
Harvard-MIT Division

Felix M. H. Villars, D.Sc.Nat., D.Sc.
Professor of Physics
MIT Department of Physics
Lecturer on Physics in the Faculty of Medicine
Harvard Medical School

Christopher T. Walsh, Ph.D.
Professor of Chemistry and Biology
Uncas and Helen Whitaker Professor in the Whitaker College
Head, MIT Department of Chemistry

Edward W. Webster, Ph.D.
Professor of Radiology (Physics)
Harvard Medical School

Thomas F. Weiss, Ph.D.
Professor of Electrical and Bioengineering
MIT Department of Electrical Engineering and Computer Science

Augustus A. White III, M.D., D.Med.Sci.
Professor of Orthopedic Surgery
Harvard Medical School

Richard J. Wurtman, M.D.
Professor of Neuroendocrine Regulation
MIT Department of Nutrition and Food Science

Ioannis V. Yannas, Ph.D.
Professor of Mechanical Engineering and Materials Sciences and Engineering
MIT

Laurence R. Young, Sc.D.
Professor of Aeronautics and Astronautics
MIT Department of Aeronautics and Astronautics

Marvin Zelen, Ph.D.
Professor of Statistical Science in the Department of Biostatistics
Harvard School of Public Health

Associate Professors

Abul Khair Abbas, M.B.
Associate Professor of Pathology
Harvard Medical School

Donald Antonioli, M.D.
Associate Professor of Pathology
Harvard Medical School

Martin C. Carey, M.D.
Lawrence J. Henderson Associate Professor of Health Sciences and Technology in the Harvard-MIT Division
Associate Professor of Medicine
Harvard Medical School

Victoria Chan-Palay, M.D., Ph.D.
Associate Professor of Neurobiology
Harvard Medical School

W. Hallowell Churchill, M.D.
Associate Professor of Medicine
Harvard Medical School

Cecil H. Coggins, M.D.
Associate Professor of Medicine
Harvard Medical School

Richard J. Cohen, M.D., Ph.D.
Hermann von Helmholtz Associate Professor of Health Sciences and Technology in the Harvard-MIT Division
Associate Professor of Physics
MIT

I. John Davies, M.D.
Associate Professor of Obstetrics and Gynecology
Harvard Medical School

William M. Deen, Ph.D.
Associate Professor of Chemical Engineering and Health Sciences and Technology
MIT Department of Chemical Engineering

G. Richard Dickersin, M.D.
Associate Professor of Pathology
Harvard Medical School

Alan J. Grodzinsky, Sc.D.
Associate Professor of Electrical and Bioengineering
MIT Department of Electrical Engineering and Computer Science

Joel Habener, M.D.
Associate Professor of Medicine
Harvard Medical School

Charles A. Hales, M.D.
Associate Professor of Medicine
Harvard Medical School

Jeffrey E. Harris, M.D., Ph.D.
Associate Professor of Economics and Health Sciences and Technology
MIT Department of Economics

Wilson C. Hayes, Ph.D.
Associate Professor of Orthopedic Surgery
Harvard Medical School

Herbert B. Hechtman, M.D.
Associate Professor of Surgery
Harvard Medical School

George A. Jacoby, M.D.
Associate Professor of Medicine
Harvard Medical School

Roger D. Kamm, Ph.D.
Associate Professor of Mechanical Engineering
MIT

Robert S. Langer, Jr., Sc.D.
Associate Professor of Biochemical Engineering in the Department of Nutrition and Food Science and Dorothy W. Poitras Associate Professor in Medical Engineering in Whitaker College
MIT

Roger G. Mark, M.D., Ph.D.
Matsushita Associate Professor of Electrical Engineering in Medicine
MIT Department of Electrical Engineering and Computer Science
Assistant Professor of Medicine
Harvard Medical School

E. Regis McFadden, Jr., M.D.
Associate Professor of Medicine
Harvard Medical School

Barbara J. McNeil, M.D., Ph.D.
Associate Professor of Radiology
Harvard Medical School

Michael A. Moskowitz, M.D.
Associate Professor of Neurology
Harvard Medical School
Visiting Lecturer
MIT Department of Nutrition and Food Science

John R. Murphy, Ph.D.
Lawrence J. Henderson Associate Professor of Health Sciences and Technology
Harvard-MIT Division
Associate Professor of Microbiology and Molecular Genetics
Harvard Medical School

James E. Pennington, M.D.
Associate Professor of Medicine
Harvard Medical School

Dwight R. Robinson, M.D.
Associate Professor of Medicine
Harvard Medical School

Robert H. Schapiro, M.D.
Associate Clinical Professor of Medicine
Harvard Medical School

Isaac Schiff, M.D.C.M.
Associate Professor of Obstetrics and Gynecology
Harvard Medical School

Alan L. Schiller, M.D.
Associate Professor of Pathology
Harvard Medical School

Daniel C. Shannon, M.D.
Associate Professor of Pediatrics
Harvard Medical School

Göran K. Svensson, D.Sc.
Associate Professor of Radiation Therapy
Harvard Medical School

James Ware, Ph.D.
Associate Professor of Biostatistics
Harvard School of Public Health

Warren Zapol, M.D.
Associate Professor of Anesthesia
Harvard Medical School
Lecturer, MIT Department of Chemical Engineering

Assistant Professors

Dennis R. Carter, Ph.D.
Assistant Professor of Orthopedic Surgery, (Bioengineering)
Harvard Medical School

Jeffrey B. Cooper, Ph.D.
Assistant Professor of Anesthesia (Biomedical Engineering)
Harvard Medical School

Allan S. Detsky, M.D., Ph.D.
Assistant Professor in the Harvard-MIT Division (Visiting)

David J. Edell, Ph.D.
Assistant Professor in the Harvard-MIT Division and in the MIT Department of Electrical Engineering and Computer Science

John T. Fallon, M.D., Ph.D.
Assistant Professor of Pathology
Harvard Medical School

Lee Gehrke, Ph.D.
Assistant Professor of Anatomy
Harvard Medical School
Assistant Professor of Anatomy in the Harvard-MIT Division

Charles J. Hatem, M.D.
Assistant Professor of Medicine
Harvard Medical School

Bernard Hoop, Jr., Ph.D.
Assistant Professor of Radiology
Harvard Medical School

Philip F. Judy, Ph.D.
Assistant Professor of Radiology
Harvard Medical School

Robert V. Kenyon, Ph.D.
Assistant Professor of Aeronautics and Astronautics
MIT Department of Aeronautics and Astronautics

William M. Kettyle, M.D.
Assistant Clinical Professor of Medicine
Marvard Medical School

George E. Lewinnek, M.D.
Assistant Professor of Orthopedic Surgery
Harvard Medical School

Edmund G. Lowrie, M.D.
Assistant Clinical Professor of Medicine
Harvard Medical School

James L. Madara, M.D.
Assistant Professor of Pathology
Harvard Medical School

Eugene J. Mark, M.D.
Assistant Professor of Pathology
Harvard Medical School

Clarke F. Millette, Ph.D.
Assistant Professor of Anatomy
Harvard Medical School

Richard C. Mulligan, Ph.D.
Assistant Professor of Biology
MIT

Alan C. Nelson, Ph.D.
Assistant Professor of Nuclear Engineering, MIT Department of Nuclear Engineering
Assistant Professor of Health Sciences and Technology
Harvard-MIT Division

Ronald S. Newbower, Ph.D.
Assistant Professor of Anesthesia (Biomedical Engineering)
Harvard Medical School
Lecturer, MIT Department of Electrical Engineering and Computer Science

Mark Phillippe, M.D.
Assistant Professor of Obstetrics and Gynecology
Harvard Medical School

John L. Rowbotham, M.D.
Assistant Clinical Professor of Surgery
Harvard Medical School

Frederick J. Schoen, Ph.D., M.D.
Assistant Professor of Pathology
Harvard Medical School

Daniel Souder, M.D.
Assistant Professor of Medicine
Harvard Medical School

Richard Teplick, M.D.
Assistant Professor of Anesthesia
Harvard Medical School

Jack R. Wands, M.D.
Assistant Professor of Medicine
Harvard Medical School

Senior Lecturer

John B. Stanbury, M.D.
Senior Lecturer, MIT Department of Nutrition and Food Science
Lecturer on Medicine
Harvard Medical School
Officer of Instruction
Harvard-MIT Division

Lecturer

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 Associate

Robert E. Zimmerman, M.S.E.E.
Principal Research Associate in Radiology (Physics)
Harvard Medical School
Officer of Instruction
Harvard-MIT Division

Instructors

John B. Cadigan, Jr., M.D.
Clinical Instructor in Medicine
Harvard Medical School

Roger L. Christian, M.D.
Instructor in Surgery
Tutor in Medical Sciences
Harvard Medical School

Michael C. Long, M.D.
Instructor in Anesthesia
Harvard Medical School

Deedra McClearn, M.A.
Instructor in Anatomy in the Harvard-MIT Division

James H. Philip, M.D.
Instructor in Anesthesia
Harvard Medical School

Edwin D. Trautman, Ph.D.
Instructor in Anesthesia (Biomedical Engineering)
Harvard Medical School

Senior Research Scientists

Stephen K. Burns, Ph.D.
Senior Research Scientist
Biomedical Engineering Center
Harvard-MIT Division

Daniel H. Levin, Ph.D.
Senior Research Scientist
Harvard-MIT Division

Postdoctoral Associates

Annette Weber-Benarous, Ph.D.
Harvard-MIT Division

Jane-Jane Chen, Ph.D.
Harvard-MIT Division

Timothy Cox, M.D.
Visiting Scientist
Harvard-MIT Division

Robert Matts, Ph.D.
Harvard-MIT Division

Raymond A. Petryshyn, Ph.D.
Harvard-MIT Division

William Solomon, M.D.
Harvard-MIT Division

Huynh van Tan, Ph.D.
Visiting Scientist
Harvard-MIT Division

Shaun Thomas, Ph.D.
Harvard-MIT Division

Dorothy Tuan, Ph.D.
Principal Research Scientist
Harvard-MIT Division

Administrative Staff

Irving A. Berstein, Ph.D.
Assistant Director for Research Program Development
Harvard-MIT Division

H. Frederick Bowman, Ph.D.
Senior Academic Administrator
Harvard-MIT Division

Walter L. Koltun, Ph.D.
Assistant Director for Resources
Harvard-MIT Division

Keiko F. Oh, M.A.
Administrative Officer
Harvard-MIT Division

Virginia Safford
Administrative Assistant
Harvard-MIT Division

William A. Toscano, B.A.
Staff Accountant
Harvard-MIT Division

Harvard-MIT Division of Health Sciences and Technology

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.

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; but these requirements and the MCAT must be satisfactorily accomplished at a level comparable to prior academic performance no later than one year after matriculation in the HST Division. 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 E25-519 at MIT, (617) 253-4305.

Information on the interdepartmental study opportunities in biomedical engineering may be found in Chapter V of this catalogue.

The Center for Health Effects of Fossil Fuels Utilization, which is under the aegis of the Division and the Energy Laboratory, is described in Chapter V of this catalogue.

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: The Neurosciences I	6 3 6
HST 580J	Principles of Biomedical Measurements	3 0 9
HST 581J	Measurements in Medicine and Biomedical Research	2 5 5
HST 590	Biomedical Engineering Seminar	1 0 0
	Four clinical experiences, one of which must be in the field of Medicine	
	Doctoral Thesis	

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

Kenneth C. Almquist, M.S.
Major, US Air Force
Technical Instructor

Joseph P. Bisognano, Jr., M.S.
Major, US Air Force
Technical Instructor

Laura C. Counts, M.A.
Captain, US Air Force
Technical Instructor

Steven K. Sudderth, M.A.
Captain, US Air Force
Technical Instructor

John F. MacPherson
Technical Sergeant, US Air Force
Technical Instructor

Daryl D. Waldrop
Technical Sergeant US Air Force
Technical Instructor

Sylvester E. Dublin
Technical Sergeant, US Air Force
Technical Instructor

Ronald W. Berry
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 $40,000. 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.

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 Harvard, Tufts, or Wellesley, 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 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.

Army ROTC Program

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. Scholarship recipients must take a writing composition course and at least one term of a foreign language.

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)

G. Sidney Smith, Jr., M.S., M.B.A.
Colonel
Corps of Engineers
Visiting Professor of Military Science
Director, Office of Military Science

William P. Roe, B.S.
Lieutenant Colonel,
Corps of Engineers
Technical Instructor

William B. Miller, B.A., M.A., Ph.D.
Major, USAR, Civil Affairs
Technical Instructor

John L. Shannon
Sergeant Major, US Army
Technical Instructor

Gary A. Ross, A.A.S.
Master Sergeant, US Army
Technical Instructor

Cezar T. Mendoza, B.S.
Staff Sergeant, US Army
Technical Instructor

Donald B. Willhide
Staff Sergeant, US Army
Technical Instructor

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 and summer training requirements qualifies the student for commission upon graduation.

The academic portion of the ROTC program consists of the Program of Instruction as listed and one related subject per year, plus a one-hour leadership laboratory 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 first two years for appropriate academic or military work experience. Selected subjects may be offered during the Summer Session. Elective subjects accepted for the ROTC program are derived primarily from the humanities, political science, management, and psychology areas. They 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 the ROTC advisor. Participation in the first two years of the ROTC program satisfies one-half of the Institute's Physical Education Requirement.

Students completing the ROTC program will receive their commissions upon graduation and go on to serve a specified period. The commitment depends 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 the academic background and experience of the student. 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

Corps, Ordnance Corps, Military Police Corps, Medical Service Corps, and the Medical Specialist Corps. Commissions are also available in the allied health professions and in the Judge Advocate General Corps.

Enrollment in the first year of the four-year program is voluntary and does not obligate the student to any type of active duty or reserve commitment. Students desiring to continue in the program beyond the freshman year may incur an active duty or reserve 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, and are furnished food, housing, equipment, and medical care at Government expense, 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.

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, supplies, laboratory fees, and related expenses, plus a stipend of $100 per month. Full details on the scholarship program may be obtained by contacting the Professor of Military Science.

In addition to the requirements outlined above, Army Airborne, Ranger, and other Military schooling and training programs are available on a voluntary basis to qualified students. Full details on these programs are also available from the Professor of Military Science (PMS).

Eligibility Requirements

The requirement for entry into the Basic Course of the four-year program is that the student must be able to qualify for a commission before reaching his or her 28th birthday. A non-citizen may enroll in and complete the program, but must at least become a permanent resident 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 a commission before reaching their 28th birthday. Veterans may, with PMS approval, immediately qualify for the two-year program.

Application Procedures

Application for the four-year program is effected by enrollment in MS 111. Students enroll in this course 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, or by calling (617) 253-4471.

Program of Instruction

One Institute elective subject is required for each year in addition to the following:

First Year

MS111 Introduction to ROTC and the Army (1-1-1) (no MIT credit)
MS121 The Army Today (1-1-1) (no MIT credit)

Second Year

MS21 Leadership (2-0-1) (no MIT credit)
MS211 Instructional Methodology (1-1-1) (no MIT credit)
MS221 Branches of the Army (1-1-1) (no MIT credit)

Third Year

MS31 Small Units Tactics (2-0-1) (no MIT credit)
MS311 Military Management (1-1-1) (no MIT credit)
MS321 Land Navigation (1-1-1) (no MIT credit)

Fourth Year

MS41 Military History (2-0-1) (no MIT credit)
MS411 Military Law and Administration (1-1-1) (no MIT credit)
MS421 Military Ethics and Professionalism (1-1-1) (no MIT credit)

Naval ROTC Program

David V. Burke, Jr., Ph.D.
Captain, US Navy
Visiting Professor of Naval Science
Director, Office of Naval Science
Professor of Naval Architecture

Robert J. McClure
Commander, US Navy
Lecturer

Guy Durand
Captain, US Marine Corps
Technical Instructor

Paul F. Farrell
Lieutenant, US Navy
Lecturer

Douglas S. Forman
Lieutenant, US Navy
Lecturer

David E. Guza
Lieutenant, US Navy
Lecturer

Frank Mello
Master Chief Aviation Storekeeper,
US Navy
Technical Instructor

Garrett A. Schultz
Senior Chief Quartermaster
US Navy
Lecturer

John M. Bailey
Chief Yeoman, US Navy
Technical Instructor

James M. Sauer
Gunnery Sergeant
US Marine Corps
Technical Instructor

Naval ROTC Program

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- or five-year active duty obligation depending on duty option.

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 semiannually, 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 summer cruise, as well as the current active duty pay rate during the cruise.

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 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 Tufts 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 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)

Second Year

NS21* Naval Ships Systems II (2-2-2) (no MIT credit)

NS22 Seapower and Maritime Affairs (2-0-2) (no MIT credit)
Modern Indo-European or Asiatic Language

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), or a staff specified MIT subject such as STS 321 (3-0-6)

NS34 Marine Corps Doctrine and Tactics (2-0-2) (Marine option only, in lieu of NS32) (no MIT credit)

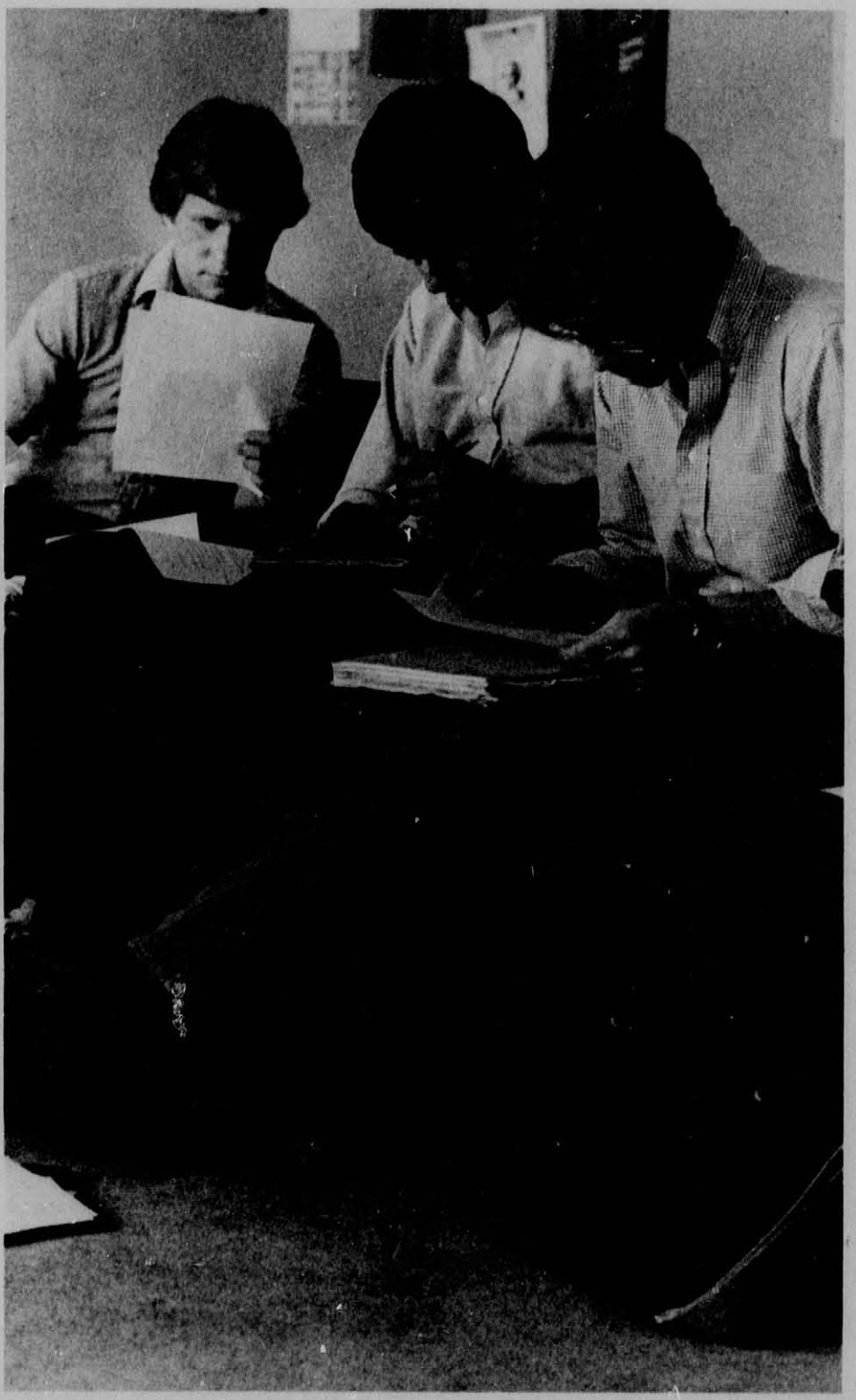
Fourth Year

NS41 Leadership and Management I (2-0-2) (no MIT credit) or a staff specified MIT subject such as 15.301 (2-6-4)

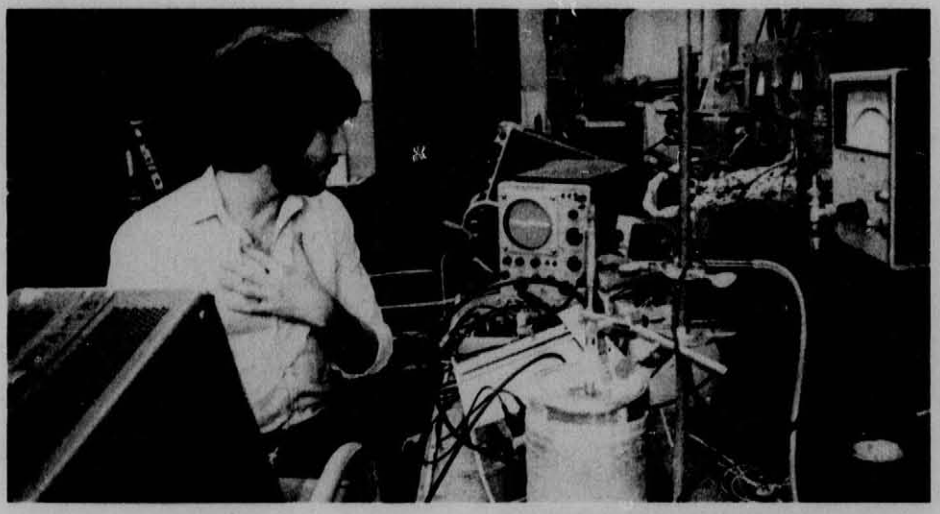
NS42 Leadership and Management II (2-0-2) (no MIT credit)

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.



Description of Subjects









Explanatory Notes

The subject descriptions given in this chapter are subject to change. The final list of subjects to be given in 1983-84 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 **year offered comment** states "Next offered 1984-85," "Not offered 1984-85," or there is no comment if it is offered both 1983-84 and 1984-85.

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.: —
U (1, 2)
Arr.

Individual research or laboratory study under faculty supervision. Also, opportunities in ongoing research program. Limited number of funded traineeships available.
H. F. Hemond

1.00 Introduction to Computers and Engineering Problem Solving

Prereq.: —
U (2) SD
3-1-8

Fundamentals of computer hardware and software organization and the principles and methods of structuring, impiementing, 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. Structuring of programs and data. Fundamentals of programming using the FORTRAN language. Extensive interaction with and use of digital computers.
B. Schumacker

1.01J Engineering Aspects of Economic Analysis

(Same subject as 14.014J)
Prereq.: —
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 count toward Humanities Requirement.
Staff

1.02 Civil Engineering Systems Analysis I (Revised Unit)

Prereq.: 18.02, *1.01J*
U (1)
3-2-7

With 1.03 a two-term overview of Civil Engineering systems analysis. Includes approaches to formulation and problem structure, evaluation criteria, optimization techniques, elements of probability with emphasis on engineering application. Mini-projects during required recitation period in conjunction with 1.04. Simultaneous registration with 1.04 required, except by permission of instructor.
D. H. Marks, S. R. Lerman

1.03 Civil Engineering Systems Analysis II (Revised Unit)

Prereq.: 1.02, *18.03*
U (2)
3-2-7

Continuation of 1.02. Probability topics include analysis of Bernoulli Events, common distributions including exponential, Poisson, normal, lognormal, and extreme value. Statistics include point and interval estimation and hypothesis tests. Systems modeling topics include dynamic programming, nonlinear programming, and decision analysis. Mini-projects during required recitation in conjunction with 1.05. Simultaneous registration with 1.05 required except students in Course I-A Option 2, or by permission of instructor.
S. R. Lerman, D. H. Marks

1.04 Behavior of Physical Systems I (Revised Unit)

Prereq.: 18.02
U (1) SD
3-2-7

Applies statics, geometric compatibility, and force-deformation relations in analysis of simple determinate and indeterminate structures. Reactions, internal forces, and deflections for beams and trusses. Introduces stress-strain behavior of construction materials, stress and strain in 2-dimensions (Mohr's circle), and stability and buckling. Exercises in Microcomputer Laboratory. Mini-projects during required recitation period in conjunction with 1.02. Simultaneous registration with 1.02 required, except by permission of instructor.
R. V. Whitman

1.05 Behavior of Physical Systems II (Revised Unit)

Prereq.: 1.04, *18.03*
U (2)
3-2-7

Applies basic physical principles to the engineering analysis of solid and fluid systems. Includes static equilibrium of fluids, conservation of mass and momentum of moving fluids, thermodynamic properties, first and second laws of thermodynamics. Applications to fluid forces on structures, flow in conduits and channels, state changes, mechanical and thermodynamic energy cycles. Mini-projects during required recitation period in conjunction with 1.03. Simultaneous registration with 1.03 required, except by permission of instructor.
K. D. Stolzenbach

For additional undergraduate introductory subjects, see: 1.16J, 1.20, 1.30, 1.40, 1.50, 1.60, 1.70, 1.80.

Undergraduate Laboratory Subjects

1.102 Transportation Laboratory

Prereq.: —
U (2) LAB
0-3-3

Laboratory experience with the properties of transportation systems. 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.: —
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.: —
U (2) 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.
Staff

1.105J Structural Engineering Laboratory

(Same subject as 4.315J)
Prereq.: —
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.: —
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. Applies these techniques in the context of laboratory experiments and one or more field studies. Certain experiments complement lectures in 1.60, but concurrent registration in 1.60 or previous fluid mechanics experience is not required.
E. E. Adams

1.107 Aquatic Chemistry and Biology Laboratory

Prereq.: 5.40
U (2) LAB
2-6-4

Field sampling and laboratory analysis techniques for determining chemical (e.g., salinity, O_2, nutrients, haloforms, petroleum hydrocarbons) and biological (e.g., coliforms, chlorophyll) parameters in aquatic samples. Both wet-chemical and instrumental (e.g., spectrophotometry and gas chromatography) methods. Three field trips are taken to acquire "real world" samples for analysis and interpretation of the data in terms of water quality and the processes affecting it. Permission of instructor required.
P. M. Gschwend, S. W. Chisholm

See also 1.312.

General Methods and Concepts

Listed below are a number of subjects concerned with general methods and concepts rather than specific applications areas. Topics include:
- **Information Systems and Computational Methods**
- **Analytical Mechanics**
- **Engineering Systems, Economics, and Management**
- **Engineering Risk Assessment and Probabilistic Analysis**
- **Institutions and Public Policy**

Subjects under these headings are of interest to students from a variety of backgrounds, both from within and outside the Department. Subjects more oriented to applications based on these methodologies are noted at the end of each section.

Information Systems and Computational Methods

1.11 Microcomputer Project Laboratory (Revised Unit)

Prereq.: 1.00
U (2)
3-2-7

Techniques for configuring and implementing microcomputers in various aspects of civil engineering usage. Fundamentals of microprocessor and microcomputer hardware and software. Interfacing standards and techniques. Similarities and differences among various products. Design and implementation projects carried out through the term oriented toward applications in the disciplines of civil engineering. Projects involve microcomputer usage as a desk-top system, an intelligent terminal, a laboratory data acquisition system, and a real-time controller.
B. Schumacker

1.12 Computer Models of Engineering Systems

Prereq.: 18.02, 8.01
U (1) SD
3-0-9

School-Wide Elective Subject. Description given at end of this chapter on SWE page.
B. Schumacker

1.121 Numerical Modeling of Physical Systems (A)

Prereq.: 18.03, 1.04
G (1)
3-0-6

Introduces computational methods for predicting the response of physical systems. Provides numerical analysis background for structural, geotechnical, hydrodynamics, and environmental modeling subjects. Topics: matrix algebra, solution techniques for linear and nonlinear systems of algebraic equations, eigenanalysis, Fourier analysis, finite difference methods, numerical integration of time-dependent equations, weighted residual methods. Emphasizes development and use of computer programs.
S. Shyam Sunder

1.122 Finite Element Analysis in Continuum Mechanics (A)

Prereq.: 1.121, 1.51
G (2)
3-0-6

Finite element methods for the analysis of continuous media. Variational principles, weighted residual methods, penalty methods, selective integration, Boundary Element Methods. Applications to three-dimensional solids, plates, shells, transport processes, fluid flow, soil media.
J. J. Connor, Jr.

For additional related subjects, see: 1.204J, 1.368, 1.70.

Analytical Mechanics

1.131 Analytical Methods in Physical Systems (A) (New)

Prereq.: 18.03
G (1) **Not offered 1984-85**
3-0-6

A utilitarian survey of elementary and intermediate analytical techniques, and their applications in physical systems. Linear partial differential equations. Separation of variables. Integral transforms, Green's functions. Complex variables and contour integration. Asymptotic approximation of integrals and perturbation methods. Illustrations by cases in groundwater seepage, elastic foundations, water waves, elastic waves, structural vibrations, soil consolidation, and pollutant diffusion. Alternate years.
C. C. Mei

1.132 Advanced Engineering Mechanics (A)

(1.491)
Prereq.: 1.51
G (2)
3-0-6

A unified introduction to the engineering mechanics of elastic, plastic, and time-dependent solid materials and structures. Review of stress and strain. Tensor representation and principal values. Principles of virtual work and variational theorems. Elastic stress-strain relations. Inelastic material response, plastic yield criteria, and flow rules. Plastic limit analysis. Thermoelasticity. Visoelasticity. Mechanics of brittle and ductile fracture in structural materials. Energy methods. Representative boundary value problems chosen from bending and torsion of rods, plane strain, plane stress.
V. C. Li

1.133 Geomechanics (A)

(1.492)
Prereq.: 1.132
G (1)
3-0-6

Nonlinear constitutive laws and field equations for porous media. Dynamic soil-structure interaction. Dynamic amplification in soil deposits. Wave passage and seismic environment. Hysteresis and correspondence principle. Dynamics of foundations and pile groups. Transmitting boundaries and infinite elements. Computational techniques and applications to certain constructed facilities such as nuclear power plants, buried structures, pipelines, tall buildings, bridges.
E. A. M. Kausel

1.137 Studies in Analytical Mechanics (A)

(1.497)
Prereq.: Permission of Instructor
G (1, 2, S)
Arr.

Individual study of advanced subject material under staff supervision.
Staff

For additional related subjects see: 1.351, 1.382, 1.541, 1.542, 1.56J, 1.571, 1.572, 1.63, 1.64, 1.691.

Engineering Systems, Economics, and Management

1.143J Mathematical Optimization Techniques (A)

(Same subject as 13.622J)
Prereq.: Permission of Instructor
G (1)
3-0-6

Systematic survey of a broad spectrum of mathematical optimization techniques. Emphasis on formulation, solution methodology, algorithmic efficiency, and applications. Covers Lagrange multiplier and Kuhn-Tucker theory; duality; network problems; linear, integer, dynamic, stochastic, large-scale, and quadratic programming; and heuristics. Assumes some familiarity with linear algebra, calculus, and the computer.
D. H. Marks, H. N. Psaraftis

1.146 Engineering Systems Analysis (A)

Prereq.: Permission of Instructor
G (1)
3-0-6

School-Wide Elective Subject. Description given at end of this chapter on SWE page.
R. de Neufville, J. P. Clark

1.147J Applied Microeconomics Analysis (A)

(Same subject as 14.110J, CTS 110J)
Prereq.: 14.01 or 1.01J
G (1)
3-0-6

See description under subject 14.110J.
C. Winston

1.148J Economics of Project Evaluation (A)

(Same subject as 14.111J)
Prereq.: 14.03 or 14.120
G (2) **Next offered 1984-1985**
3-0-6

See description under subject 14.111J.
D. L. McFadden, C. Winston

For additional related subjects see: 1.202J, 1.203J, 1.207, 1.283J, 1.284J, 1.44, 1.70, 1.731. Subjects dealing with management of engineering systems are: 1.253, 1.259, 1.40-1.487J, 1.78.

Engineering Risk Assessment and Probabilistic Analysis

1.151 Risk Assessment in Engineering I (A)

Prereq.: Permission of Instructor
G (1)
3-0-6

Quantitative analysis of uncertainty in planning, design, construction, and operation of engineered facilities. Interprets fundamentals of probability, random processes, statistics, and decision analysis in the context of engineering applications, in particular, description of variability of loads and environmental conditions, material properties, performance prediction, system reliability analysis, and risk-based decision analysis.
E. Vanmarcke, D. Veneziano

1.152 Risk Assessment in Engineering II (A)

Prereq.: 1.151
G (2)
3-0-6

Advanced probabilistic modeling and statistical analysis for engineering systems. Part 1: Second-moment characterization of random vectors, sequences, functions, and fields. Time and frequency domain analysis. Linear filtering and random vibration, Gaussian, Poisson, and Markov models. Extremes of random functions. Digital simultation. Part 2: Estimation of covariance observations. Models for decision-making: Poisson and Markov processes with reward.
D. Veneziano, E. Vanmarcke

1.155 Engineering Risk-Benefit Analysis (A)

Prereq.: 18.02
G (2)
3-0-6

School-Wide Elective Subject. Description given at end of this chapter on SWE page.
A. W. Drake, A. R. Odoni

1.158 Introduction to Queueing Theory (A)

Prereq.: Permission of Instructor
G (1)
1-0-2

A specialized mini-subject offered in the last third of the term. Topics: Fundamental concepts of queueing theory; Markovian, semi-Markovian, and non-Markovian queues; priority queues; queueing networks. Selected applications. Instructor should be contacted for information about starting date.
A. R. Odoni

For additional related subjects, see: 1.203J, 1.34, 1.44, 1.581, 1.587, 1.711, 1.712, 1.732.

Institutions and Public Policy

1.16J Ethics and Technocrats

(Same subject as STS 412J)
Prereq.: —
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. Assists in clarifying the ethical commitments of professional life. Examines models of the decision-making and problem-solving processes employed in these professions. Analyzes how particular professionals 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. May count toward Humanities Requirement.
M. L. Manheim

1.161 Ethical Issues in Professional Work (A)

Prereq.: Permission of Instructor
G (2)
3-0-6

Explores the roles of professionals in reaching decisions about large-scale technological projects with significant societal impacts. Assists the student in clarifying his/her own personal and professional objectives. 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.
M. L. Manheim

1.165 Introduction to Technology and Law

Prereq.: —
U (1)
3-0-9

School-Wide Elective Subject. Description given at end of this chapter on SWE page.
J. D. Nyhart

For additional related subjects, see: 1.251, 1.254J, 1.78, 1.811J, 1.812J.

Transportation

1.20 Transportation Systems Analysis (Revised Unit)

Prereq.: 1.03
U (1)
4-0-8

1.201J Transportation Systems Analysis (A) (Revised Content and Unit)

(Same subject as CTS 100J)
Prereq.: 1.03
G (1)
3-0-6

Introduces the analysis of passenger and freight transportation systems. Deterministic and stochastic models of system performance. Determinants of demand for transportation: travel behavior, logistics analysis, and location theory. Analyzes transportation networks including prediction of flow patterns and service quality. Evaluates impacts and design of transportation services and facilities. Additional recitation section required for undergraduates to cover selected topics in more detail. Permission of instructor required.
N. H. M. Wilson, G. A. Kocur

1.202J Transportation Demand and Activity Analysis (A)

(Same subject as CTS 150J)
Prereq.: 1.147J; CTS 100J or 1.201J or 1.20
G (2)
3-0-6

Analysis and forecasting of demand for transportation services including urban, intercity, freight, and passenger demand. Includes theory of transportation demand for individuals and firms, aggregate and disaggregate methods for location and demand analysis, forecasting methods, applications to various sectors. Assumes knowledge of statistics at introductory level. Prerequisites may be met by equivalent subjects.
S. R. Lerman, M. E. Ben-Akiva

1.203J Logistical and Transportation Planning Methods (A)

(Same subject as 6.281J, 11.526J, 13.665J, 15.078J, 16.76J, TPP 43J)
Prereq.: 6.431, 15.075
G (1)
3-0-9

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.
A. I. Barnett, R. C. Larson, A. R. Odoni, H. N. Psaraftis

1.204J Computer Algorithms in Transportation (A) (New)

(Same subject as 16.71J)
Prereq.: 1.00 or 16.008; 1.03
G (2)
3-0-6

Applies software engineering and analytical techniques to transportation systems. Structured programming, data structures, systems analysis and design, and user interfaces. Case studies using operations research techniques for problems in transportation networks, vehicle routing and scheduling, crew scheduling, facility location, and operations management. Extensive micro- and minicomputer assignments. Permission of instructor required.
G. A. Kocur. D. F. X. Mathaisel

1.205 Advanced Transportation Demand Modeling (A)

Prereq.: 1.202J or CTS 150J
G (1)
3-0-6

In-depth consideration of theories and applications of travel and mobility behavior models. Includes: 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. Reviews recent modeling efforts to improve existing travel forecasting systems. Term paper required.
M. E. Ben-Akiva, S. R. Lerman

1.207 Transportation Networks Equilibrium Analysis (A) (Revised Unit)

Prereq.: 1.02, 1.03
G (1)
3-0-9

Analytical and algorithmic approaches to the formulation and solution of transportation network equilibrium assignment problems. Topics: mathematical programming formulation of user and stochastic user equilibrium problems; combined modal split, distribution and assignment formulation; implementation of solution algorithms; applications of discrete choice models.
Y. Sheffi

1.208 Topics in the Analysis of Transportation Systems (A)

Prereq.: CTS 100J or 1.20
G (1)
Arr.

Case studies using Microcomputer Laboratory and special topics.
M. L. Manheim, M. E. Ben-Akiva

1.213 Introduction to Freight Transportation (Revised Unit)

Prereq.: —
U (2)
4-0-8

See description under subject 1.286.
G. A. Kocur, Y. Sheffi

1.214 Public Transportation

Prereq.: 1.20
U (1)
4-0-8

See description under subject 1.258.
N. H. M. Wilson

1.218 Case Study in Transportation Planning

Prereq.: 1.20
U (2) **Next offered 1984-85**
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, 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. Alternate years.
Staff

1.231J Planning and Design of Airport Systems (A)

(Same subject as 16.781J)
Prereq.: Permission of Instructor
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. Demand prediction, determination of the capacity of the airfield, estimation of levels of congestion. 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 international practice and developments.
R. de Neufville, A. R. Odoni

1.251 Transportation Institutional Analysis and Policy (A)

Prereq.: Permission of Instructor
G (1)
3-0-6

Introduces policy and institutional analysis in the transportation sector. Principal policy-making actors and interest groups at national, state, and local levels. Emphasizes 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. Compares strategic planning in the private sector and policy analysis in the public sector.
M. L. Manheim

1.252J Urban Transportation Planning (A)

(Same subject as 11.380J)
Prereq.: Permission of Instructor
G (2)
3-0-6

Development of urban transportation planning over the past two decades. 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. Discusses in detail the methodological change that has accompanied the evolution in transportation planning. Also presents promising theories for understanding institutional relations and change.
R. A. Gakenheimer

1.253 Regional Transportation Program Development and Management (A)

Prereq.: 1.201J or CTS 100J
G (1)
3-0-6

Provides an understanding of the technical and financial management issues to be faced by regional and state transportation program managers in the 1980s. All modes of transportation covered; focus on state, regional, and local issues with consideration of federal influences. Technical issues include analysis of transportation needs, including both engineering and economic analysis.
T. F. Humphrey

1.254J Transportation and Infrastructure in Developing Countries (A) (Revised Content)

(Same subject as 11.384J)
Prereq.: Permission of Instructor
G (1)
3-0-6

See description under subject 11.384J.
M. L. Manheim, R. A. Gakenheimer

1.258 Public Transportation Service and Operations Planning (A)

Prereq.: 1.201J
G (2)
3-0-6

Evolution and role of urban public transportation modes, systems, and services, including bus and rail. Description of technological characteristics and their impacts on capacity, service quality, and cost. Current practice and new methods for performance monitoring, route design, vehicle and crew scheduling. Effect of pricing policy and service quality on ridership. Methods for estimating costs associated with a proposed service change. Permission of instructor. Additional recitation section required for undergraduates to cover selected topics in more detail.
N. H. M. Wilson

1.259 Transit Management (A)

Prereq.: 1.258
G (1)
3-0-6

Management methods of relevance to public transportation systems. Topics: strategic planning management; labor relations; maintenance planning and administration; financial planning; marketing; and management information and decision support systems. Shows how these general management tasks are dealt with in the transit industry and presents alternative strategies. Identifies alternative arrangements for service provision, including different ways of involving the private sector in public transportation. Permission of instructor required.
N. H. M. Wilson

1.261 Transportation Workshop (A)

Prereq.: 1.201J or CTS 100J
G (2)
3-0-6

Integrates 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. Emphasizes 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.
Staff

1.27 Studies in Transportation Engineering (A)

Prereq.: Permission of Instructor
G (1, 2, S)
Arr.

Individual advanced study of a topic in transportation systems selected with the approval of the instructor.
Staff

1.282 Transportation Operations Management (A)

Prereq.: 1.201J or 1.20
G (2)
3-0-6

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
G (1)
3-0-9

See description under subject 11.410J.
W. C. Wheaton

1.284J Topics in Transportation Economics (A)

(Same subject as 14.576J)
Prereq.: 14.03 or 14.04
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

1.286 Freight Transportation Management (A)

Prereq.: 1.201J
G (2)
3-0-6

Analytical methods for freight systems emphasizing applications to shippers, rail and truck carriers. Logistics and inventory theory focusing on choice of carrier, routing, and facility location. Performance and cost models of terminals and line-haul operation for rail and truck. Integration of shipper and carrier perspectives in system models. Reviews regulatory, pricing, labor, and other issues facing the industry. Additional recitation section required for undergraduates to cover selected topics in more detail.
G. A. Kocur, Y. Sheffi

1.298 Research in Transportation

Prereq.: —
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.: —
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

Constructed Facilities

Geotechnical Engineering

1.30 Soil Mechanics

Prereq.: 1.04
U (1)
3-1-8

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 equilibrium analysis for soil masses. Methods for estimating soil deformations. Lectures supplemented by a laboratory and interactive computer-aided design projects.
A. S. Azzouz

1.311 Geotechnical Engineering

Prereq.: 1.30
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
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.: —
U (1) SD
3-3-6

Basic principles of physical geology, emphasizing 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
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
G (2) **Next offered 1984-85**
3-0-6

Applies theory of wave propagation and dynamics of lumped systems to problems in soil dynamics. Stress-strain behavior during transient and repeated loadings; relation to wave velocity. Analysis of machine foundations; effect of soils upon seismic motions; earth dams and retaining walls during earthquakes; soil-structure interaction; other selected applications.
R. V. Whitman

1.34 Reliability in Geotechnical Engineering (A)

Prereq.: 1.151, 1.30
G (2)
Arr.

Case studies dealing with quantitative treatment of uncertainty in soil properties and the performance of geotechnical facilities. Probabilistic description of loadings and environmental conditions affecting soil behavior. Reliability of predictions of deformation, stability, and flow. Treatment of risk and uncertainty in decision situations involving soil exploration, design, and performance monitoring. Applications to earth structures, foundations, dams, and underground construction.
D. Veneziano, G. B. Baecher

1.351 Theoretical Soil Mechanics (A)

Prereq.: 1.30
G (1)
3-0-6

Discusses 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
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
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.
G. B. Baecher

1.364 Foundation Engineering (A)

Prereq.: 1.361
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
G (1)
3-0-6

Identification, presentation and illustration of principles of soil mechanics. Considers the following topics: the nature of soil; the effective stress principle; permeability and seepage; stress-strain-strength behavior of soil; lateral earth stresses. Applies principles to stability and deformation problems. Restricted to graduate students not specializing in Geotechnical Engineering. Same lectures as for 1.361.
C. C. Ladd

1.368 Computer-aided Analysis in Geotechnical Engineering (A)

Prereq.: 1.351
G (2)
3-0-6

Use of computers in the analysis of geotechnical problems: steady and transient flow in porous media, stability of embankments and slopes, retaining structures, pile driving, excavations and tunneling. For each area, the necessary theoretical background reviewed and discrete modeling methods as implemented in computer programs discussed and applied to selected problems. Extensive use of digital computers. Working knowledge of FORTRAN expected.
A. S. Azzouz

1.37 Geotechnical Measurements and Exploration (A)

Prereq.: 1.30
G (1)
2-4-3

Students perform a variety of laboratory experiments illustrating fundamental aspects of soil behavior including classification, index, and engineering properties. Emphasizes measurement of load-deformation characteristics under several different boundary conditions. Exposure to special devices, geotechnical exploration, field investigation, and *in situ* testing. Experiments involve data reduction, evaluation, and presentation of results in report form.
J. T. Germaine

1.38 Engineering Geology (A)

Prereq.: 1.30, 1.32
G (2) **Next offered 1984-85**
3-0-6

Effect of geologic features on constructed facilities. Geologic aspects of subsurface exploration. Interaction between man-made structures and the geologic environment. Emphasizes sediment engineering geology with an overview of hard-rock engineering geology. Alternate years.
H. H. Einstein

1.381 Rock Mechanics I (A)

Prereq.: 1.30, 1.32; or 12.01
G (2) **Not offered 1984-85**
3-0-6

Introduces 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.
H. H. Einstein

1.382 Rock Mechanics II (A)

Prereq.: 1.381
G (2) **Not offered 1984-85**
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.
H. H. Einstein

1.383 Underground Construction (A)

Prereq.: 1.361, 1.381
G (1) **Next offered 1984-85**
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.
H. H. Einstein

1.384J Introduction to Mining and Mineral Technology

(Same subject as 2.742J, 3.095J, 12.043J)
Prereq.: —
U (1)
3-0-6

See description under subject 3.095J.
H. H. Einstein, R. G. Burns, J. F. Elliott, C. R. Peterson

1.39 Studies in Geotechnical Engineering (A)

Prereq.: Permission of Instructor
G (1, 2, S)
Arr.

For graduate students desiring further individual study of special topics.
Staff

Construction Engineering and Management

1.40 Project Management

Prereq.: 1.30, 1.50
U (2)
3-2-7

Overview of construction industry, its organizations and interactions. Project and construction management methodologies presented for project and company planning, control. and decision making. Includes scheduling, accounting, estimating, resource planning, organization structuring used throughout all project phases.
R. D. Logcher

1.411J Building Construction I

(Same subject as 4.402J)
Prereq.: —
U (1)
3-3-6

See description under subject 4.402J.
E. Dluhosch

1.412J Building Construction II (Revised Content and Unit)

(Same subject as 4.403J)
Prereq.: 1.02, 1.04; or 4.402J, 4.30 or 4.331
U (2)
2-4-3

See description under subject 4.403J.
E. Dluhosch

1.413 Construction Technology and the Building Development Process (A)

Prereq.: Permission of Instructor
G (1)
3-0-6

Investigates the nature of the building design and construction process with respect to the contractual, managerial, and financial implications of alternative technologies and construction methods. Particular attention to interfaces between various subsystems (e.g., structure, cladding, mechanical) and between design and construction activities. Uses cost estimating and scheduling as techniques to support analysis of alternatives.
H. G. Irwig, J. M. Becker

1.421 Learning From Construction Failures (A)

Prereq.: Permission of Instructor
G (2)
3-0-6

Uses case studies of failures to demonstrate the individual, group, enterprise, and institutional decision-making processes involved in the regulation and development of constructed facilities. Examines nature of these processes; identifies typical pathologies and their effect on the technical characteristics and ultimate performance of these facilities.
H. G. Irwig, J. M. Becker

1.431 Structuring Construction Industry Organizations (A)

Prereq.: Permission of Instructor
G (1)
3-0-6

Examination, from a socio-technical perspective, of the organizations and organizational processes underlying the operation of the construction industry. Studies the structure and functioning of firms, sub-units of firms, and conglomerations of firms with regard to the influence of a wide range of factors including strategy, human and other resources, and role in the project development process. Frameworks for observation, description, analysis, and design of both individual enterprises and project organizations presented and applied to real-world situations.
H. G. Irwig

1.432 Project Control (A)

Prereq.: *1.431*
G (1)
3-0-6

Computer techniques and systems for control of design and construction projects. Relationship of project breakdown to estimating, budgeting, and financial control. Use of network-based systems for planning and time control of projects, including CPM and PERT and resource-constrained scheduling. Database design concepts for decision support systems. Integrating control of costs and time, with cash flow and manpower projections, with comparison of potential to current practice. Requires background in accounting principles.
R. D. Logcher

1.44 Analysis Methods in Construction Engineering and Management (A) (New)

Prereq.: 1.151
G (2)
Arr.

A series of mini-subjects involving the use of analytic methods in construction engineering and management. Topics: decision analysis, simulation, queueing and optimization applications in such problems as bidding, infrastructure analysis, maintenance, comparison of alternatives, risk analysis and sharing, equipment selection. Offers a special three-unit section of private sector evaluation, supplementing public sector methods taught in 1.148J.
D. H. Marks, E. Vanmarcke, R. D. Logcher

1.481 Research Seminar in Construction Engineering and Management (A) (New)

Prereq.: Permission of Instructor
G (2)
2-0-1

Seminar intended mainly for master's and doctoral candidates in the Center for Construction Research and Education. Oral and written presentation by students on thesis activities and by faculty on research topics.
D. H. Marks, R. D. Logcher, H. Irwig

1.482 Studies in Construction Engineering and Management (A)

Prereq.: Permission of Instructor
G (1, 2, S)
Arr.

Individual study of an advanced topic in construction engineering and management selected with approval of faculty supervisor.
Staff

Management of Technology

1.485J Current Issues in Engineering

(Same subject as 3.562J, 6.941J, 13.682J, 22.87J)
Prereq.: —
G (2)
3-0-6

Reviews a selection of technological developments of great significance to industrialized societies, choosing from current areas such as conventional and new energy technology, electronics and information systems, materials and genetic engineering. Key features of the technologies and their relationships to social, economic, and managerial issues that their development implies.
T. H. Lee

1.486J Cases and Projects in Engineering Management (A)

(Same subject as 3.563J, 6.942J, 13.683J, 22.88J)
Prereq.: 1.485J
G (1)
3-1-5

Case studies of real engineering and scientific issues in industrial firms and government agencies. Cases chosen from new ventures as well as mature firms, to illustrate different aspects of engineering management: strategic planning, product strategy, project management, technology assessment, value engineering, technology transfer, and R&D program planning. Knowledge in probability and regression analysis required.
T. H. Lee

1.487J Technology Planning (A)

(Same subject as 3.564J, 13.684J)
Prereq.: Permission of Instructor
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 Design and Analysis

1.50 Introduction to Structural Engineering

Prereq.: 1.04
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. H. Slater

1.51 Structural Mechanics

Prereq.: 1.04
U (1)
4-1-7

In-depth treatment of the mechanics of elastic solids. Elastic stress analysis in torsion, plane stress and plane strain, and stress concentrations. 2-D problems in rectangular and polar coordinates. Stress functions, fracture problems. Energy methods, including elastic reciprocity and principle of virtual work. Introductory treatment of plates and shells. Lab work assigned to compliment analysis. Subject serves as an instrument in understanding the physics of mechanical behavior in structures.
V. C. Li

1.52 Structural Analysis and Design

Prereq.: 1.50, 1.51
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

1.541 Behavior of Concrete Structures (A)

Prereq.: 1.52
G (1)
3-0-6

Strength and deformation of concrete under various states of stress; failure criteria. Fundamental behavior of reinforced concrete structures and their members. Basis for design, and code constraints. Bond and cracking, deflections. Slabs, yield line theory. Cylindrical concrete shells. Behavior models and nonlinear analysis. Complex systems: offshore gravity and containment structures.
O. Buyukozturk

1.542 Behavior of Steel Structures (A)

Prereq.: 1.51
G (2)
3-0-6

Mechanical properties of steel. Yield criteria. Ductility. Fatigue failure. Stability considerations in member design. Structural connections. Stress concentrations. Residual stresses. Inelastic analysis procedures. Limit states. Applications in framed structures, bridges, and shells.
J. H. Slater

1.543 Bridge Design (A)

Prereq.: 1.541, *1.542*
G (2)
2-0-4

Planning, design, and construction of bridges. Discusses bridge types and factors affecting the selection of type: concrete vs steel, prestressed, composite, segmental concrete bridges. Design issues and techniques. Detailed case study of a particular bridge. Recent technological developments in bridge engineering.
O. Buyukozturk

1.544 Structural Design of Buildings (A)

Prereq.: 1.541, *1.542*
G (2)
2-0-4

Structural systems for buildings. Special considerations in the design of high-rise buildings. Loads in buildings. Wind and earthquake effects. Comparisons of steel and concrete systems. Approximate methods for preliminary design. Case studies.
Staff

1.551J Analysis and Design of Offshore Structures (A) (Revised Content and Unit)

(Same subject as 13.112J)
Prereq.: 1.51 or 13.10J
G (2)
4-0-8

Fundamental concepts in analysis and design of fixed offshore platforms. Design philosophies and criteria. Specification of environmental design criteria and computation of design loads; in-depth treatment of wave theories, wave statistics and hydrodynamic loads. Construction materials and their behavior in the marine environment. Preliminary and detailed structural and foundation design procedures. Deterministic and stochastic dynamic analysis. Design for fatigue and seismic effects. Reliability analysis procedures.
S. Shyam Sunder, J. K. Vandiver

1.552J Dynamics of Ocean Structures (A) (Revised Content)

(Same subject as 13.88J)
Prereq.: 1.572 or 13.80J or 2.06J
G (2)
3-0-9

See description under 13.88J.
J. K. Vandiver, S. Shyam Sunder

1.56J Structural Mechanics in Nuclear Power Technology (A)

(Same subject as 2.084J, 3.82J, 13.14J, 16.261J, 22.314J)
Prereq.: Permission of Instructor
G (1)
3-0-9

See description under subject 22.314J.
O. Buyukozturk, J. E. Meyer

1.571 Advanced Structural Analysis (A)

Prereq.: *1.121*, 1.51
G (1)
3-0-6

Matrix methods for the analysis of discrete structural systems such as trusses and frames considering geometric, kinematic, and material nonlinearity. Numerical methods for the solution of nonlinear problems and the calculation of critical loads. Linear engineering beam theory and second-order nonlinear beam theory, Euler buckling. Curved members, arches.
E. A. M. Kausel

1.572 Structural Dynamics (A)

Prereq.: 1.121, 1.51
G (2)
3-0-6

Analyzes 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

1.581 Structural Reliability (A)

Prereq.: 1.151
G (2)
3-0-6

Analysis and design specification of structural performance and safety through probability theory. Description of common structural loads (seismic, wind, tornado, snow, occupancy, vehicles). Procedures for data analysis and probabilistic modeling. Variability of material properties. Structural system reliability, statics, and dynamics. Bases for modern structural code specifications and for design procedures used in more advanced practice. Optimum design accounting for uncertainty and failure consequences.
D. Veneziano

1.587 Safety of Structures and Foundations Under Dynamic Loads (A)

Prereq.: 1.572 or 1.331, 1.03
G (2)
3-0-6

Evaluates safety of structures and soil-structure systems under earthquake, wave, and wind loads. Description of forcing functions as random processes in time and space. Linear and nonlinear system probabilistic response analysis. Extremes and cumulative performance measures. Uncertainty in dynamic properties and component resistance. Integrated risk assessment. Concepts of design to resist uncertain dynamic loads.
E. Vanmarcke

1.588 Structural Engineering Research Seminar (A) (New)

Prereq.: Permission of Instructor
G (2)
1-0-2

For structural engineering students registered for thesis or seeking research topics. Presentation of ongoing or proposed research by students. Occasional seminars by faculty or outside speakers. Participants required to submit written critique on each lecture.
E. Vanmarcke

1.589 Studies in Structural Design and Analysis (A)

Prereq.: Permission of Instructor
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

Construction Materials

1.59J Materials of Construction

(Same subject as 3.143J)
Prereq.: 8.01
U (2) SD
3-0-9

Mechanical behavior of construction materials. Topics: micromechanics of materials; concepts of stress and strain; constitutive equations; elasticity, plasticity, viscoelasticity, and fracture mechanics. Applies principles to structural metals, Portland cement concrete, wood, ceramics, polymers, and composite materials.
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
G (1)
3-0-6

See description under subject 3.90J.
F. J. McGarry, K. Masubuchi

1.592 Mechanical Behavior of Construction Materials (A)

Prereq.: 1.59J
G (1)
3-0-6

Studies mechanical behavior of concrete, and structural steel, emphasizing 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.
Staff

1.593J Mechanical Behavior of Plastics (A)

(Same subject as 3.91J)
Prereq.: 1.59J
G (1)
3-2-4

See description under subject 3.91J.
F. J. McGarry, D. K. Roylance

1.594J Composite Materials (A)

(Same subject as 3.92J)
Prereq.: 1.59J
G (2)
3-2-4

See description under subject 3.92J.
F. J. McGarry

1.597 Studies in Construction Materials (A)

Prereq.: Permission of Instructor
G (1, 2, S)
Arr.

Advanced topics in construction materials selected by students for individual study with staff approval.
Staff

1.598 Research in Constructed Facilities

Prereq.: —
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.: —
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

Hydrodynamics and Coastal Engineering

1.60 Fluid Dynamics

Prereq.: 1.05, 18.03
U (1)
4-0-8

Continuation of 1.05. Dynamic similitude, theory of models and data presentation. Boundary layers flow in conduits and open channels. Dynamic drag and lift forces on immersed objects. Hydraulic machinery. Turbulent diffusion and mass transport. Transient phenomena such as water hammer and simple harmonic surface waves. Lectures coordinated with 1.106 and supplemented by problem sessions.
P. S. Eagleson

1.62 Free Surface Hydraulics

Prereq.: 1.60
U (2)
3-1-8

Derivation of the one-dimensional form of the continuity, momentum, and energy equations. Boundary resistance. Steady uniform and nonuniform flow in open channels, including lateral in-outflow. Significance of the Froude Number; sub- and supercritical flow and channel transitions. Applications of momentum and energy principles. Flow controls: weirs, sluice gates, spillways, stilling basins. Unsteady flows: elements of floodrouting, overland flow, and oscillatory waves. Class project.
O. S. Madsen

1.63 Principles of Hydrodynamics (A)

Prereq.: 1.60
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).
W. K. Melville

1.64 Dynamics of Stratified Fluids (A)

Prereq.: 1.63
G (2)
3-0-6

Advanced treatment of stratified-fluid dynamics, emphasizing the basic phenomena that influence environmental flows. Linear and nonlinear internal waves in multiple layer and continuously stratified fluids. Thermal and double-diffusive convection, dynamics of intrusions and selective withdrawal. Boundary layers, stability and onset of turbulence. Introduction to turbulence modeling and the 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
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
G (2) **Not offered 1984-85**
3-0-6

Emphasizes the quantitative description of the mechanics of sediment transport in steady and unsteady flows based on hydrodynamic principles. Equations of motion for particles in a turbulent flow, entrainment, bedload, and suspended load. Bedform mechanics, ripples, dunes. Flow resistance and boundary layer mechanics. Wave-induced longshore currents, longshore and on-offshore sediment transport. Coastal protection. Basic theory of water waves assumed known; contact instructor in early January.
O. S. Madsen

1.68 Physics of Natural Water Bodies (A)

Prereq.: 1.63
G (1) **Next offered 1984-85**
3-0-6

Treats the principal physical processes in natural water bodies. Emphasizes the molecular and turbulent vertical transport of mass, momentum, heat, and mechanical energy. Includes: physical properties of air and water; governing conservation equations in exact and approximate form; meteorological forcing; fluxes across the water surface; mixed layer dynamics and stratification; bottom boundary conditions; hydrologic, tidal, wind, and density driven circulations; linkages between physical, chemical, and biological processes.
K. D. Stolzenbach

1.69 Introduction to Coastal Engineering (A)

Prereq.: 1.60
G (1)
3-0-6

Basic hydrodynamics of waves in deep and shallow water. Linear theory, dispersion, superposition, spectral representation. Energy, energy transport, dissipation by bottom friction. Refraction, diffraction by breakwaters. Some nonlinear aspects, cnoidal waves, wave breaking. Emphasizes physical interpretation of mathematical results and their engineering application. Storm surges, forecasting of wind wave characteristics. Wave structure interaction: forces on piles; breakwater stability.
O. S. Madsen

1.691 Wave Dynamics in Coastal Engineering (A)

Prereq.: 1.69, 18.075, 18.076
G (2) **Next offered 1984-85**
3-0-6

Problems in water waves and currents of interest to coastal engineers. Emphasizes mechanical principles and theoretical methods of analysis. Topics chosen from the following areas: Ray theory of refraction, scattering of shallow water waves, linearized theory of harbor oscillations. Diffraction by a breakwater. Effect of entrance losses. Mass transport due to viscosity. Radiation stresses and near-shore currents. Nonlinear waves in shallow water. Solitons and harmonic generation. Nonlinear resonances on a beach or in a bay. Alternate years.
C. C. Mei

1.692 Wave Dynamics in Oceanographic Engineering (A)

Prereq.: 1.69, 18.075, 18.076
G (2) **Not offered 1984-85**
3-0-6

Problems in waves and currents of interest to oceanographic engineers. Transient aspects of dispersion and tsunamis. General theory of floating bodies, linearized radiation and diffraction, analytical and numerical aspects. Power absorption from sea waves. Short and long waves over uneven bottom. Nonlinear short waves: slow modulation and instability of Stokes waves by slender or blunt cylinders. Effects of currents or topography on wave evolution. Wave effects on a porous elastic sea bed. Alternate years.
C. C. Mei

1.697J Oceanographic Systems I

(Same subject as 13.990J)
Prereq.: —
G (S)
2-4-6

See description under subject 13.990J.
(Woods Hole Staff)

1.698J Oceanographic Systems II

(Same subject as 13.991J)
Prereq.: —
G (S)
2-4-6

See description under subject 13.991J.
(Woods Hole Staff)

1.699J Special Projects in Oceanographic Engineering (A)

(Same subject as 13.999J)
Prereq.: Permission of Instructor
G (1, 2, S)
Arr.

See description under subject 13.999J.
(Woods Hole Staff)

Hydrology and Water Resource Systems

1.70 Analysis Methods in Water Resources and Environmental Engineering

Prereq.: 1.60
U (2)
3-3-6

Uses analytical tools (e.g., computer models) in the design and evaluation of water resources projects such as flood control, river basin development and water quality. Lectures discuss governing principles, common models, and typical applications. In case studies students select/develop models, run simulations and interpret results in written and oral reports. For advanced undergraduates or graduate students wishing exposure to broad applications. Some programming experience assumed.
E. E. Adams

1.71 Introduction to Hydrology

Prereq.: 1.05
U (1)
3-1-8

Principles of meteorology and climate; earth water and energy balance; radiation; precipitation formation; evaporation; infiltration; runoff process. Streamflow analysis. Flood routing and rainfall-runoff models. Groundwater, well hydrology. Introduction to hydrologic probabilistic models. Deterministic, numerical, models in hydrology. Data analysis, design of collection systems. Useful for graduate students with no hydrology background.
R. L. Bras

1.711 Hydro-climatology (A)

Prereq.: 1.03, 1.60
G (2) **Not offered 1984-85**
3-0-6

Dynamics and derived statistics of the principal processes of interest in the coupled balances of water and heat at a landsurface. Philosophy and techniques of hydrologic modeling. Structure of the hydro-thermal coupling in hydrology. Modeling the one-dimensional annual water and heat balances. Emphasizes the dynamic interaction of climate, soil, and vegetation. Hydrothermal climate classification.
P. S. Eagleson

1.712 Sampling, Synthesis, and Forecasting of Hydrologic Processes (A)

Prereq.: 18.444
G (2)
3-0-6

The sampling, synthesis, and forecasting of signals in geophysics. Emphasizes hydrologic systems. Study of time series. Correlation and spectral analysis of periodic and aperiodic signals. Time and frequency domain analysis of random processes and fields. Stochastic simulation of rainfall and runoff. Estimation of static and dynamic systems. Kriging and Kalman filtering techniques. Applications in geology, oceanography, mining.
R. L. Bras

1.72 Groundwater Hydrology (A)

Prereq.: 1.60
G (1)
3-0-6

Introduces subsurface flow theory and applications; storage properties, Darcy equation, flow nets, mass conservation, the aquifer flow equation, heterogeneity and anisotropy, regional vertical circulation, unsaturated flow, and recharge. Well hydraulics, stream-aquifer interaction, distributed- and lumped-parameter numerical models. Groundwater quality, mixing cell models, contaminent transport processes, dispersion, decay and adsorption; pollution sources. Includes laboratory and computer demonstrations.
L. W. Gelhar

1.721 Advanced Subsurface Hydrology (A)

Prereq.: 1.72, 18.075
G (2)
3-0-6

Advanced treatment of flow in natural porous media with applications to resource development and environmental protection. Fluid transport processes in deformable media, boundary conditions, and problem formulation. Stochastic treatment of temporal and spatial variability. Contaminant transport, macrodispersion, tracer tests, salt water intrusion, heat transport, unsaturated flow and solute transport, flow and transport in fractured rocks. Numerical simulation techniques, parameter estimation, and predictive capabilities of models. Permission of instructor required.
L. W. Gelhar

1.723 Subsurface Water Quality (A)

Prereq.: 1.77
G (2)
3-0-6

Examines subsurface water quality problems from chemical and physical viewpoints. Physical transport of quality constituents, adsorption chemistry, microbiological transformations, and the mixing introduced by molecular diffusion, mechanical dispersion, and formation dispersion. Development of a mass transport equation, and analytical and numerical solutions. Case studies of quality problems including hazardous waste disposal.
H. F. Hemond, P. M. Gschwend

1.731 Water Resources Systems I (A)

Prereq.: Permission of Instructor
G (1)
3-0-6

Systematic approach to the analysis and management of large-scale water resource systems. This term deals with largely deterministic model formulation, optimization and multiobjective evaluation methods applied to such problems as water quality management, urban water supply, river basin planning for multi-purposes (irrigation, hydropower, low-flow augmentation, municipal and industrial water supply, recreation, environmental enhancement). Assumes some knowledge of economics, probability, and optimization methods.
D. H. Marks

1.732 Water Resources Systems II (A)

Prereq.: 1.731, 18.444
G (2) **Next offered 1984-85**
3-0-6

Analyzes nonlinear and stochastic systems. Derived distributions for probabilistic models specification. Decision analysis, risk. Joint use of simulation and optimization for water systems study and management. Forecasting and real-time control in water resources systems. Dynamic Programming. Case studies: reservoir operation, management and planning of irrigated agriculture, water distribution, water quality management.
R. L. Bras

Water Quality Control and Environmental Management

1.75 Limnology and Wetland Ecology (A)

Prereq.: Permission of Instructor
G (1)
3-0-6

Dominant physical, chemical, and biological features of lakes and wetlands: basin geology, water budget, wind-driven hydromechanical phenomena, heat balance, thermal stratification, radiation environment, biological communities, and cycles of major elements. Characterization of wetlands, wetland biota, and chemical conditions of wetlands. 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
G (1)
3-0-6

Quantitative treatment of variables that govern chemical behavior of aquatic systems such as lakes, oceans, rivers, estuaries, groundwaters, and wastewaters. Topics: thermodynamics, acids and bases, dissolved carbon dioxide, interactions between solid phases and solutes, coordination, and redox. Emphasis on quantitative study of 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
G (1)
3-0-6

Emphasizes mathematical models for predicting distribution and fate of effluents discharged into lakes, reservoirs, rivers, estuaries, and oceans; and on formulation and structure of models rather than on solution techniques. Role of element cycles, such as oxygen, nitrogen and phosphorus, as water quality indicators. Offshore outfalls and diffusion. 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
G (2)
3-0-6

Systematically approaches management of water quality emphasizing role of physical and decision models on policy formation. Implications of control alternatives, institutional arrangements, regional management, standard setting, legal and regulatory process for point source (municipal and industrial) and nonpoint source (land use related) quality problems. Special topics include user/effluent charges and water demand/conservation. Assumes some knowledge of economics, statistics and probability, and optimization methods.
D. H. Marks

1.79 Plankton Ecology (A)

Prereq.: —
G (2)
3-0-6

Basic graduate subject dealing with selected aspects of the ecology of marine and freshwater systems. Emphasizes physiological processes of planktonic organisms. Topics: 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.: —
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.
S. W. Chisholm

1.811J Environmental Law: Pollution Control (A)

(Same subject as TPP 33J)
Prereq.: Permission of Instructor
G (1)
3-0-6

Reviews and analyzes common law, legislation, and regulation of air and water pollution and hazardous wastes. Emphasizes use of legal mechanisms and alternative approaches for controlling environmental pollution. Economic consequences of pollution control discussed. The Clean Air Act, Clean Water Act, Resource Conservation and Recovery Act, and National Environmental Policy Act analyzed regarding the goals of pollution control, economic consequences, and role of the courts. Discusses both classical pollutants and highly toxic industrial chemicals.
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
G (2)
3-0-6

Topics related to environmental, health, and safety regulation are selected from the following: risk assessment techniques, Toxic Substances Control Act, occupational safety and health, noise, pesticides, food additives, pharmaceuticals, radiation, 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, D. B. Hattis, G. R. Heaton, Jr.

1.82 Problems in Aquatic Biology and Chemistry (A)

Prereq.: Permission of Instructor
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.
S. W. Chisholm, F. M. M. Morel

1.83 Organic Compounds in Aquatic Environments (A)

Prereq.: 5.41
G (1)
3-0-6

After an introduction to the cycling of natural organic matter in aquatic environments discussions focus on the sources and fates of anthropogenic organic compounds. Uses physical chemical properties to predict chemical transfers between environmental compartments (air, water sediments, biota). Uses empirical approaches to estimate chemical and biochemical transformations. Ultimately develops models to assess the environmental concentrations (and related biological exposures) of hazardous organic compounds introduced into water resources. Permission of instructor required.
P. M. Gschwend

1.85 Introduction to Wastewater Treatment Engineering

Prereq.: 1.60 or 1.80
U (2)
2-0-4

Basic theory of mixing and transport in reactor vessels. Microbiology of water and wastewater treatment, biochemical processes related to the carbon, oxygen, nitrogen, and phosphorus cycles. Waste treatment by suspended culture processes and oxidation ponds. Theory and design of sedimentation tanks. It is recommended that students register for both 1.85 and 1.86. Taught first seven weeks of term.
D. R. F. Harleman

1.86 Element Cycles in the Environment

Prereq.: Permission of Instructor
U (2) SD
2-0-4

Cycles of major elements such as water, oxygen, nitrogen, carbon, and phosphorus 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 human interaction with the environment as it affects distribution and processing of elements. It is recommended that students register for both 1.85 and 1.86. Taught last seven weeks of term.
F. M. M. Morel

1.898 Research in Water Resources and the Water Environment

Prereq.: —
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.: —
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

Special Studies

1.91 Civil Engineering Internship

Prereq.: —
U (1, 2, S)
0-6-0

1.92 Advanced Civil Engineering Internship

Prereq.: 1.91
G (1, 2, S)
0-6-0

1.91 provides credit for the first two work assignments of Course I students affiliated with the Engineering Internship Program. 1.92 provides credit for the third and fourth work assignments for students affiliated with the Engineering Internship Program. Students register for both 1.91 and 1.92 twice and must complete both work assignments in order to receive academic credit for the subjects. Enrollment limited to students registered in the Course I Internship Option.
H. G. Irwig

1.961-1.965 Special Graduate Studies in Civil Engineering (A)

Prereq.: Permission of Instructor
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
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 16.783J, TPP 13J)
Prereq.: Thesis Registration
G (1, 2)
2-0-1

See description under subject TPP 13J.
R. de Neufville, A. R. Odoni

1.991, 1.992 Special Undergraduate Studies in Civil Engineering

Prereq.: Permission of Instructor
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.: —
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.: —
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
U (1, 2) SD
4-0-8

Introduces 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. Emphasizes computer methods and matrix structural analysis.
N. H. Cook

2.015 Mechanics of Solids

Prereq.: —
G (S)
2-0-4

Review of mechanics of solids primarily for incoming graduate students; a shortened version of 2.01. No graduate credit allowed for students in Course II.
F. A. McClintock

2.02 Introduction to Systems Dynamics

Prereq.: 8.01, 18.02
U (1, 2) SD
4-0-8

Dynamic modeling by linear and nonlinear lumped multiport elements of physical systems. 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. System functions, pole-zero configurations and their interpretation. Generalized impedance and source equivalents. Extensive use of engineering examples.
J. E. Hubbard, Jr.

2.023 Dynamic Systems

Prereq.: —
G (S)
3-0-6

Review of system dynamics primarily for incoming graduate students; a shortened version of 2.02. No graduate credit allowed for students in Course II.
D. N. Wormley

2.03J Dynamics

(Same subject as 13.003J)
Prereq.: *2.01* or *13.002*, 2.02 or 13.001, 18.03
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 Lagrange'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, J. K. Vandiver

2.032 Dynamics (A)

Prereq.: 2.03J
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 Probabilistic Modeling and Analysis of Engineering Systems (A) (Revised Content and Unit)

Prereq.: 18.075
G(2)
3-0-9

Fundamentals of probability and statistics for mechanical engineering applications. Presents material as a modeling tool. Discrete and continuous random variables, common distributions, integral transforms; multivariate distributions and geometric interpretation; parameter estimation, confidence intervals and sampling distributions; random processes, Markov property, autocorrelation and spectral density. Emphasizes analysis and solution of real mechanical engineering problems.
N. J. Hogan

2.05 Kinematics and Dynamics of Mechanisms and Manipulators (A) (New)

Prereq.: 2.03J
G (1)
3-0-9

Analyzes kinematic and dynamic characteristics of planar and spatial mechanisms, including machines and robotics manipulators. Use of vector, complex variable and 4 by 4 matrices methods for kinematic analysis. Systems including flexible and rigid elements and active control systems. A brief introduction to kinematic synthesis methods and use of digital simulations for dynamics. Applications from industrial machine systems and robotic manipulators.
S. Dubowsky

2.06J Mechanical Vibration

(Same subject as 13.80J)
Prereq.: 2.03J or 13.003J
G (1)
3-0-9

See description under subject 13.80J.
R. H. Lyon, 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
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 scatterings. Acoustic, thermal, and vorticity fluctuations as first order perturbation of equations of fluid dynamics; energy density and in-

tensity. Multipole expansions of source fields, spherical harmonics, radiation impedance and directivity. Scattering and diffraction of sound by obstacles. Natural modes 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
G (2) **Next offered 1984-85**
3-0-9

Description of stochastic processes. Impulse response and frequency response of linear time-invariant dynamic systems. Correlations and spectra of stationary response. Crossing rates, peaks, and envelopes. Failure under random loading. Poisson pulse processes. Measurement, identification, and response problems. Coherence. Space-time correlations and cross-spectra. Digital data processing. Applications to vehicles and structures subjected to wide-band random excitation. Alternate years.
S. H. Crandall

2.062 Wave Propagation (A)

Prereq.: 2.03J, 18.075
G (1) **Not offered 1984-85**
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.
S. H. Crandall, T. R. Akylas

2.063J Sound and Structural Vibration (A)

(Same subject as 13.82J)
Prereq.: 2.03J or 16.004, 13.004, or 18.075
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.: 2.20, 16.02 or 13.021
G (1) **Not offered 1984-85**
3-0-9

See description under subject 13.84J.
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
U (1)
3-0-9

See description under subject 13.10J.
J. H. Williams, Jr., P. C. Xirouchakis

2.072 Mechanics of Continuous Media (A)

Prereq.: Permission of Instructor
G (2) **Next offered 1984-85**
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 tensor notation. Stress and strain measures and constitutive equations. Solution of many basic problems for various materials as relevant in metallurgy, materials processing, geomechanics and fluid dynamics, fracture mechanics and structural analysis. Analytical and numerical solution methodology for differential and integral equations.
M. P. Cleary

2.073 Solid Mechanics — Plasticity and Inelastic Deformation (A)

Prereq.: 2.01, 2.31, 2.32
G (1) **Next offered 1984-85**
3-0-9

Focuses on analysis of inelastic deformations of solids emphasizing behavior of polycrystalline metals. Develops continuum constitutive models including consideration of physical bases of deformation. Limit analysis of continua, structures, and polycrystalline aggregates. Variation formulations of governing equations including finite element implementation. See also 13.131 and 16.24. Alternate years.
D. M. Parks

2.074 Applications of Mechanics for Porous/Geological Materials (A)

Prereq.: Permission of Instructor
G (1)
3-0-9

Extension of continuum mechanics to fluid-infiltrated porous media: coupled heat/fluid flow and solid deformation/frictional yielding/fracture. Constitutive relations, micromodeling localization instabilities and structural analysis. Laboratory simulation. Examples from energy and materials resources, prospecting and extraction: machine excavation, oil/gas drilling/fracturing, solution mining, geothermal; from geophysics: wave propagation, earth-fault mechanisms, igneous intrusions; and from biomechanical load-bearing elements.
M. P. Cleary

2.083 Applied Elasticity (A)

Prereq.: 2.01, *18.075*
G (2)
3-0-9

Introduces basic concepts and special methods in linear elasticity. Reviews 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. Introduces plate theory.
J. H. Williams, Jr., L. L. Bucciarelli, Jr.

2.084J Structural Mechanics in Nuclear Power Technology (A)

(Same subject as 1.56J, 3.82J, 13.14J, 16.261J, 22.314J)
Prereq.: Permission of Instructor
G (1)
3-0-9

See description under subject 22.314J.
O. Buyukozturk, J. E. Meyer

2.092 Methods of Engineering Analysis (A)

Prereq.: 18.075
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
G (2) **Next offered 1984-85**
3-0-9

Formulation of finite element methods for analysis of dynamic problems in solids, structural, fluid mechanics, and heat transfer. Computer calculation of matrices and numerical solution of equilibrium equations by mode superposition and direct integration. Effective eigensolution techniques for calculation of frequencies and mode shapes. Digital computer coding techniques and use of an existing general purpose finite element analysis program. Modeling of problems and interpretation of numerical results.
K. J. Bathe

2.094 Theory and Practice of Continuum Mechanics (A)

Prereq.: Permission of Instructor
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

System Dynamics and Control

2.10 Elementary Programming and Machine Computation (Revised Unit)

Prereq.: —
U (1, 2)
3-2-4

Introduces students to the use of digital computers in the fields of science and engineering. FORTRAN is taught since it is the most widely used and available scientific programming language. Covers methods of digital computation, algorithm formulation, elementary numerical techniques, graphic display, and character manipulation. Problems include examples from many disciplines. Emphasizes program development on a VAX-11/370 computer. Assumes no prior computing experience.
D. Rowell, D. Ottenheimer

2.101 Computer Models of Engineering Systems

Prereq.: 18.02, 8.01
U (1) SD
3-0-9

School-Wide Elective Subject. Description given at end of this chapter of SWE page.
B. Schumacker

2.14 Control System Principles

Prereq.: 2.02
U (1, 2)
3-2-7

Introduces 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. Rowell, P. K. Houpt

2.141 Modeling and Simulation of Dynamic Systems (A)

Prereq.: 2.151
G (2)
3-0-9

Modeling of complex linear and nonlinear energetic dynamic engineering systems. Emphasizes subdivision into simple multiport elements and representation by bond graph language. Distributed systems. Field lumping. Analytical and graphical reductions. Efficient digital simulation using the Department computing facilities. Examples including mechanisms, electromechanical transducers, electronic and fluid systems, thermal systems, chemical and biochemical processes.
H. M. Paynter

2.151 Advanced System Dynamics and Control (A)

Prereq.: 2.02
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.
N. J. Hogan, D. Rowell

2.152 Modern Control Theory and Applications (A)

Prereq.: 2.151 or 6.231 or 16.31
G (2)
3-0-9

Applies linear-quadratic-Gaussian (L-Q-G) method to design multiple input-multiple output control systems. Response of linear dynamic systems to Gaussian inputs; includes propagation of mean and covariance and frequency domain description of stationary processes. Classical control methods includes random disturbances. Deterministic linear-quadratic design including optimal integrators, full and reduced order observers, and numerical methods. Kalman filtering and stochastic optimal control. Emphasizes 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
G (1)
3-0-9

Fundamental properties of nonlinear systems: multiple equilibrium points, limit cycles and jump resonance. Phase plane analysis of second order systems. Analyzes system stability using Lyapunov methods. Time scaling and transformation methods. Frequency domain stability criteria. Sinusoidal describing function methods for limit cycle and forced response prediction. Design of control systems using Popov and describing function methods. Applies 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
G (1) **Next offered 1984-85**
3-0-9

Unified study of dynamic behavior and control of systems of interconnected rotating machines used for power and propulsion and for instrumentation and control. Treatment 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), together with their energy sources, power modulators, and control equipment. Case studies of a number of particular machine systems.
H. M. Paynter

2.155 Dynamics and Control of Thermofluid Processes and Systems (A)

Prereq.: Permission of Instructor
G (1) **Next offered 1984-85**
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 including heat pumps, steam generators, power plants, and distillation columns. Reviews fundamental physical principles emphasizing mass, momentum, and energy balances. Treats system components, as well as complete systems. Case studies of actual plants and processes.
H. M. Paynter

2.157 Computer-Aided Design (A)

Prereq.: Permission of Instructor
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. Reviews and discusses state-of-the-art CAD systems. Emphasizes development and usage of systems for computer-aided design. FORTRAN proficiency required.
D. C. Gossard

2.158 Vehicle Dynamics (A)

Prereq.: Permission of Instructor
G (2) **Not offered 1984-85**
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. Guideway and aerodynamic inputs to vehicle are described both statistically and deterministically. 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.
J. K. Hedrick

2.161 Computer-Controlled Experimentation (A)

Prereq.: 2.14 or 2.151
G (2)
3-0-9

State-of-the-art techniques involving use of digital and analog computers to monitor and control physical processes. Topics: 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 Digital Control Systems (A)

Prereq.: 2.151; 2.14
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. Covers elements of real-time computer architecture; input-output interfaces and data converters; analysis and synthesis of sampled-data control systems using classical and modern (state-space) methods; analysis of trade-offs in control algorithms for computation speed and quantization effects. Laboratory projects emphasize practical digital servo interfacing and implementation problems with timing, noise, nonlinear devices.
P. K. Houpt

2.18J Human Factors in Design

(Same subject as 9.39J, 22.088J)
Prereq.: Permission of Instructor
U (2)
3-1-8

Analyzes human and computer roles, interfacing and reliability in nuclear and chemical plants, air traffic control, industrial robots, office automation, and other systems. Introduces methods for measurement of and statistical inference about human behavior in such interactions. Reviews human sensory and motor performance characteristics and the derivation of human engineering design criteria for displays and controls. Readings from the human factors engineering literature. Case studies and design projects.
T. B. Sheridan, D. D. Lanning, A. V. Hein

2.181J Models of Man-Machine Systems (A)

(Same subject as 16.355J)
Prereq.: 18.03
G (1)
3-1-8

Introduces mathematical models of human performance and man-machine interaction. Psychophysical methods. Theory and models of manual control, supervisory control, information transmission, signal detection, Bayesian decision-making. Multi-attribute utility, fuzzy set and other judgement scaling techniques. Application to process control, aircraft and robotic systems. Readings from the literature. Laboratory demonstrations and case studies. Text: Sheridan and Ferrell, *Man-Machine Systems*. Permission of instructor required.
T. B. Sheridan, L. R. Young

2.192 Engineering Systems Analysis (A)

Prereq.: Permission of Instructor
G (1)
3-0-6

School-Wide Elective Subject. Description given at end of this chapter on SWE page.
R. de Neufville, J. P. Clark

Fluid Mechanics and Combustion

2.20 Fluid Mechanics

Prereq.: 8.02, *18.03*
U (1, 2) SD
4-0-8

Introduces 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

2.21 Applications in Fluid Mechanics

Prereq.: 2.20, *2.40*
U (2)
3-0-9

Applies fluid mechanics to specific problem areas such as lift and drag, flow in open and closed conduits, boundary layers, separation. Reviews fundamentals, emphasizing order-of-magnitude estimates, similarity laws, and modeling. Introduces 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

2.25 Advanced Fluid Mechanics (A)

Prereq.: 2.20, *18.075*
G (1)
3-0-9

Surveys 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
G (2)
3-0-9

Fundamental survey of compressibility effects in transient and steady flows. Examples from engineering practice. Steady one-dimensional flows with area change, shock waves, friction, and energy exchange. Unsteady one-dimensional flows: wave phenomena, method of characteristics, water hammer, shocks and rarefactions, two-phase flows. Steady, two-dimensional subsonic flows: Gothert and Prandtl-Glavert rules. Steady, supersonic flows: method of characteristics, standing shock waves.
A. H. Shapiro, T. Y. Toong

2.272 Laminar Flows and Stability (A)

Prereq.: 2.20
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
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 closure approaches 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.
A. A. Sonin

2.274 Computational Fluid Dynamics (A) (New)

Prereq.: 2.25
G (1)
3-0-9

Techniques for the numerical simulation of viscous incompressible flows. Spatial discretization: finite-difference, finite-element, spectral methods. Time-stepping. Accuracy, stability, and generality considerations. Numerical diffusion, dispersion. Implementation of turbulance models. Survey of vortex methods, compressible flow techniques. Examples from internal and external flows, heat transfer. Familiarity with elementary numerical analysis helpful. Computer assignments requiring knowledge of FORTRAN.
A. T. Patera

2.275 Turbomachinery Design (A)

Prereq.: 2.20 or 2.25; 2.40 or 2.41J
G (1) **Not offered 1984-85**
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.
D. G. Wilson

2.277 Biomedical Fluid Mechanics (A)

Prereq.: 2.20
G (2) **Not offered 1984-85**
3-0-9

Engineering approach to the function of circulatory and respiratory systems and to other problems in physiology involving fluid dynamics. Reviews relevant anatomy and physiology emphasizing quantitative considerations. Presents and discusses mathematical or engineering models in relation to physiological phenomena they are intended to simulate. Directed to graduate students in Engineering and Science, but open to medical students and undergraduates with the permission of the instructor. Alternate years.
R. D. Kamm

2.281 Reacting Gas Dynamics (A)

Prereq.: 2.20 or 16.02
G (1) **Next offered 1984-85**
3-0-9

Treats 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.
T. Y. Toong

2.282 Combustion (A)

Prereq.: 2.20 or 16.02
G (1) **Not offered 1984-85**
3-0-9

Comprehensive treatment of combustion principles and their applications. Topics emphasized vary 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.
T. Y. Toong

Materials

(See also listing under Polymers and Fibers)

2.301 Advanced Mechanical Behavior of Materials (A)

Prereq.: Permission of Instructor
G (2)
3-0-9

Dependence of stress on strain, time, temperature, and material, including introduction to its physical basis: elasticity, viscosity, rubber elasticity, plasticity, creep. Viscoelastic shift factor and superposition. Elastic and plastic fracture mechanics. Statistical effects in brittle fracture. Fatigue crack initiation and growth. Hardness, friction, wear. High-strength materials and composites. Requires background in materials or mechanics. Students with 2.31-.32 should take 2.333J. Text: F. A. McClintock, A. S. Argon, *Mechanical Behavior of Materials.*
F. A. McClintock

2.31 Mechanical Behavior of Materials I

Prereq.: 2.01
U (1)
3-1-5

Introduces mechanical behavior of engineering materials emphasizing a combined materials science and continuum mechanics approach. Rate-independent constitutive behavior of materials. Microscopic and continuum analysis of elastic and plastic deformation. Simple concepts of linear elastic fracture mechanics and fatigue failure. Surveys materials in engineering use. Laboratory experiments involving a variety of materials, testing methods, and analyses, and a special project. Requires competency in 2.01. Recommended that it be taken in term following 2.01.
L. Anand

2.32 Mechanical Behavior of Materials II

Prereq.: 2.31, *2.86*
U (2)
3-1-5

Combined materials science and continuum mechanics treatment of rate-dependent deformation and failure in engineering materials. Major topics: phase microstructure of materials and methods for their control; mechanisms and mechanics of viscoelasticity, creep and creep fracture; oxidation, corrosion and wear. Project laboratory provides opportunity for independent research into mechanical behavior of materials. Competency required in 2.31 and taken in term following.
L. Anand

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
G (1) **Not offered 1984-85**
3-0-9

See description under subject 3.25J.
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
G (2) **Next offered 1984-85**
3-0-9

See description under subject 3.26J.
A. S. Argon, W. S. Owen

2.34J The Mechanics of Fracture

(Same subject as 3.141J)
Prereq.: 2.31, 2.32
G (2)
3-0-9

The understanding and prevention of fracture of engineering materials requires an integration of basic concepts in materials science and solid mechanics. Focuses on connecting microstructural fracture processes with appropriate macroscopic (continuum) models. Topics: linear elastic and elastic-plastic fracture; fatigue and fatigue crack growth; creep rupture and creep crack growth.
D. M. Parks, R. M. N. Pelloux

Thermodynamics and Statistical Mechanics

2.40 Thermodynamics

Prereq.: 8.02, *18.03*
U (1, 2) SD
4-0-8

Classical thermodynamics emphasizing 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

2.41J Thermodynamics of Power Systems

(Same subject as 13.25J)
Prereq.: 2.40
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

2.451J General Thermodynamics I (A)

(Same subject as 22.571J)
Prereq.: Permission of Instructor
G (1)
3-0-9

General foundations of thermodynamics valid for small and large systems, and equilibrium and nonequilibrium states. Definitions of state, property, work, energy, stable equilibrium, available energy, entropy, thermodynamic potential, and interactions other than work (nonwork, heat, mass transfer). Applications to properties of materials, bulk flow, energy conversion, chemical equilibrium, combustion, and industrial manufacturing.
E. P. Gyftopoulos, G. P. Beretta

2.452J Quantum Thermodynamics (A)

(Same subject as 22.572J)
Prereq.: Permission of Instructor
G (2)
3-0-9

Non-statistical unified quantum theory of mechanics and thermodynamics for all systems, including a single particle, and all states, including nonequilibrium. Equation of motion for reversible and irreversible processes. Self-contained review of necessary background. Stability of equilibrium states. Applications to fermions, bosons, black-body radiation, electrons in metals, and crystals. Nonequilibrium states. Applications to rate processes, and relaxation phenomena.
E. P. Gyftopoulos, G. P. Beretta

Heat and Mass Transfer

2.51 Heat and Mass Transfer

Prereq.: 2.20, 2.40
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.: —
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
G (1, S)
3-0-9

Reviews 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*
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
G (2)
3-0-9

See description under subject 22.36J.
W. M. Rohsenow, P. Griffith, M. S. Kazimi

2.58J Radiative Transfer (A)

(Same subject as 10.74J)
Prereq.: 2.51 or 10.302
G (1) **Next offered 1984-85**
3-0-9

See description under subject 10.74J.
L. R. Glicksman, A. F. Sarofim

Power Systems

2.601J Thermal Power Systems (A)

(Same subject as 13.26J)
Prereq.: 2.20; 2.40 or 2.402, 2.51
G (2)
3-0-9

Design of thermal power system components and system optimization. Reviews 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. Takes problems and examples from the fields of space, electrical utility and marine power systems. Assumes knowledge of elementary heat transfer and simple thermal power cycles.
W. M. Rohsenow, A. D. Carmichael

2.615 Internal Combustion Engines (A)

Prereq.: 2.20, 2.40
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 different types of engines: spark-ignition, stratified charge, 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
G (1) **Next offered 1984-85**
3-0-9

Applies 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.
D. G. Wilson

2.63 Energy Production from Renewable Resources (A)

Prereq.: 2.20, 2.51
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
G (1) **Next offered 1984-85**
3-0-9

Methods and technologies for producing clean liquid, gaseous, and solid fuels from coal, oil, shale, and tar sands and biomass. Topics: 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. Text: R. F. Probstein and R. E. Hicks, *Synthetic Fuels*. Open to undergraduates by permission of instructor.
R. F. Probstein

2.649 Low Temperature Refrigeration (A)

Prereq.: 2.40
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 superconductors. Laboratory projects on related topics according to individual interests.
J. L. Smith, Jr.

2.65J Fluidization (A)

(Same subject as 10.651J)
Prereq.: Permission of Instructor
G (1) **Not offered 1984-85**
3-0-9

See description under subject 10.651J.
L. R. Glicksman, A. F. Sarofim

Experimental Engineering

2.671 Measurement and Instrumentation

Prereq.: 2.02
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. Emphasizes 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, thermocouples, etc. Required background for lab projects developed in lectures. 6 units may be applied to the General Institute Laboratory Requirement.
R. H. Lyon

2.672 Project Laboratory

Prereq.: *2.20, 2.40,* 2.671
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. Communication (written and oral) of results is also a strong component of the course. Groups of three students work together on three problems during the term.
W. C. Unkel

Design

2.70 Introduction to Design

Prereq.: —
U (1)
2-3-4

Introduces 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

2.701 Drafting for Engineers

Prereq.: —
U (1, 2)
1-2-1

Lectures and laboratory sessions on basics of drafting as used to delineate engineering design information and data. Introduces orthographic projection, sectional and auxiliary views, techniques of dimensioning and tolerancing, and computer-aided drafting. Use of drafting tools explained and practiced in addition to orthographic and pictorial sketching techniques.
W. C. Flowers, J. B. Grinnell, Jr.

2.72 Elements of Mechanical Design

Prereq.: 2.01, 2.70
U (1)
3-3-6

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: typical machine elements, power transmission elements, motors and prime movers, control elements, material selection, and assembly techniques. 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
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. Emphasizes pursuing creative solutions to current, real, engineering design problems. Guest lecturers 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

2.731 Advanced Engineering Design (A)

Prereq.: 2.73
G (1)
3-3-6

Two sections. 1) Involves advanced topics in engineering design: optimization, kinematics and mechanics, human factors engineering, and idea generation and creative problem solving. 2) As ongoing case studies of the design process, students design, build, and test pieces of mechanical hardware for industrial clients. Requires two semesters for design, assembly, and "debugging" of the mechanical devices. During the fall, defines problems, creates and evaluates solutions, and generates a detailed design. Graduate status or permission of instructor.
W. P. Seering

2.732 Advanced Design Projects (A) (Revised Unit)

Prereq.: 2.731
G (2)
3-0-6

Continuation of 2.731. Includes discussions of such topics as applications of microprocessors, product liability and safety, entrepreneurship, marketing of a product, patent applications, and methods of redesign. From parts built for them by participating industrial clients, students assemble and "debug" devices which they designed during term 1 in 2.731. By the end of term devices are brought to specification and presented to the respective sponsors. Permission of instructor required.
W. P. Seering

2.741 Fundamentals of Mining Technology (A)

Prereq.: Permission of Instructor
G (1) **Not offered 1984-85**
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. 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. Alternate years.
C. R. Peterson

2.742J Introduction to Mining and Mineral Technology

(Same subject as 1.384J, 3.095J, 12.043J)
Prereq.: —
U (1)
3-0-6

See description under subject 3.095J.
C. R. Peterson, H. H. Einstein, R. G. Burns, J. F. Elliott

Biomedical Engineering

(See also 2.277, 2.900J and 2.907)

2.75 Physiology and Biomechanics of Human Movement (A)

Prereq.: Permission of Instructor
G (1) **Next offered 1984-85**
3-3-6

Synergistic 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 pathophy-

siological conditions and of appropriate technological responses, i.e. amputation prosthesis, arthroidial joint deterioration and replacement, etc. Human performance measurement and sports medicine.
R. W. Mann

2.76J Ultrasound: Physics, Biophysics, and Technology (A)

(Same subject as 6.562J, HST 530J)
Prereq.: Permission of Instructor
G (1) **Next offered 1984-85**
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.
P. P. Lele, F. R. Morgenthaler

2.761J Principles of Medical Imaging (A)

(Same subject as 22.56J, HST 561J)
Prereq.: Permission of Instructor
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)

(Same subject as HST 531J)
Prereq.: Permission of Instructor
G (1) **Not offered 1984-85**
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.
P. P. Lele, Staff

2.77 Research in Biological Effects and Applications of Ultrasound and Other Non-Ionizing Radiations (A)

Prereq.: 2.76J
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
G (1, 2)
2-0-4

Seminar providing a contemporary overview of research, professional roles, and conceptual framework in application of engineering to rehabilitation medicine and underlying pathophysiology. A critical review paper and presentation related to a seminar topic required. Lecturers include authorities from the Boston area, including MIT and Harvard Medical School faculty; members of the international research community; students conducting research and participants in the seminar series. Open to undergraduates with permission of instructor.
M. J. Rosen, R. W. Mann

2.791J Quantitative Physiology: Cells and Tissues

(Same subject as 6.021J, HST 541J)
Prereq.: 2.02 or 6.002 or 6.071; 8.02; 18.03
U (1)
4-2-6

See description under subject 6.021J.
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
U (1)
3-2-7

See description under subject 6.022J.
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
U (2)
3-2-7

See description under subject 6.022J.
R. W. Mann, L. S. Frishkopf, L. R. Young

Manufacturing

(See also 2.922)

2.800 Tribology (A)

Prereq.: Permission of Instructor
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 Metals Processing

Prereq.: Permission of Instructor
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, computer aids for manufacturing analysis and optimization.
N. H. Cook, B. M. Kramer

2.820J Polymer Processing (A)

(Same subject as 10.57J)
Prereq.: 10.301 or 2.20
G (2)
3-0-9

See description under subject 10.57J.
L. Erwin, T. G. Gutowski, R. C. Armstrong

2.830 Control for Manufacturing Automation (A)

Prereq.: 2.14
G (2)
3-0-9

Provides background for applying computer-based control system techniques to batch manufacturing processes. Follows a brief review of classical control concepts and servo-systems with an in-depth study of the modeling and control problems associated with several manufacturing processes. These include metal cutting, metal forming, and welding processes, as well as the control problem associated with robots in a manufacturing context.
D. E. Hardt

2.835 Design and Analysis of Robotic Manipulators (A) (New)

Prereq.: 2.05, 2.151
G (2)
3-0-9

Modeling and characterization: brief review of kinematics, statics, and dynamics of mechanical linkages; design and analysis of mechanical structure, actuators/transmissions, and sensors. Control system design; trajectory control, force control, adaptive and optimal control. Planning, programming, and applications; teaching, language, simulators, CAD/CAM links. Emphasizes applications in manufacturing processes.
H. Asada, S. Dubowsky, N. J. Hogan

2.841 Elements of Manufacturing

Prereq.: Permission of Instructor
G (2)
3-0-9

Introduces operating concepts and functions in manufacturing. For juniors, seniors, and graduate students interested in careers related to manufacturing. Includes 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, emphasizing student participation in class discussion. Supplementary readings and field visits to manufacturing plants.
R. T. Lund

2.842 Managing Systems of People and Machines for Quality and Productivity (A) (New)

Prereq.: Permission of Instructor
G (1)
3-0-6

Applies statistical and managerial principles to processes involving systems of people and machines. Relation between quality of process and system productivity. Practical problems of applications taken from industrial experience.
M. Tribus

2.86 Manufacturing Processes

Prereq.: —
U (1, 2) LAB
3-3-3

Introduces modern manufacturing techniques for metals, polymers, ceramics, and composite materials. Examples of application of computer automation, engineering mechanics, thermodynamics, and chemical kinetics to the design and control of manufacturing systems. Laboratories supplement lectures in computer applications, metal and polymer processing.
B. M. Kramer

2.900 Biomedical Materials

Prereq.: 2.901J or 3.091 or 7.01
U (2)
2-0-4

Science and engineering of materials used in medical applications: orthopedic implants, artificial joints, blood vessel replacements, artificial organs. Structure and properties of polymers, ceramics, and metals on interaction with the human body. Histological analysis of connective tissue on materials science and engineering. Fracture, structure, healing of normal and abnormal bone. Implantation problems: inflammation, thrombogenesis, rejection, resorption, corrosion.
I. V. Yannas

Polymers and Fibers

2.901J Introduction to Polymer Science and Engineering

(Same subject as 3.061J)
Prereq.: 3.091 or 5.41
U (2) SD
3-0-9

See description under subject 3.061J.
I. V. Yannas, D. R. Uhlmann

2.907 Science and Engineering of Biological Membranes and Structural Tissue (A)

Prereq.: Permission of Instructor
G (2) **Next offered 1984-85**
3-0-9

Covers biophysical design and function of the cellular membrane and of skin considered as a membrane. First part: introduces basic molecular components of the cellular membrane, models of membrane structure and experimental models of membrane proteins. 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.
I. V. Yannas

2.921 Polymer Deformation and Fracture (A)

Prereq.: 2.30 or 2.31, 2.32
G (2)
3-0-9

Linear and nonlinear viscoelasticity below and above T_g. Phenomenology of plastic deformation in crystalline, and glassy polymers, molecular theories for yielding, 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, 2.31, 2.32
G (2) **Not offered 1984-85**
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.
S. Backer

2.924 Structural Mechanics of Fiber Assemblies (A)

Prereq.: 2.01 or 3.11, 2.31, 2.32
G (2) **Not offered 1984-85**
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.
S. Backer

2.926J Materials Science of Polymers (A)

(Same subject as 3.93J)
Prereq.: 3.061J, 10.691
G (1)
3-0-9

See description under subject 3.93J.
D. R. Uhlmann

2.927J Materials Engineering of Polymers (A)

(Same subject as 3.97J)
Prereq.: 3.601J, 10.691
G (1)
3-0-9

See description under subject 3.97J.
D. R. Uhlmann

Special Studies

2.941J Invention

(Same subject as 10.802J, 13.77J, 16.671J)
Prereq.: Permission of Instructor
G (1)
3-0-6

Analyzes invention process. Presents methodology for invention. Topics: 1) observing technology; 2) analyzing needs; 3) indentifying critical parameters to trigger potential solutions; 4) creative synthesis based on key parameters. Also patents, licensing, and marketing. Requires term project. Students work on inventing to meet needs of their own choice as well as those from companies belonging to the Innovation Center's industry program.
D. G. Jansson, A. D. Carmichael, W. R. Markey, J. P. Longwell

2.942 Entrepreneurship

Prereq.: —
G (2)
4-0-5

School-Wide Elective Subject. Description given at end of this chapter on SWE page.
D. G. Jansson

2.943 Engineering Risk-Benefit Analysis (A)

Prereq.: 18.02
G (2)
3-0-6

School-Wide Elective Subject. Description given at end of this chapter on SWE page.
A. W. Drake, A. R. Odoni

2.944 The Idea/Product Transformation (New)

Prereq.: Permission of Instructor
G (2)
3-1-5

Project-centered subject addressing transformation of new ideas into technology-based products, attaining a proper match between product and marketplace, from the perspective of both source and customer. Product design issues: evaluation, market perception, aesthetics and human interfacing, design for manufacturability, reliability, and repairability, pricing, and legal implications.
D. G. Jansson, W. C. Flowers, W. P. Seering

2.951 Engineering Internship

Prereq.: —
U (1, 2, S)
0-6-0

2.952 Advanced Engineering Internship (A)

Prereq.: 2.951
G (1, 2, S)
0-6-0

Provides academic credit for undergraduate and graduate work assignments for Mechanical Engineering students participating in the Engineering Internship Program. Undergraduate participation is approximately six months over two summers of practical work in manufacturing, engineering, research and development at an industrial plant. Graduate participation by students admitted to the Department's graduate program consists of approximately seven months at industrial plant. Credit is awarded after evaluation and approval of the actual work performed.
I. Paul

2.96 Management in Engineering

Prereq.: —
U (1)
3-0-9

School-Wide Elective Subject. Description given at end of this chapter on SWE page.
R. T. Lund, D. P. Hoult, H. S. Marcus

2.97 Independent Activities

Prereq.: —
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 (A)

(Same subject as TPP 11J)
Prereq.: Permission of Instructor
G (1)
4-0-8

2.982J Project Proseminar in Technology and Policy II (A)

(Same subject as TPP 12J)
Prereq.: TPP 11J
G (2)
4-0-8

See description under subjects TPP 11J and TPP 12J.
T. B. Sheridan, D. F. Noble, M. A. Sirbu

2.995 Special Topics in Mechanical Engineering

Prereq.: —
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.: —
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.: —
U (1)
3-0-9

School-Wide Elective Subject. Description given at end of this chapter on SWE page.
J. D. Nyhart

2.999 Engineer's Degree Thesis Proposal Preparation (A)

Prereq.: —
G (1, 2, S)
Arr.

For students who must do additional work to convert 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.: —
U (1, 2, S)
Arr.

Extended participation in work of a research group; includes independent study of literature, direct involvement in group's research commensurate with student skills, project work under an individual faculty member.
T. B. King

3.00 Thermodynamics of Materials

Prereq.: 3.091 or 5.41, 18.02
U (1) SD
4-0-8

Essential features of first, second, and third laws of thermodynamics and their application to materials. Statistical interpretation of entropy. Experimental techniques used to measure thermodynamic functions. Introduces phase diagrams, phase rule, and thermodynamics of solutions. Thermochemistry of homogeneous and heterogeneous reactions.
G. J. Yurek

3.01 Physical Chemistry of Materials

Prereq.: 3.00 or 5.60 or 2.40 or 10.13
U (2)
4-0-8

Reactions involving pure condensed phases and gaseous phase, behavior of solutions, free energy-composition and phase diagrams of binary and ternary systems, reaction equilibria in systems containing components in condensed solution. Electrochemistry, corrosion, Gibbs phase rule, chemical kinetics, elementary mechanisms, reaction rate constant, activation energy, surface tension.
T. W. Eagar

3.02 Phase Transformations and Structure Development (Revised Unit)

Prereq.: 3.01 or 10.14
U (1)
3-0-6

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 (Revised Unit)

Prereq.: 3.01 or 10.14
U (1)
3-0-6

Chemical principles of extractive metallurgy. Representations of heterogeneous equilibria. Unit operations and processes. Roasting of sulphides. Gaseous reduction of iron oxide. Reduction of zinc oxide and ferroalloy oxides. Reduction of halides. Smelting of iron ores, matte smelting of copper ores. Refining processes-gas-liquid, solid-liquid and liquid-liquid. Hydrometallurgy and electrometallurgy. Kinetics of high-temperature processes. Examples taken from industrial processes.
T. B. King

3.04 Special Problems in Materials Science and Engineering

Prereq.: —
U (1, 2, S)
Arr.

For undergraduates desiring to carry on projects of their own choosing which may be experimental, theoretical, or of a design nature. Also for undergraduate studies arranged by students or staff which may consist of seminars, assigned reading, or laboratory projects.
J. B. Vander Sande

3.041 Thesis Seminar

Prereq.: —
U (1, 2)
Arr.

Lectures on basic skills necessary for conducting thesis planning, research, analysis, and preparation of final document. Included: library resources, how to plan experiments, departmental central facilities, laboratory safety, data analysis, technical writing, and thesis format. Seminar also requires that each student present an initial oral research proposal and deliver a lecture reporting on completed thesis. Must be taken both terms to receive 3 units of credit.
S. M. Allen

3.05 Computer Models of Engineering Systems

Prereq.: 18.02, 8.01
U (1) SD
3-0-9

School-Wide Elective Subject. Description given at end of this chapter on SWE page.
B. Schumacker

3.06 Engineering of Glasses and Polymers

Prereq.: 3.11, 3.01 or 10.14
U (1)
3-0-5

Considers structure and micro-structure of polymers and glasses and their relation to processing and properties. Attention to glass formation, viscous flow and relaxation phenomena, glass melting, glass forming processes, fabrication and properties of glass-ceramic materials. Also discusses: crystallization of polymers, forming processes for polymers, rubber elasticity, viscoelasticity, yield and fracture behavior of polymers, and polymer-based composite materials. Emphasizes recent developments, and on present state of the particular industries.
D. R. Uhlmann

3.061J Introduction to Polymer Science and Engineering

(Same subject as 2.901J)
Prereq.: 3.091 or 5.41
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

3.062 Introduction to Polymer Chemistry (New)

Prereq.: 3.091 or 5.41
U (1)
3-0-6

Preparation of polymeric materials and their characterization. Topics: fundamentals of chain and step growth polymerization, chemistry of organic radicals and ions, synthesis-structure-property relationships and use of modern techniques for determination of polymer composition, molecular weight, and microstructure.
G. E. Wnek

3.064 Polymer Engineering (New)

Prereq.: 3.11
U (2)
3-0-6

Quantitative models for engineering analysis and design as applied to polymers. Includes linear and nonlinear viscoelasticity, yield models, homogeneous and flaw models for fracture and fatigue, rheological properties of polymer fluids, governing equations for thermomechanical fluid processing, and models for industrially important processing methods.
D. K. Roylance

3.065 Polymer Laboratory (New)

Prereq.: 3.091
U (1)
0-6-3

Synthesis of typical plastics. Methods of processing. Techniques of polymer characterization: IR, DSC, viscosity, density, dynamic mechanical analysis, light scattering, microscopy, photoelasticity. Also modulus, strength, impact, creep, time-temperature superposition, environmental stress cracking.
F. J. McGarry

3.069 Introduction to Ceramics Processing

Prereq.: 3.12, 3.01 or 10.14, 3.07
U (2)
3-0-9

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: 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 (Revised Unit)

Prereq.: 3.12, 3.01 or 10.14
U (1) SD
3-0-9

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. Applies 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

(Same subject as 22.070J)
Prereq.: 3.091 or 3.14 or 3.071J
U (2)
3-0-9

See description under subject 22.070J.
R. G. Ballinger

3.071J Physical Metallurgy Principles for Engineers

(Same subject as 22.071J)
Prereq.: 3.091
U (1)
3-0-9

See description under subject 22.071J.
I-W. Chen

3.075 Ceramics and Glass Laboratory (Revised Unit)

Prereq.: 3.081
U (1)
2-7-3

Laboratory investigates ceramic and glass processing by means of a series of laboratory experiments plus an extensive project. Laboratory experiments cover a range of powder and glass processing together with physical property measurements. Laboratory project is undertaken with faculty supervision. Limited enrollment. Permission of instructor required.
D. R. Clarke, W. D. Kingery, P. B. Vandiver

3.08 Economics of Engineering Materials

Prereq.: —
U (2)
3-0-6

Economics of production and utilization of engineering materials. Primary sources of materials. Reclamation of secondary materials. Economic and technical features of production processes, including energy requirements and pollution effects. Public policy affecting materials production and consumption. Economics of materials selection. Competition between materials. Future supply and demand.
M. B. Bever, J. P. Clark

3.081 Materials Laboratory I

Prereq.: 3.091
U (1, 2) LAB
1-6-5

Introduces study of materials by light, X-ray, and electron microscopy. Examines structures and relationship of structure to mode of fabrication. Applies both classical techniques and recently developed methods in transmission and scanning electron microscopy. In special project part of laboratory students employ many of these modern analytical tools. Limited enrollment. Permission of instructor required.
R. E. Ogilvie

3.082 Materials Laboratory II

Prereq.: 3.081
U (1)
1-6-5

Introduces relationship between processing-structure-properties and performance of materials. Each student participates in three laboratory experiments drawn from metals processing. Includes instruction in safety, technical writing, oral presentation, and experimental design.
T. W. Eagar, Staff

3.083J Introduction to Microelectronic Technology

(Same subject as 6.150J)
Prereq.: 3.15 or 6.012
U (1, 2)
1-3-2

See description under subject 6.150J.
H. L. Tuller, D. J. Edell, C. G. Fonstad, L. R. Reif

3.084 Semiconductor Devices Project Laboratory

Prereq.: 3.083J
U (1)
0-6-0

Student use of facilities of 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, 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.: —
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.: —
U (2)
2-0-4

Surveys, in some depth, materials science and its applications at levels suitable for those with no prior experience in the field. Lectures by MIT staff and guests form series of integrated seminars on important aspects of field.
A. F. Witt

3.093 Magnetic Materials

Prereq.: 3.091, 8.02
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.: —
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

(Same subject as 1.384J, 2.742J, 12.043J)
Prereq.: —
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. Burns, H. H. Einstein, C. R. Peterson

3.10 Chemical Physics of Materials (Revised Unit)

Prereq.: 3.01 or 10.14, 18.03
U (2) SD
3-0-6

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

3.11 Mechanics of Materials I

Prereq.: 8.01, 18.02
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. Subject includes an introduction to computational mechanics, including FORTRAN/CMS student projects.
D. K. Roylance

3.12 Mechanics of Materials II

Prereq.: 2.01 or 3.11
U (2)
3-0-5

Applies 3.11 principles to the mechanics of plastic deformation and fracture of materials. Introduces dislocation theory. Deformation of single crystals and polycrystals. Application to work hardening, solid-solution strengthening and two-phase hardening. Point defects, recovery processes, mechanical twinning. Deformation of noncrystalline materials. Failure by brittle fracture, ductile fracture, and fatigue.
S. M. Allen

3.13 Structure of Solids (Revised Unit)

Prereq.: 8.02, 18.02
U (2)
4-0-8

Uses symmetry theory in the description of the atomic arrangement in crystals. Derivation of space lattices, point groups, crystal systems, and plane groups. Principles of space group derivation and equivalent positions and their use in specifying structure. Interprets structures in terms of packing and coordination polyhedra. The nature of imperfections in real materials: point defects and the structure of line and planar defects.
B. J. Wuensch

3.14 Physical Metallurgy (Revised Unit)

Prereq.: 3.02, 3.12
U (2)
3-0-6

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.
W. S. Owen, K. C. Russell

3.143J Materials of Construction

(Same subject as 1.59J)
Prereq.: 8.01
U (2) SD
3-0-9

See description under subject 1.59J.
F. J. McGarry, F. Moavenzadeh

3.146 Electronic Materials (New)

Prereq.: 3.00, 3.01, 3.02
U (1)
2-0-6

Various aspects of semiconductors such as crystal growth, impurity segregation, crystal structure, and electronic properties relevant to device applications. Emphasizes relationships among structure, bonding, and properties in elemental and compound semiconductors. Meets with 3.46J, 6.761J.
H. C. Gatos

3.147 Electronic Materials Processing (New)

Prereq.: 3.00, 3.01
U (2)
3-1-8

Focus on preparation of electronic materials emphasizing elemental and compound semiconductors for device applications. Growth of single crystals from the melt, solution and vapor phase analyzed through respective phase equilibria. Studies effects of heat and mass transfer on composition and defect formation. Discusses in detail processes such as epitaxy, junction formation, annealing, wafer oxidation, external and internal gettering in silicon. Meets with 3.47.
A. F. Witt

3.15 Electrical, Optical, and Magnetic Materials and Devices

Prereq.: *3.10* or 6.017J
U (2)
3-0-5

Electronic, optical, and magnetic properties of materials in terms of electronic structure, chemical composition, and bonding. Properties of metals, semiconductors, and insulators including electrical conduction, thermoelectric power, Hall effect, optical absorption and reflection, luminescence, magnetism related to microstructure, impurities, and degree of disorder. Manipulation of properties for incorporation into devices. Can be taken concurrently with 3.10.
H. L. Tuller

3.16 Corrosion Science and Engineering

Prereq.: 3.01
U (2)
3-0-6

Electrochemical, environmental, and materials aspects of corrosion at both high and low temperatures. Forms of corrosion, corrosion testing, and corrosion control. Thermodynamics and kinetics of aqueous corrosion and high-temperature oxidation. Extension to fuel cells, batteries, and photoelectrodes. Discusses corrosion of materials in established and emerging technologies.
R. M. Latanision, G. J. Yurek

3.171 Ceramic Artifact Interpretation

Prereq.: —
U (2) **Not offered 1984-85**
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. Limited enrollment. Permission of instructor required.
W. D. Kingery

3.172 Inventions and Patents

Prereq.: 14.02
U (1)
3-0-6

School-Wide Elective Subject. Description given at end of this chapter on SWE page.
R. H. Rines

3.18 Materials Processing

Prereq.: 3.02, 18.03
U (2) **Next offered 1984-85**
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 Mass, Heat, and Fluid Transport

Prereq.: 3.02, 18.03
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.
T. A. Ring, J. Szekely

3.19 Techniques of Metal Sculpture

Prereq.: —
U (1, 2, S)
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
G (1)
4-0-8

Offers advanced treatment of thermodynamic properties of inorganic materials including introductory statistical thermodynamics and surface thermodynamics. Applies laws of thermodynamics to chemical behavior of elements, compounds, and solutions. Discusses heterogeneous equilibria, chemical reactions, and thermodynamics of interfaces and structural defects.
H. K. Bowen, G. Kalonji

3.205 Applied Thermo and Kinetics (A)

Prereq.: 3.01, 3.02
G (1)
3-0-9

Analyzes case studies of thermochemical processes in materials science and materials processing. Delineates the thermodynamic driving force and the rate limiting kinetic step. Applies estimations and calculations to experimentally determined systems. Case studies: vapor phase nucleation, calcination, coarsening, grain growth, oxidation, creep, solid state reactions, corrosion, etc.
H. K. Bowen

3.21 Kinetic Processes in Materials (A)

Prereq.: 3.01, 3.02
G (2)
4-0-8

Presents unified treatment of kinetics from phenomenological and atomistic viewpoints. Covers diffusion in metals and non-metals, chemical kinetics, and kinetics of phase transformations including nucleation, growth, coarsening and spinodal decomposition. Also includes non-catalytic gas-solid reactions and oxidation of metals and alloys.
D. R. Sadoway

3.22J Solid-State Surface Science (A)

(Same subject as 10.613J)
Prereq.: 3.20 or 10.40
G (2) **Next offered 1984-85**
3-0-6

Structural, chemical, and electronic properties of surfaces of crystalline solids. Surface analytical tools used to characterize surfaces including Auger and photoelectron spectroscopies and electron diffraction techniques. Surface thermodynamics and kinetics. Phase transitions at surfaces. Engineering applications.
R. M. Latanision, H. H. Sawin

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
G (1) **Not offered 1984-85**
3-0-9

Derives from the theory of elasticity 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
G (2) **Next offered 1984-85**
3-0-9

Rate mechanisms in crystal plasticity, kinetics and dynamics of slip, superposition of mechanisms controlling flow stress. Mechanisms of inelastic 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 three-dimensional constitutive relations for inelastic deformation. Mechanisms of fracture in metals and polymers.
W. S. Owen, A. S. Argon

3.27 Diffraction and Structure (A)

Prereq.: 8.03, 18.03
G (2) **Next offered 1984-85**
4-0-8

X-ray and neutron production, absorption, and scattering. Overview of symmetry theory, point groups, and space groups. Interprets diffraction effects through the Ewald construction, reciprocal lattice, and Fourier transforms. Instrumentation and the interpretation of diffraction patterns produced by the Laue, Debye-Scherrer, Weissenberg, and precession techniques. Diffractometer geometries. Applies diffraction to determination of particle size, pole figures, texture, and crystal structure.
B. J. Wuensch

3.271 Structure of Materials (A)

Prereq.: 18.03, 3.10
G (1)
4-0-8

Quantitative description of atomic arrangements in selected metals, oxides, and silicates important in materials science. Interprets structures in terms of coordination polyhedra and packing. Relationships between structures: polymorphism, polytypism, and derivative structures. Describes diffraction using Fourier transforms and series. Determines structure through diffraction effects: the phase problem, Patterson function, and direct methods for phase determination.
B. J. Wuensch

3.30 Electron Microscopy: Image Interpretation (A)

Prereq.: 3.081, 3.12, 3.13
G (2)
3-2-7

Derives relationship between detail in transmission electron microscopy images and internal structure of an object to the atomic level. Fourier theory of diffraction. Lens action, aberrations and transfer functions. Elastic and inelastic interaction of electrons with atoms. Kinematical and dynamical theories of electron diffraction. Phase object approximations and high-resolution imaging methods. Imaging of defects with displacement and replacement fields. Laboratory sessions.
L. W. Hobbs

3.31 Phase Transformations (A)

Prereq.: 3.20, 3.21
G (1)
3-0-9

Advanced treatment of phase transformations in solids. Homogeneous and heterogeneous nucleation. Theories of thermally activated growth processes and morphological stability. Transformation by spinodal decomposition and continuous ordering. Transformation mechanisms in systems with multicritical points. Eutectoidal transformations and cellular precipitation. Crystallographic theory and mechanisms of martensitic transformations.
S. M. Allen

3.32 Introduction to Electron Optical Instruments (A)

Prereq.: 3.13, 3.14
G (1)
2-4-6

Treats interaction of electrons with materials in detail. Describes modern scientific tools employing results of these interactions to obtain information about structure and chemistry of materials on a microscale. Techniques: electron microanalysis, Auger spectrometry, scanning and transmission electron microscopy, low-energy electron diffraction, and field ion microscopy.
L. W. Hobbs, J. B. Vander Sande

3.33 Defects in Crystals (A)

Prereq.: 3.02, 3.12
G (1)
3-0-9

Unified treatment of point, line, and planar defects in crystals. Point defects include vacancies, self-interstitials, and solute atoms. Line defects include dislocations. Planar defects include stacking faults, small and large angle grain boundaries, and interphase boundaries. Discusses geometrical structure and physical properties such as stress fields, energies, and mobilities. Treats interactions between defects including point defect clustering, point defect-dislocation pinning, dislocation climb and grain boundaries as point defect sources/sinks.
R. W. Balluffi

3.34 Physical Metallurgy of Deformation (A)

Prereq.: 3.14, 3.20, 3.21
G (2)
3-0-9

Advanced treatment of basic deformation mechanisms in single-crystal and polycrystalline metals and single-phase alloys. Dislocation glide, arbitrary strain of single crystals and polycrystals. Deformation twinning. Deformation by martensitic transformation, reversible deformation, shape memory. Thermally activated deformation, dislocation climb, diffusional mass flow under applied stress, temperature dependence of martensitic deformation. Strain-rate effects in dislocation dynamics, twinning, and martensitic deformation.
W. S. Owen

3.35 Solidification Processing (A)

Prereq.: 3.02 or 3.141
G (2)
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.
R. W. Balluffi

3.36J Welding Engineering (A)

(Same subject as 13.17J)
Prereq.: 3.02 or 3.141
G (1)
3-0-6

See description under subject 13.17J.
K. Masubuchi

3.37 Deformation Processing (A)

Prereq.: 3.11, 3.14 or 3.141
G (2) **Next offered 1984-85**
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.
T. W. Eagar

3.38 Behavior of Metals at Elevated Temperatures (A)

Prereq.: 3.14 or 3.141
G (1)
3-0-6

Studies 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
G (1)
3-0-9

Reviews 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. Discusses case studies and reviews current research in fracture.
R. M. N. Pelloux

3.40 Physical Metallurgy (A) (New)

Prereq.: 3.02, 3.11
G (1)
3-0-9

Discusses structure-property relationships in metallic alloys selected to illustrate some basic concepts of physical metallurgy and alloy design. Considers mostly mechanical properties. Also considers structural features: structural stability, grain size, interstitial and substitutional solutes, precipitates, second-phase particles, eutectics and eutectoids, and composites.
W. S. Owen

3.41J The Mechanics of Fracture

(Same subject as 2.34J)
Prereq.: 2.31, 2.32
G (2)
3-0-9

See description under subject 2.34J.
R. M. N. Pelloux, D. M. Parks

3.43 Physics and Chemistry of Materials (A) (Revised Content)

(3.23)
Prereq.: 8.03, 18.03
G (1)
4-0-8

Introduces physics and chemistry of materials, based on unified treatment of quantum physics, chemistry, and statistics of electrons, atoms, molecules, and solids. Includes: review of classical mechanics and electromagnetic theory; basic concepts and formalism of quantum mechanics; free electron, molecular-orbital, and band theories; quantum statistics of electrons; defect and interface states; lattice heat capacities; Boltzmann theory of electrical and thermal transport; Ising model of order-disorder transformations; electronic phase transitions.
K. H. Johnson

3.46J Electronic Materials (A)

(3.76J)
(Same subject as 6.761J)
Prereq.: 3.15 or 6.012, 6.301
G (1)
2-0-6

Advanced and quantitative homework assignments. See description under subject 3.146.
H. C. Gatos

3.47 Electronic Materials Processing (New)

Prereq.: 3.15, 3.20
G (2)
3-1-8

Advanced and quantitative homework assignments. See description under subject 3.147.
A. F. Witt

3.50 Physical Chemistry of Metallurgical Processes (A)

Prereq.: 3.20
G (2)
3-0-6

Studies 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

3.501 Physical Chemistry in Pyrometallurgical Processes (A) (New)

Prereq.: 3.20
G (1) **Not offered 1984-85**
3-0-6

Studies current state of understanding of the thermodynamic and kinetic behavior of reactions, components, and phases in pyrometallurgical systems. Advanced treatment of the reactions among components in metals, gases, slags, and mattes. Emphasizes current literature on the subject.
J. F. Elliott

3.51 Process Metallurgy (A)

Prereq.: 3.03
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
G (2) **Not offered 1984-85**
3-0-6

Investigates metallurgical systems by decomposing them into unit operations and evaluates the dynamic behavior of each unit operation by model development or control theory. Then assembles these model unit operations into a metallurgical system model and characterizes its dynamic behavior.
J. F. Elliott, T. A. Ring

3.53 Electrochemical Processing of Materials (A)

Prereq.: 3.20 or 3.54
G (2) **Next offered 1984-85**
3-0-6

Discussion of principles of electrochemistry: thermodynamics and kinetics of electrode processes, polarization, electrical charge doublelayers, 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.
J. F. Elliott, R. M. Latanision

3.54 Corrosion—The Environmental Degradation of Materials (A)

Prereq.: 3.00
G (1)
3-0-6

Applies thermodynamics and kinetics of electrode reactions to aqueous corrosion of metals and alloys. Forms of corrosion and corrosion testing. Methods of corrosion control including alloy selection, water chemistry, design rules, anodic and cathodic protection, and coatings. Extension to environmental degradation of ceramics and polymers. Discusses materials degradation problems in marine environments, oil and gas production, energy conversion and generation systems.
R. M. Latanision

3.541 Oxidation and Corrosion of Materials at Elevated Temperatures (A)

Prereq.: 3.20, 3.21
G (2) **Not offered 1984-85**
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.
G. J. Yurek

3.55 Macroscopic Transport in Materials Processing (A)

Prereq.: 18.03
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
G (2) **Not offered 1984-85**
3-0-6

Gas-solid reactions, involving single particles; chemical kinetics, heat and mass transfer, pore diffusion, and structural changes. Reaction of porous and non-porous particles, reactions between solids, proceeding through gaseous intermediates. Reviews experimental techniques for study of gas-solid reactions, including physical characterization of solid specimens. Multi-particle systems, such as packed beds, fluidized beds, and rotary kilns. Gas-solid reactions of industrial importance. Text: J. Szekely, J. W. Evans, and H. Y. Sohn, *Gas-Solid Reactions*, Academic Press, 1976.
J. Szekely

3.555 Principles of Materials Engineering (A) (New)

Prereq.: Permission of Instructor
G (2)
3-0-6

Synthesis of materials selection, design, and manufacturing from the viewpoint of the materials engineer. Includes: fundamentals and applications of manufacturing processes, failure modes, materials systems analysis and cost engineering. Considers wide variety of materials. Uses lectures and case studies.
H. K. Bowen, J. P. Clark, T. W. Eagar, N. J. Grant, D. K. Roylance

3.56 Engineering Systems Analysis (A)

Prereq.: Permission of Instructor
G (1)
3-0-6

School-Wide Elective Subject. Description given at end of this chapter on SWE page.
J. P. Clark, R. de Neufville

3.561 Materials Systems Analysis (A)

Prereq.: 3.56
G (2) **Not offered 1984-85**
3-0-6

Systems analysis as applied to materials engineering problems, presented at a level beyond 3.56. Two main components are: Optimization methods, including hill climbing methods, constrained optimization problems, optimization of decomposable structured systems, trajectory optimization of lumped and distributed systems. Systems modeling, including regression analysis, simulation modeling, time series analysis, multiobjective analysis. Practical examples are included for each component.
J. P. Clark, J. Szekely

3.562J Current Issues in Engineering

(Same subject as 1.485J, 6.941J, 13.682J, 22.87J)
Prereq.: —
G (2)
3-0-6

See description under subject 1.485J.
T. H. Lee

3.563J Cases and Projects in Engineering Management (A)

(Same subject as 1.486J, 6.942J, 13.683J, 22.88J)
Prereq.: 6.941J
G (1)
3-1-5

See description under subject 1.486J.
T. H. Lee

3.564J Technology Planning (A)

(Same subject as 1.487J, 13.684J)
Prereq.: —
G (1)
3-0-6

See description under subject 1.487J.
J. M. Utterback, R. D. Logcher

3.565J Manufacturing/Technology Interface (A)

(Same subject as 13.685J, 15.365J)
Prereq.: Permission of Instructor
G (2)
3-0-6

See description under subject 15.365J.
J. M. Utterback

3.566 Entrepreneurship

Prereq.: —
G (2)
4-0-5

School-Wide Elective Subject. Description given at end of this chapter on SWE page.
D. G. Jansson

3.57 Particulate Technology

Prereq.: 3.21
G (2) **Next offered 1984-85**
3-0-6

Methods of particle size analysis are presented in detail to set the stage for a discussion of the following ceramic and metallurgical processes in particulate technology: comminution, classification, sedimentation, crystallization, agglomeration, and powdered metal generation. 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
G (2)
3-0-6

See description under subject TPP 32J.
J. P. Clark, N. A. Ashford, G. R. Heaton, Jr.

3.577 Engineering Risk-Benefit Analysis (A)

Prereq.: 18.02
G (2)
3-0-6

School-Wide Elective Subject. Description given at end of this chapter on SWE page.
A. W. Drake, A. R. Odoni

3.58 Seminar on Problems in Materials Policy

Prereq.: —
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 Ocean Resources Management (A)

(Same subject as 13.961J)
Prereq.: Permission of Instructor
G (2)
3-0-6

See description under subject 13.961J.
J. P. Clark, J. T. Kildow

3.59 Research Proposals — Planning for Discovery (A)

Prereq.: —
G (2) **Not offered 1984-85**
2-0-4

Analyzes individual research proposals aimed at new discoveries 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 research proposals and includes individual counseling and evaluation by a faculty member other than advisor or thesis supervisor. Limited enrollment. Permission of Instructor required.
W. D. Kingery

3.60 Thermal and Tensor Properties of Ceramics (A)

Prereq.: 3.06 or 3.07
G (2) **Not offered 1984-85**
3-0-6

Analyzes tensor representation of properties of crystalline ceramics. Includes anisotropy, representation surfaces and effects of crystal symmetry, as well as application to piezoelectric and elastic properties and propagation of elastic waves in crystals. Discusses thermal properties: heat capacity, thermal expansion, and thermal conductivity, emphasizing materials and influences of microstructure.
B. J. Wuensch

3.601 Electrical, Optical, and Magnetic Properties of Ceramics (A)

Prereq.: 3.07
G (1) **Not offered 1984-85**
3-0-6

Analyzes electrical, optical, and magnetic properties of ceramics in terms of band theory, transport theory, and defect chemistry. Examines effects of materials processing, composition and microstructure on properties. Discusses applications of theory towards new materials development.
H. L. Tuller

3.602 Mechanical Properties of Ceramics (A) (New)

Prereq.: —
G (2) **Next offered 1984-85**
3-0-6

Discusses use of ceramics as structural materials including both fracture and deformation as related to engineering applications.
D. R. Clarke

3.603 Advanced Topics in Mechanical Properties of Ceramics (A)

Prereq.: Permission of Instructor
G (2) **Next offered 1984-85**
2-0-4

Examines 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 including effects of microstructure, composition, and environment. Emphasizes crystalline and polyphase ceramics, particularly advanced or new ceramic materials.
D. R. Clarke

3.604 Problems in Nonstoichiometry (A)

Prereq.: 3.601
G (1) **Next offered 1984-85**
2-0-4

Derives thermodynamics of nonstoichiometric phases and analyzes inherent limitations of this approach. Extends theory to highly defective systems. Applies defect chemical analysis to binary and higher order systems. Analyzes cluster models and extended defects in highly nonstoichiometric systems. Examines implications of defect structure on structural, kinetic, electrical, and other properties of such materials.
L. W. Hobbs, H. L. Tuller

3.61 Glass Structure and Properties (A)

Prereq.: 3.06 or 3.07
G (2) **Not offered 1984-85**
3-0-6

Considers 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. Emphasizes information from recent publications. Alternate years.
D. R. Uhlmann

3.611 Polyphase Ceramics (A) (Revised Unit)

Prereq.: 3.06, 3.07
G (2) **Next offered 1984-85**
3-0-9

Applies 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.
W. D. Kingery, D. R. Uhlmann

3.63 Ceramic Processes (A)

Prereq.: 3.06 or 3.08, 3.20
G (1) **Next offered 1984-85**
3-0-6

Presents quantitative treatment of unit operations in powder processing-powder preparation, fabrication, and firing. Discusses glass processing-homogenization during melting: relationship to mixing theory-glass forming. Also covers growth of crystals, thermodynamics, transport processes, and kinetics in relation to structures developed.
R. L. Coble

3.631 Processing of Metals, Ceramics, and Glasses (A) (New)

Prereq.: Permission of Instructor
G (1) **Not offered 1984-85**
3-0-6

Powder preparation, grinding, precipitation, sol-gel processing, fabrication, and firing. Herring's scaling laws and application of the diffusion sintering/hot pressing models. Cast ceramics — normal and rapid solidification. Melting and fining glasses and glass ceramics. Fabrication, annealing, tempering, optical fiber, sol-gel glasses.
R. L. Coble

3.64 Special Problems in Ceramics (A)

Prereq.: —
G (1, 2, S)
Arr.

Explores advanced work in this field. Coursework includes lectures, conferences, assigned readings, and laboratory work.
W. D. Kingery

3.691-3.699 Teaching Materials Science and Engineering

Prereq.: —
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.: —
G (1, 2, S)
Arr.

Minor investigation in one of the special branches of metallurgy. (Open only to students properly qualified in the special field.)
R. W. Balluffi

3.71J Physical Metallurgy Principles for Engineers (A)

(Same subject as 22.71J)
Prereq.: Permission of Instructor
G (1)
3-0-9

See description under subject 22.71J.
I-W. Chen

3.711J Materials for Nuclear Applications (A)

(Same subject as 22.70J)
Prereq.: 3.14 or 3.71J
G (2)
3-0-9

See description under subject 22.70J.
R. G. Ballinger

3.72J Nuclear Fuels (A)

(Same subject as 22.72J)
Prereq.: 3.14 or 22.71J
G (1)
3-0-9

See description under subject 22.72J.
R. G. Ballinger

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
G (2)
3-0-9

See description under subject 22.73J.
I-W. Chen

3.73 Special Problems in Advanced Computer Applications (A)

Prereq.: —
G (1)
1-0-8

Individual, graduate-level project focusing on computer-based analysis by modeling, simulation, optimization, or other numerical analyses. Student chooses problem, decides approach (with guidance), undertakes program design, coding, implementation, debugging, and testing. Requires working knowledge of necessary basic mathematics and suitable programming language.
L. W. Hobbs

3.75J Radiation Effects in Reactor Structural Materials (A)

(Same subject as 22.75J)
Prereq.: 3.71J or 22.71J, 22.73J
G (2) **Next offered 1984-85**
3-0-9

See description under subject 22.75J.
K. C. Russell

3.77 Laboratory Measurement and Control

Prereq.: —
G (2)
2-1-3

Discusses 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

3.82J Structural Mechanics in Nuclear Power Technology (A)

(Same subject as 1.56J, 2.084J, 13.14J, 16.261J, 22.314J)
Prereq.: Permission of Instructor
G (1)
3-0-9

See description under subject 22.314J.
J. E. Meyer, O. Buyukozturk

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
G (1)
3-0-6

Analyzes criteria for crack initiation and propagation leading to structural failure. Studies 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. Emphasizes current research in field.
F. J. McGarry, K. Masubuchi

3.91J Mechanical Behavior of Plastics (A)

(Same subject as 1.593J)
Prereq.: 1.59J
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
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. Discusses failure mechanisms of chemical, 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
G (1)
3-0-9

Considers 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. Emphasizes student participation in class discussion. Permission of instructor.
D. R. Uhlmann, Staff

3.930 Industrial Practice

Prereq.: —
U (S)
0-12-0

Enrollment restricted to students in Course III-B. Provides academic credit for first approved work assignment at a company.
J. M. Dhosi, T. B. King

3.931 Industrial Practice

Prereq.: —
U (S)
0-12-0

Enrollment restricted to students in Course III-B. Provides academic credit for second approved work assignment at a company.
J. M. Dhosi, T. B. King

3.932 Industrial Practice (A)

Prereq.: —
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.
J. M. Dhosi, T. B. King

3.95 Environmental Properties of Polymers (A)

Prereq.: 3.061J
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, G. E. Wnek

3.96 Spectroscopy and Electrical Properties of Polymers (A)

Prereq.: 3.062 or 10.641
G (2)
3-0-9

The first two-thirds of subject focus on working knowledge of modern spectroscopic techniques (primarily UV-VIS, IR, and NMR) for determination of polymer composition, microstructure, and molecular dynamics. Selected instrumentation available for laboratory work. Also discusses topics of current interest concerning electrical properties including dielectric behavior and highly conductive polymers.
G. E. Wnek

3.961 Polymer Synthesis and Properties (A)

Prereq.: 10.691
G (1)
3-1-5

Fundamental chemistry of polymerization reactions. Reaction mechanisms and polymerization techniques. Emphasizes relationships among preparation, structure, and properties. Topics: coupling reactions, radical, ion, and coordination polymerization and chemical modification of polymers.
G. E. Wnek

3.97J Materials Engineering of Polymers (A)

(Same subject as 2.927J)
Prereq.: 3.601J, 10.691
G (1)
3-0-9

Considers engineering of polymers, tailoring molecular structure and process parameters to produce materials with desired end-use properties. Specific attention to cellulosic polymers, thermosetting resins, thermally stable polymers, engineering thermoplastics, adhesives, formation of fibers, films, foams and coatings, and flammability of polymers. Emphasizes student participation in class discussion.
D. R. Uhlmann, Staff

3.99 Special Problems in Polymer Science and Engineering (A)

Prereq.: —
G (1, 2, S)
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.: —
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.: —
U (1)
3-3-6

Introductory architectural design studio about seeing and understanding the built world in a way that provides a framework of places for people. 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
U (1) LAB
3-6-3

Introduces microclimate design principles through lecture and field investigations. Wind effects on buildings, noise control, solar and nocturnal radiation control, human comfort determination, thermal storage design. Investigates how vegetation affects microclimate and how microclimate influences vegetation. Modeling methods for testing design alternatives and measurement techniques for adequate site reconnaissance. Concludes with a comprehensive environmental design problem.
T. E. Johnson

4.125, 4.126 Architectural Design[1]

Prereq.: 4.26
U (1, 2)
0-12-8

Establishes basic attitudes to architectural organization and its reflection in form. Includes projects where imposed conditions of site, program, and building system emphasize the interrelationship of fundamental elements in the pattern of decision making that constitutes architectural design. Develops presentations through drawings and models. Intended for juniors, seniors, and entering graduate students.
Staff

4.131, 4.132 Architectural Design[1]

Prereq.: 4.125, 4.126
U (1, 2)
0-12-8

4.143, 4.144 Architectural Design (A)[1]

Prereq.: 4.125, 4.126
G (1, 2)
0-12-8

Projects 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 multistory construction. Considers natural and artificial environmental controls as they influence the design concepts and the installations associated with them.
Staff

4.155, 4.156 Architectural Design (A)[1]

Prereq.: 4.144
G (1, 2)
0-12-8

Emphasizes 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. Studies 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
G (2)
0-12-8

4.161 Urban Settlement Design in Developing Countries II (A)

Prereq.: 4.160
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

[1] Note about the subjects in Architectural Design: The sequence 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.

4.163J Urban Design (A)

(Same subject as 11.332J)
Prereq.: Permission of Instructor
G (2)
Arr.

Focuses on design of extensive physical environments. Involves structuring the layout of large areas of cities to be developed over time and involving many different actors. Stresses fitting built forms to the natural, man-made, social, and cultural contexts, enabling desirable patterns of social relationships, conceptualizing built form, infrastructure and service systems, and guiding the sensory character of development. Requires individual designs, or design and process guidelines.
I. Halasz, W. L. Porter

4.164 Housing Design and Methods (A)

Prereq.: 4.211, *4.224*
G (2)
0-12-8

Understanding problems related to design of residential environments and development of skills to deal with these problems. Emphasizes application of methods which deal with issues of change, evaluation of the capacity of a given environment to accommodate to changing uses and lifestyles. Assesses the impact of changing normative criteria on the physical environment. Developing alternative solutions within a given set of constraints. Projects in the design of buildings and of urban (residential) environments.
N. Hamdi

4.17, 4.171 Special Problems in Architectural Design

Prereq.: —
U (1, 2)
Arr.

4.19, 4.191 Special Problems in Architectural Design (A)

Prereq.: Permission of Instructor
G (1, 2)
Arr.

Supplementary work on individual or group basis. Registration subject to prior arrangement for subject matter and supervision by staff.
Staff

4.211 Interventions to Urban Housing (A)

Prereq.: 4.125 or 4.126
G (1)
3-3-6

Introduces the relative roles which users and institutions play in shaping the urban residential environment and the processes of planning and building. Evaluating the evolution of these processes in various cultural and historical contexts, tackling related design information and regulatory controls. Assessing professional, governmental, and industrial interventions in these processes, types, tools, and implications. Case studies illustrate alternative approaches at dwelling and neighborhood levels.
N. Hamdi

4.224 Thematic Design: Theory (A)
(Revised Content and Unit)

Prereq.: 4.125, 4.126
G (2)
3-4-5

Lectures and exercises on the principles of thematic design. Theme, pattern, and type as ordering devices. Spatial and physical thematic systems. Levels among thematic systems. Change and the dimension of time in design. Territory and territorial order. Inside-outside and public-private transitions. Social and personal values and their relations to form. Provides understanding and skills for general use in architectural and urban design.
N. J. Habraken

4.225 Thematic Design: Methods (A)
(Revised Content and Unit)

Prereq.: 4.125, 4.126
G (1)
3-4-5

Methodological principles of thematic design and their application. Develops a spatial theme and its elaboration on the level of the building as well as the urban tissue. Involves development of variants within given thematic rules; evaluation of the capacity of specific configurations; analysis of zones, sectors, and sector groups; formulation and use of selection and position rules. Familiarizes students with generation and control of more complex form systems and appropriate use of available methods.
N. J. Habraken

4.227 Issues of Theory and Method in Design (A)
(Revised Unit)

Prereq.: Permission of Instructor
G (1)
2-0-4

Examines questions of methodology in design, theory of design, and theory of the built environment based on readings and visual documentations. Topics vary each semester.
N. J. Habraken

4.231 Computers and Graphics
(Revised Content and Unit)

(4.201)
Prereq.: Permission of Instructor
G (1)
4-2-6

A general introduction to computer graphics and its applications in design, architecture, and the graphic arts. Practical assignments provide experience in the use of 2-D and 3-D graphics in the extensive facilities of the Architecture Machine Group, including touch-sensitive screens, color raster displays, and computer-linked video systems. PL1 is the programming language most in use. Programming experience not mandatory. Open to undergraduates.
P. Purcell

4.232 Advanced Computer Graphics and its Applications (A)
(Revised Content)

(4.202)
Prereq.: 4.231
G (2)
4-0-8

Main thrust is enhancement of human/machine communication at computer graphics interface. Formulation of individual projects within current research of the Architecture Machine Group: modeling of human form and gesture and integrating of text and visual images in development of graphic information systems. Presents a wide spectrum of interactive techniques, including gesture modeling systems, voice recognition, synthesis methods, and touch-sensitive displays.
P. Purcell

4.241 Computer Graphics Programming

Prereq.: —
U (1)
4-0-8

Overview of the techniques of computer image synthesis, including both hardware and software. Line drawing and color raster graphics. Homogeneous coordinates, hidden surface, and smooth-shading algorithms. Programming problems and a term project. Limited enrollment. Previous programming experience required.
K. R. Sloan, Jr.

4.242 Advanced Computer Graphics (A)

Prereq.: 4.241
G (2)
4-0-8

Treats in-depth current research in 3-D computer graphics. Readings from recent papers. Significant term projects including an implementation, written report, and classroom presentation.
K. R. Sloan, Jr.

4.251 Digital Video (A)

Prereq.: Permission of Instructor
G (2)
2-0-7

Provides a technical introduction to video imaging, storage, and display devices, and their digital counterparts. Regards the video system as a general communications link capable of transmission of analog images as well as computer data, connected to image processing equipment as well as digital computers and displays. Topics: raster scan display architecture, anti-aliasing, optical storage, video encoding. Requirements include individual term projects.
A. Lippman

4.254J Mass Communications Technology and Policy (A)
(New)

(Same subject as 17.742J)
Prereq.: Permission of Instructor
G (2)
3-0-9

See description under subject 17.742J.
A. B. Lippman, W. R. Neuman

4.259 Special Projects in Media Technology (A)
(New)

Prereq.: Permission of Instructor
G (1, 2)
Arr.

Supplementary work on individual or group basis. Registration subject to prior arrangement for subject matter and supervision by staff.
Staff

4.26 Built-Form Observations
(Revised Content)

Prereq.: 4.01
U (2)
2-3-7

Introduces disciplined observation of the built environment. Projects indicating the various ways in which buildings, landscape, and urban form can be described and interpreted. Explores relationships among modes of description, environmental content, and design methods. Lectures, field studies, and drawing laboratory.
M. K. Smith

4.261 Design Skills Workshop
(New)

Prereq.: Permission of Instructor
G (1)
Arr.

Supplements Level I Architectural Design Studio. Emphasizes acquisition of drawing and observational skills. Field trips, guest lectures, and presentations focus on issues specific to developing a design drawing repertoire. Individual tutorials in graphic skills. Restricted to and intended for entering M.Arch. students.
J. R. Myer

4.273 Methods of Inquiry in Architecture Studies

Prereq.: Permission of Instructor
G (1)
3-2-7

Introduces ways of acquiring systematic knowledge about the built environment. Examines what constitutes valid knowledge in architecture and compares various approaches to the understanding of the built environment. Emphasizes theory building and testing appropriate to architectural studies. Requirements include exercises aimed at improving skills in conceptualizing problems; developing concepts; interpreting information; and communicating results. Required of all first-year S.M.Arch.S. students.
E. Robbins

4.276 Introduction to Building Economics (New)

Prereq.: Permission of Instructor
G (2)
4-2-6

Introduces basic analytical concepts of micro and macroeconomics, with applications to building and the building industry. Prepares for microeconomic analysis of firms engaged in planning, real estate development, design, construction, and maintenance of buildings, as well as for macroeconomic analysis of the building industry in developed and developing countries. Required of all first-year S.M.Arch.S. students.
R. Bon

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
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.: Permission of Instructor
U (1, 2)
Arr.

4.295-4.299 Special Topics in Design Information (A)

Prereq.: Permission of Instructor
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
U (2) SD
3-3-6

Introduces the static behavior of structures and strength of materials. Reactions, truss analysis, stability of structures. Stress and strain at a point, shear and bending moment diagrams. Stresses in beams, Mohr's Circle, column buckling. Deflection of beams. Laboratory to solve structural problems by building simple models and testing them.
L. B. Groisser

4.315J Structural Engineering Laboratory

(Same subject as 1.105J)
Prereq.: —
U (1) LAB
0-3-3

See description under subject 1.105J.
W. P. Zalewski

4.331 Synthesis of the Behavior of Structural Systems I

Prereq.: —
G (1)
4-0-4

4.332 Synthesis of the Behavior of Structural Systems II

Prereq.: 4.331
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. Studies relationship between shape of structure and its technological and mechanical efficiency as a way to general optimization. Applies mastery of simplified procedures — graphical and numerical — to the design of structural systems.
W. P. Zalewski

4.341 Framing Systems for Small Structures

Prereq.: 4.30 or 4.331
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 columns. Application to a wood house including alternative wood floor framing, walls, columns, and rafters. Optimum truss depth.
L. B. Groisser

4.348 Structural Design Workshop (A)

Prereq.: 4.126, 4.30 or 4.331, 4.402J
G (2)
4-4-4

Allows participation in faculty-initiated structural design research projects related to architectural applications of new building components and methods of their assembly.
W. P. Zalewski

4.39 Special Problems in Structural Design (A)

Prereq.: 4.30 or 4.331
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 Building Construction I

(Same subject as 1.411J)
Prereq.: —
U (1)
3-3-6

Basic principles of materials and methods of construction as applied to common generic building types. Emphasizes integrated team approach from preliminary design to on-site implementation. Lectures, problem sets, demonstrations, and field trips illustrate principles.
E. Dluhosch

4.403J Building Construction II (Revised Content and Unit)

(Same subject as 1.412J)
Prereq.: 1.02, 1.04; or 4.402J, 4.30 or 4.331
U (2)
2-4-3

Technical analysis and on-site case studies of selected building projects and/or their constituent sub-systems and elements. Investigates operational integration and technical implementation of materials and processes to realize explicitly stated design criteria by means of best current building practice. Develops construction documentation, details, and basic specifications within given limits of codes, regulations, and other legal restrictions.
E. Dluhosch

4.409 Special Problems in Building Technology (A)

Prereq.: 4.30, 4.402J, 4.43
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.: —
U (2)
3-3-6

Introduces the uses and physical properties of building and industrial materials, techniques of their manipulation, fabrication, and construction, and their behavior in structures with regard to functional and visual appropriateness. Work consists of exacting shop projects.
I. H. Garabieta-Orueta

4.43 Environmental Control — Acoustics

Prereq.: 4.402J, 8.02
U (1) SD
4-0-4

Develops basic principles and techniques for control of noise and vibration in buildings using sound-absorbing materials as well as constructions to isolate air-borne and structure-borne noise. Presents detailed design considerations to produce good hearing conditions in auditoriums and rooms of all sizes and for electroacoustic systems often needed to augment natural sound.
R. B. Newman

4.431 Special Problems in Architectural Acoustics (A)

Prereq.: 4.43
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
U (1)
3-0-6

Explores energy utilization in buildings specially emphasizing energy conservation. Emphasizes a qualitative understanding of the various energy flows affecting buildings as well as a quantitative understanding of the major factors influencing building design and operation. Topics: thermal comfort, climatic analysis, thermophysical properties of building materials, psychrometrics, heat gain and loss, lighting, and HVAC selection and integration.
H. J. Bryan

4.46 Solar Architecture (A) (Revised Unit)

Prereq.: 4.45
G (2)
3-0-6

Develops and applies principles for the utilization of solar energy in buildings. Covers methods for designing solar energy systems and predicting their performance. Topics: solar movement, solar radiation, fundamentals of solar heating and cooling, active solar design for space heating, cooling, and domestic hot water, passive solar design for space heating and cooling, performance and economic analysis, and the integration of solar concepts into building design.
H. J. Bryan

4.468 Energy Conscious Design (A)

Prereq.: 4.071J, 4.131 or 4.143, 4.45, *4.46*
G (2)
4-4-12

Examines energy-conscious design issues using a commercial design problem in a studio format. Presents design and modeling methods for predicting thermal and lighting behavior. Studies building material choices and introduces the latest building technology for conserving energy.
T. E. Johnson

4.474 Uses of Daylighting in Buildings (A) (Revised Content and Unit)

Prereq.: 4.45
G (1)
3-0-6

Explores and analyzes in detail the principles associated with utilization of daylighting in buildings. Topics: history of daylighting, fundamentals of light, daylight availability, strategies for daylighting design, architectural considerations, calculations and design methods, thermal and energy considerations, integration of daylighting with artificial lighting, lighting control strategies and integration of daylighting into building design.
H. J. Bryan

4.497-4.499 Special Problems in Environmental Controls (A)

Prereq.: —
G (1, 2)
Arr.

Supplementary work on individual or group basis. Registration subject to prior arrangement for subject matter and supervision by staff.
Staff

4.51 Building Systems I

Prereq.: Permission of Instructor
G (1)
3-0-6

Studies technological innovation in building construction, including mechanization, prefabrication, industrialization, and automation. Analyzes processes for building system production and delivery on-site, based on user-friendly design performance criteria. Applies appropriate building systems in both industrialized and developing countries. Lectures, case studies, and field trips.
E. Dluhosch

4.52 Building Systems II

Prereq.: 4.51
G (2)
3-0-6

Seminar on applying and/or adapting appropriate technological solutions to selected generic building types and/or construction systems. Develops innovative strategies for planning, programming, procurement, and on- or off-site assembly of rationalized, prefabricated, or industrialized building systems or subsystems. Evaluates solutions in terms of functional and spatial adaptability to changing user needs.
E. Dluhosch

4.55 Building Economics: Project Life Cycle Analysis (A) (New)

Prereq.: 4.276
G (1)
3-0-6

Examines microeconomic aspects of building and building technology in framework of project life cycle analysis. Analyzes economic role of design professionals in network of key actors participating in project life cycle: planning, real estate development, design, construction, maintenance, reconstruction. Requires empirical research projects into life cycle phases and/or facets in a unified case study format.
R. Bon

4.56 Building Economics: Inter-industry Analysis (A) (New)

Prereq.: 4.276
G (2)
3-0-6

Studies macroeconomic aspects of building and building technology in framework of inter-industry analysis. Emphasizes input-output analysis and extensions: social accounting matrices, multiregional input-output analysis, development network analysis. Requires empirical research projects into industrial and regional interdependencies of building industry in developed and developing countries.
R. Bon

4.59 Special Topics in Systems Building (A)

Prereq.: Permission of Instructor
G (1, 2)
Arr.

Supplementary study on selected topics such as managerial, economic, socioeconomic, and/or political problems connected with the building industry. Registration subject to prior arrangement for subject matter and supervision.
Staff

4.601 Topical Studies in the History and Theory of Art

Prereq.: —
U (1) HUM-D
3-0-6

Introduces the history and theory of painting and sculpture from prehistoric times to late Baroque. Examines key objects in terms of style, iconography, and function, and considers them as expressions of the social, political, religious, and intellectual values of their respective cultures. Emphasizes discussion of the different functions of art and basic modes of artistic formation. May count toward Humanities Requirement.
B. S. Tower

4.605 Introduction to the History and Theory of Architecture

(4.602)
Prereq.: —
U (2) HUM-D
4-0-5

Provides an outline of the history of architecture and urbanism from Ancient Egypt to the present. Analyzes buildings as the products of culture and in relation to the special problems of architectural design. May count toward Humanities Requirement.
D. H. Friedman

4.615 Selected Topics in Architecture of the Ancient World

(4.616)
Prereq.: 4.602
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. Open to qualified undergraduates. Permission of instructor required.
K. W. Forster

4.625 Selected Topics in Architecture in the Middle Ages

(4.626)
Prereq.: 4.602
G (1) **Not offered 1984-85**
3-0-6

A history of buildings from the time of Rome's conversion to Christianity to the beginning of the Renaissance. Deals with the history of architectural form, methods of design and construction, and the historical and physical contexts of the buildings. Open to qualified undergraduates. Permission of instructor required.
D. H. Friedman

4.635 Late Gothic and Early Renaissance Architecture (New)

Prereq.: 4.602
G (1)
3-0-6

A history of the recreation in late medieval Europe of the classical style in architecture. Examines trends in late Gothic architecture from which new style emerged in Florence in 1419. Traces its development through the work of Brunelleschi, Alberti, Bramante, and others. Deals with the architectural profession, theory, and historical and physical contexts of the buildings. Open to qualified undergraduates. Permission of instructor required.
D. H. Friedman

4.636 High Renaissance and Baroque Architecture (Revised Content)

Prereq.: 4.602
G (2)
3-0-6

A history of the establishment of the normative style of European classicism in architecture in Rome at the beginning of the 16th century and its transformations through 1750 in Mannerist, Baroque, and Rococo form. Discusses the architectural profession, the place of architecture among the arts, and the historical and physical context of the buildings. Open to qualified undergraduates. Permission of instructor required.
K. W. Forster

4.639 Architects and Patrons in the Renaissance (A) (New)

Prereq.: 4.602
G (2) **Next offered 1984-85**
3-0-6

How architects lived and worked, why, and what their patrons commissioned them to design; how buildings were constructed; and what maker, sponsor, and public thought about them. Permission of instructor required.
K. W. Forster

4.642 Modern Art from Impressionism to Cubism

Prereq.: —
U (2) HUM-D
3-0-6

Presents Cezanne, Gauguin, Van Gogh, and Seurat against a background of Impressionism and other 19th-century styles and 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 count toward Humanities Requirement.
B. S. Tower

4.645 Selected Topics in Architecture — 1750 to the Present

(4.647)
Prereq.: 4.602
G (1)
3-0-6

General study of modern architecture in Europe and America in the context of architectural and social programs. Open to qualified undergraduates. Permission of instructor required.
S. Anderson

4.646 American Landscapes, Towns, and Buildings

(4.648)
Prereq.: 4.602
G (1)
3-0-6

Introduces environmental history in the US concentrating on 19th- and 20th-century developments. Open to qualified undergraduates. Permission of instructor required.
S. Anderson, D. H. Friedman

4.647 American Architecture: Boston (New)

Prereq.: Permission of Instructor
G (2)
3-0-6

Studies urban and architectural development of Boston and its region. Selected topics in American architecture and urbanism as context for or comparison with Boston. Open to qualified undergraduates.
S. Anderson, D. H. Friedman

4.651 Modern Art from Cubism to the Present

Prereq.: —
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. Considers Post-Painterly Abstraction styles, Pop Art, Minimalism, and the resurgence of Realism both historically and critically. May count toward Humanities Requirement.
B. S. Tower

4.653 Advanced Study in 20th Century Art (A)

(4.658)
Prereq.: Permission of Instructor
G (2)
Arr.

Seminar on a selected topic from 20th-century art. Requires original research and presentation of oral and written reports.
Staff

4.654 Advanced Studies in Iconography and Symbolism (A)

(4.659)
Prereq.: Permission of Instructor
G (2)
3-0-6

Selected topics and guided research in iconography and symbolism in 19th- and 20th-century art. Registration subject to prior arrangement for subject matter and supervision by instructor.
W. V. Andersen

4.656 Modern Architecture in Europe from 1895 to the Bauhaus (A)

(4.653)
Prereq.: 4.645
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

4.661 Theory and Method in the Study of Architecture and Art (A) (Revised Unit)

Prereq.: Permission of Instructor
G (1)
3-0-6

Studies theoretical and historiographical works pertaining to the fields of architecture, art, and environmental studies. Members of seminar pursue work designed to elucidate and criticize their own presupposition and methods. Open only to Ph.D. candidates and other advanced students.
S. Anderson, K. W. Forster

4.663 Studies Toward a Theory of Architecture and Environmental Design (A)

(4.666)
Prereq.: Permission of Instructor
G (2) **Next offered 1984-85**
3-0-6

Considers contemporary theoretical positions. Requires reports in the context, criticism, or support of the seminar thesis.
S. Anderson

4.664 Criticism of Architecture (A)

(4.665)
Prereq.: Permission of Instructor
G (1) **Not offered 1984-85**
3-0-6

Surveys various approaches (social, environmental, economic, compositional, structural, functional) and bases for the criticism of architecture. Emphasizes the 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.
K. W. Forster

4.665 History and Ideology of the Villa (A) (New)

Prereq.: Permission of Instructor
G (2)
3-0-6

History of the villa from Antiquity to modern times. Examines the persistent ideology of country life and the requisite building types.
K. W. Forster

4.671 History of Urban Form (A)

Prereq.: Permission of Instructor
G (1)
3-0-6

Studies in the history of the physical city from Antiquity to the present with points of special focus determined by the instructor. Analyzes the typologies of urban buildings, public places, and city plans in their relation to changing contexts of culture, politics, and the structure of public and private institutions.
K. W. Forster, D. H. Friedman

4.672 Elements of Urban Evolution

Prereq.: —
U (2)
3-0-6

Considers 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 topics for term papers dealing with a particular city over a manageable time span. Lectures and seminars. Limited enrollment. May count toward Humanities Requirement.
D. H. Friedman

4.673 Seminar in Urban Communal Space (A)

Prereq.: Permission of Instructor
G (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.: —
U (2)
3-0-6

Promotes 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. Emphasizes India, China, and/or Japan. May count toward Humanities Requirement.
G. Nitschke

4.682 Selected Topics in the Study of East Asian Architecture (A)

Prereq.: Permission of Instructor
G (2)
2-0-7

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

4.683J The 'Islamic' City: History, Culture, and Form

(Same subject as 21.482J)
Prereq.: Permission of Instructor
G (2)
3-0-6

Introduces Islamic civilization, past and present, through a study of the city in the Muslim world. Illustrates how the lenses of social and architectural history, anthropology, and planning reveal different phenomena in the city and different aspects of urban culture and form. Poses the question: How far can the socioeconomic, political, architectural, and spatial features of such cities as Fez, Cairo, and Lahore be explained in terms of Islam? Open to qualified undergraduates.
P. S. Khoury, W. L. Porter, Y. Tabbaa

4.684 Islamic Art and Architecture (Revised Content)

Prereq.: —
U (2)
3-0-6

Introduces the architecture, painting, and decorative arts of the Islamic world. Emphasizes the major monuments of Islam in terms of their functions within the urban setting, their formal qualities and aesthetic principles, and their cultural connotation. Discusses such typical elements of Islamic architecture as inscriptions, arabesque, the minbar, the minaret and muqarnas. Also surveys the development of Islamic painting and decorative arts. May count towards Humanities Requirement.
Y. Tabbaa

4.685 Islamic Architecture and Urban Form (A)

Prereq.: Permission of Instructor
G (1) **Next offered 1984-1985**
3-0-6

Studies the Islamic built environment at the urban scale. Urban and rural case studies, history of urban design, preservation of historic sites.
Y. Tabbaa

4.686 The Mosque (A) (Revised Content)

Prereq.: Permission of Instructor
G (1)
3-0-6

The Mosque in Islamic architecture. Emphasizes geographic and formal elements rather than chronological development. Relation of the Mosque to the Islamic community and its practices.
Y. Tabbaa

4.687-4.689 Special Studies in the History, Theory, and Criticism of Architecture and Urban Form in the Islamic World (A)

Prereq.: Permission of Instructor
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 Special Studies in the History, Theory, and Criticism of Art (New)

Prereq.: —
U (1, 2)
Arr.

4.692, 4.693 Special Studies in the History, Theory, and Criticism of Art (A)

Prereq.: Permission of Instructor
G (1, 2)
Arr.

Individual or group projects on topics in the history, theory, and criticism of art. Registration subject to prior arrangement for subject matter and supervision by staff.
Staff

4.695 Special Studies in the History, Theory, and Criticism of Architecture and Urban Form (New)

Prereq.: —
U (1, 2)
Arr.

Individual or group projects in the history, theory, and criticism of architecture and urban form. Registration subject to prior arrangement for subject matter and supervision by staff.
Staff

4.696-4.699 Special Studies in the History, Theory, and Criticism of Architecture and Urban Form (A)

Prereq.: Permission of Instructor
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 Urban Development and Design

(Same subject as 11.301J)
Prereq.: Permission of Instructor
G (1)
3-0-9

Examines both structure of environment and nature of processes changing it. Topics: 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, urban ideals and futures. Seminars review cases from contemporary practice, current theories of design, and theories of form and professional role. For incoming S.M.Arch.S. and M.C.P. students.
G. Hack

4.743J Neighborhood Planning (A)

(Same subject as 11.420J)
Prereq.: 11.200, 11.210, 11.220; or 4.144
G (2)
3-0-6

See description under subject 11.420J.
P. L. Clay

4.744J Site Planning

(Same subject as 11.336J)
Prereq.: —
G (2)
1-8-3

See description under subject 11.336J.
D. Lee

4.745J Problem Setting in Environmental Programming (A)

(Same subject as 11.311J)
Prereq.: Permission of Instructor
G (2)
3-0-9

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. Considers conceptual, managerial, political, financial, and regulatory as well as physical design factors shaping environments. Short exercises drawn from programming for various public, institutional, and residential environments.
E. Robbins

4.747J Theory of City Form (A)

(Same subject as 11.330J)
Prereq.: 11.001 or 4.736J or 11.301J
G (2)
3-0-6

Theories about the form that settlements should take. Attempts a distinction between descriptive and normative theory by examining examples of various theories of city form over time. Concentrates on the origins of the modern city and theories about its emerging form, including the transformation of the 19th-century city and its organization. Analyzes current issues of city form in relation to city making, social structure, and physical design.
J. Beinart

4.751 Urbanization in Developing Countries: People, Dwellings, Land (A)

Prereq.: Permission of Instructor
G (1)
3-3-6

Identifies 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. Actual practice in Africa and Latin America forms the frame of reference as well as its main sources. Extensive use of case studies of actual projects.
H. Caminos, R. Goethert

4.753J Urban Settlements in Developing Countries (A)

(Same subject as 11.313J)
Prereq.: Permission of Instructor
G (2)
3-0-6

See description under subject 11.313J.
L. R. Peattie

4.763J International Cases in Urban Planning and Design (A) (New)

(Same subject as 11.331J)
Prereq.: Permission of Instructor
G (2)
3-0-6

Focuses on the evolution of four recent national efforts in developed and developing countries to shape and manage urban growth through ongoing state intervention and implementation (Paris, London, Bogota, and Tunis). Each case studied along sectoral lines and of different design scales. Structured approach to studying physical planning. Topics: appropriateness of export models, spatial allocation of activities, dislocation and diseconomies of growth and modernization, and centralized vs decentralized planning.
J. de Monchaux

4.764 Culture, Place, and Architecture (A) (New)

Prereq.: Permission of Instructor
G (2)
3-0-6

Introduces issues about culture, place, and architecture. Discusses appropriateness of various definitions of culture in explaining and describing the built environment and looks at cultural sources for the design of place and buildings in several different societies — traditional and contemporary. Research about culture to effect a richer understanding of architectural meaning and form.
E. Robbins

4.766J Community, Class, and Race: A Social Perspective

(Same subject as 11.328J)
Prereq.: Permission of Instructor
G (2) **Next offered 1984-85**
3-0-6

The nature of the community as a social reality. Emphasizes the different meanings of the concept "community." Discusses the methodological assumptions and problems underlying notions of community. Cases cover the theory of community; the community study in America and Europe; community as place; class, race, ethnicity, and community. Readings and evaluations of theoretical, descriptive, and methodological writings on community.
E. Robbins

4.767J Planning in Socialist Countries (A) (New)

(Same subject as 11.417J)
Prereq.: Permission of Instructor
G (1)
3-0-6

See description under subject 11.417J.
R. Bon, K. R. Polenske

4.771 Behavior in the Built Environment

Prereq.: Permission of Instructor
G (1)
3-3-6

Introduces behavioral science theories and methods as they relate to interactive affects of people in residential, working, and therapeutic settings. Readings supplement lectures and assigned fieldwork. Reading and interpretation of social science literature; application of 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
G (2)
3-0-6

Advanced seminar in selection and utilization of social science information in the formulation of architecture and planning programs. Current programming issues form basis of case studies. Stresses principles of information transfer and feedback in evaluation of existing programs and their built/occupied results. Representatives of public and private decision-making agencies may participate.
S. C. Howell

4.781, 4.782 Research Topics in Architecture Studies (A) (New)

Prereq.: 4.273
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
G (1, 2)
Arr.

Supplementary work on individual and group basis. Registration subject to prior arrangement for subject matter and supervision by staff.
Staff

Visual Arts

4.801 Art and the Environment

Prereq.: —
U (1)
3-0-6

Reviews art, architecture, and celebrations and their positions in workday, religious, and political life. Reconsiders the present position of art and redefines the artist's options in the contemporary environment. Examines fact and chances effected by current science and technology vis-a-vis our place in nature and history. May count toward Humanities Requirement.
O. Piene

4.802 Visual Form and Expression

Prereq.: —
U (2) HUM-D
3-0-6

Introduces the language of art and emphasizes 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 clarify assignments involving manipulation of the visual elements that constitute the vocabulary of non-verbal expression. May count toward Humanities Requirement.
R. O. Preusser

4.821 Visual Projects I

Prereq.: —
U (1, 2)
3-0-6

4.822 Visual Projects II

Prereq.: 4.821
U (2)
3-0-6

Emphasizes the interaction of media concepts and design principles in creating visual form and explores the potential for new modes of artistic performance inherent in science and technology. Projects involve experimental manipulation of materials, tools, techniques, physical processes, natural forces, and optical phenomena as means for visual invention, organization, and expression. Visual Projects II engages students in independently formulated projects. May count toward Humanities Requirement.
R. O. Preusser

4.823 Form and Design I

Prereq.: —
U (1)
2-4-6

Studies 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. Emphasizes imagination and visual sensitivity directed to enlarge the individual's ability to create an aesthetic form. May count toward Humanities Requirement.
R. Filipowski

4.824 Form and Design II

Prereq.: —
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. Emphasizes architectonic and sculptural aesthetic of form. May count toward Humanities Requirement.
R. Filipowski

4.825 Form and Color

Prereq.: —
U (1, 2)
3-0-6

Examines color in natural form. 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 count toward Humanities Requirement.
R. Filipowski

4.826 Form and Color Workshop

Prereq.: *4.825*
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 count toward Humanities Requirement.
R. Filipowski

4.827 Plastic Composition

(4.867)
Prereq.: 4.824
U (2)
2-4-6

Continuity of surfaces, synthesis of diverse geometries, group form relationships, object and the landscape, and the optimum three-dimensional relationship of the object form basis for studying plastic sculptural composition. Emphasizes inventiveness and meaning of sculptural form. May count toward Humanities Requirement.
R. Filipowski

4.828 Special Problems in Visual Design

Prereq.: 4.822 or 4.824
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.: —
U (1)
0-4-8

Design and planning of environmental art installations in given and chosen existing settings. Emphasizes 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 and to sound and video installations and performances. May count toward Humanities Requirement.
O. Piene

4.838 Special Problems in Environmental Art

Prereq.: 4.831
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
G (1)
2-4-6

4.842 Environmental Light and Color II (A)

Prereq.: Permission of Instructor
G (1)
2-9-9

Analyzes perceptual and psychological responses to light and color and explores their dynamic and qualitative attributes within the context of environmental art and architecture. Projects involve the manipulation of artificial illumination and color to affect visual scale and dimension, coordination of light and movement to animate environmental spaces, and orchestration of light and color as the means for creating expressive environments. 4.841 and 4.842 offered simultaneously. 4.841 open to qualified undergraduates.
R. O. Preusser

4.845, 4.846 Advanced Visual Design (A)

Prereq.: Permission of Instructor
G (1, 2)
0-8-12

Individual concepts, projects, design, and execution of installations, objects, and events in environmental art and performance involving elemental and science-technology means and media.
O. Piene

4.855-4.859 Special Problems in Environmental Art (A)

(4.895-4.899)
Prereq.: Permission of Instructor
G (1, 2)
Arr.

Special work on an individual or group basis using specific means such as video, holography, and multimedia. Registration subject to prior arrangement of subject matter and supervision by staff.
O. Piene

4.861 Life Drawing (Revised Content)

Prereq.: —
U (1, 2)
0-3-2

Approaches life drawing emphasizing the dynamic rather than realistic aspect of rendering. Encourages making impressions of the human figure by relying on creative instincts and natural ability to create illusions using the conte crayon and an eraser. Some exercises deal with precise observations and skill in graphic representation. May be repeated for credit.
N. Bichajian

4.862 Still-Life Drawing (Revised Content)

(4.861)
Prereq.: —
U (1, 2)
0-3-2

Approaches still-life drawing emphasizing light and shadow and linear and perspective renderings of varied subject matter. Value, color, texture, and form using conte, pen and ink, brush, and chalk to mix and create images. May be repeated for credit.
N. Bichajian

4.863 Advanced Figure Drawing

(4.862)
Prereq.: 4.861
U (1, 2)
0-3-2

Emphasizes the formal elements of line, mass, texture, and spatial development and the expressive, emotional value of the figure drawn on two-dimensional surfaces. Experimentation with a wide variety of techniques using a conte crayon and an eraser.
N. Bichajian

4.870 Words, Images, Graphics Tools, and Ideas

Prereq.: —
U (1)
2-4-6

Introduces 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. Uses photographic, print, typographic, electrostatic, video, electronic, and other graphics/imaging tools in two and three dimensions. Group exploration of mass-media tools from printing to video and audio as a final public presentation. Lab fee. May count toward Humanities Requirement.
M. R. Cooper, R. L. MacNeil

4.871 Graphics Communication Workshop

(4.876)
Prereq.: —
U (2)
2-4-6

Thinking and communicating visually and sensorially by design. Applies static and dynamic graphic principles to the design of drawing, typography, symbols, diagrams, maps, photography, video, computer-graphics, color, word and image organization, sound and animation. Develops perspective and conceptual skills culminating in a coordinated media presentation of issues and ideas in such forms as photo essays, printed reports, slide shows, videotapes. Lab fee. May count toward Humanities Requirement.
M. R. Cooper

4.872 Graphics/Imaging Workshop: Print Media (Revised Content)

Prereq.: 4.870 or 7.871
G (1)
2-4-6

Comprehensive, production-based workshop in graphic systems from photography to typography to lithography addressing the relationship between tools and the messages they convey. Emphasizes synthesis of verbal and visual communication skills and development of work from concept to product. Graphic arts darkroom experience leads to individual and group projects in variety of print media from photographic techniques and offset printing to electronic scanning and digital typesetting. Open to qualified undergraduates.
M. R. Cooper

4.873 Graphics/Imaging Workshop: Transmission Media (Revised Content)

Prereq.: 4.870 or 4.871
G (2)
2-4-6

Explores image processing systems and transformations allowing their output in two-, three-, or four-dimensions through any of the senses. Centers on analog and digital forms of expression that can be transmitted locally and globally through such means as personal and public networks, telephone, cable, and satellite in order to gain a heightened understanding of communication systems and their physical and ideational transforms. Explores notions of "image" beyond those traditionally accepted. Open to qualified undergraduates.
M. R. Cooper, R. L. MacNeil

4.874 Graphics/Imaging Workshop: Color (Revised Content)

(4.875)
Prereq.: 4.870 or 4.871
G (1)
2-4-6

Explores the uses of color theories such as modern additive and subtractive synthesis. Creates graphic color expressions in analog and digital imaging systems at the Visible Language Workshop and transforms them through color image enhancement, manipulation, and conversion from one medium to another. Uses both the VLW electronic scanner and computer graphic/imaging system to allow realization in traditional photomechanical print systems such as color-coupler materials, offset lithography, and dye transfer. Open to qualified undergraduates.
R. L. MacNeil

4.875 Computer Graphics Workshop I (New)

Prereq.: 4.870 or 4.871
G (1)
2-4-6

4.876 Computer Graphics Workshop II (New)

Prereq.: 4.876
G (2)
2-4-6

Project-based survey introduces the computer as an expressive tool in image and word manipulation/synthesis. Graphical problem solving in PL1 and Magic6 using sample programs. Connections to traditional and experimental print forms using the Visible Language Workshop's full-color computer graphics system, color graphic arts scanner, plotter, small hardware projects in digital markmaking. Requires final project produced on VLW system and a software or hardware tool which can be installed as part of that system. Open to qualified undergraduates.
M. R. Cooper

4.878, 4.879 Graphics/Imaging Media Projects (New)

Prereq.: 4.870 or 4.871
U (1, 2)
Arr.

Special work on an individual or group basis combining research and projects in graphics/imaging media. Registration subject to prior arrangement for project and supervision by staff.
Staff

4.880 Media Communication Seminar and Workshop (A) (Revised Content)

Prereq.: Permission of Instructor
G (1)
2-4-6

Explores synthesized production of media art and technology in a three-part format of research, projects, and presentations: 1) the production and evaluation of personal projects; 2) presentations by participants and researchers in art and technology; 3) seminars on media art and technology theory and issues. Topics: computer typography, animation, and imaging systems work culminates in a short conference, exhibition, and documentation of projects.
M. R. Cooper, R. L. MacNeil

4.881 Graphics/Imaging Media Research Methods (A) (New)

Prereq.: 4.880
G (2)
2-4-6

Investigates the intrinsic similarities and differences between research modes and issues in the arts, humanities, science and technology. Develops new models of research communication. Selected speakers and presentations. Final project includes the documentation, presentation, and defense of a pre-thesis project.
M. R. Cooper, R. L. MacNeil

4.887–4.889 Graphic Imaging Media Projects (A)

Prereq.: Permission of Instructor
G (1, 2)
Arr.

Special work on individual or group basis combining research and projects in graphics/imaging media. Registration subject to prior arrangement for subject matter and supervision by staff.
Staff

4.901 Creative Seeing

Prereq.: —
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 count toward Humanities Requirement.
M. R. Cooper

4.905 Small Built-Collage (A) (New)

Prereq.: 4.143
G (1)
3-0-9

The intrinsic attributes/generative principles of built- and landscape-form/additive directional-field organization. A progression of intensifications includes surfaced relief, "habitable" planar assemblages, and territorial screens.
M. K. Smith

4.908 Special Projects in Visual Arts

Prereq.: Permission of Instructor
U (1, 2)
Arr.

4.909 Special Projects in Visual Arts (A)

Prereq.: Permission of Instructor
G (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

4.915 Basic Photography for Architects

Prereq.: Permission of Instructor
G (1, 2)
3-0-9

A basic approach to architectural photography including film processing, printing, techniques, copy work, filtration, and metering. Technical information to better understand the relationship between film, camera, and light. Topics include the role of daylight and artificial light and their relation to forms, tone, and texture in picture taking, basic design, and composition. 35mm camera necessary.
N. Bichajian

4.921 Creative Photography I

Prereq.: —
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 encourage exploration of all aspects of creative photography. Assumes that possibilities for personal expression increase as technique grows. Lab fee. May count toward Humanities Requirement.
M. Bishop, B. Swift

4.931 Creative Photography II — Color Photography (Revised Content)

Prereq.: 4.921
U (2)
3-0-9

Introduces theory and craft of various color photographic printmaking processes. Emphasizes color theory. Weekly critiques, demonstrations, and slide lectures. Requires a substantial project. Lab fee. May count toward Humanities Requirement.
M. Bishop

4.932 Creative Photography II — A Personal Approach

Prereq.: 4.921
U (2)
3-0-9

Intermediate level production subject emphasizing the student's unique vision. Requires a substantial project. Weekly critiques, readings, and intensive study of related well-known photographic work. Lab fee. May count toward Humanities Requirement.
B. Swift

4.938 Special Projects in Photography

Prereq.: 4.921
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

4.939 Advanced Photography (New)

Prereq.: 4.931 or 4.932
U (1)
2-5-5

4.941 Advanced Photography (A)

Prereq.: Permission of Instructor
G (1)
2-5-5

Production-oriented workshop in photography. Students pursue and develop own unique styles. Explores advanced technical problems and various methods of evaluating images.
M. Bishop

4.945 Advanced Photography Seminar: Visiting Artists (A) (Revised Unit)

Prereq.: Permission of Instructor
G (2)
Arr.

Evaluation of student work by visiting artists. Intensive production workshop emphasizing expanding and strengthening the student's personal vision in photography.
M. Bishop

4.946 Advanced Photography Workshop (A)

Prereq.: Permission of Instructor
G (1)
3-3-6

4.947 Advanced Photography Workshop (A)

Prereq.: 4.946
G (2)
3-3-14

Focuses on the growth and development of personal work. Offers opportunities for presenting and discussing research and projects preparatory to thesis. Field trips, contribution to expanding photographic archives, technical demonstrations, guest artist participation, and exploration of linkages with other visual arts. Requires intense commitment to production and participation in weekly group meetings which discuss work in progress.
M. Bishop

4.949 Special Advanced Projects in Photography (A)

Prereq.: 4.941
G (1, 2)
Arr.

Advanced photographic production projects on an individual or group basis. Work in various fields of photography not covered by regular subjects. Registration subject to prior arrangements of subject matter and supervision.
Staff

4.953 Spatial Imaging Systems (New)

Prereq.: Permission of Instructor
G (1)
3-3-3

Surveys the technology of spatial imaging from stereoscopes to holograms, emphasizing unaided viewing systems, and explores the perceptual, technical, and aesthetic bases of satisfying three-dimensional image communication. Includes a review of the elements of imaging optics. Lab fee. Open to qualified undergraduates.
S. Benton

4.954 Holographic Imaging (New)

Prereq.: Permission of Instructor
G (2)
3-3-3

A laboratory-based exploration of the principles, techniques, and applications of holography as a visual medium, emphasizing white-light holograms and digital/photo/optical syntheses of quasiholographic images. Lab fee. Enrollment limited. Open to qualified undergraduates.
S. Benton

4.959 Special Projects in Spatial Imaging (A) (New)

Prereq.: 4.953 or 4.954
G (1, 2)
Arr.

Advanced spatial imaging and/or holographic 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
U (2)
4-6-2

Workshop in unscripted synchronous sound moviemaking with Super-8 film and portable video. Emphasizes approaches to filming real life experience, while exploring moving images in their relation to sound. Introduces techniques of camerawork, sound recording, and editing with regard to theoretical considerations of subject presentation and modes of personal expression. Lab fee. May count toward Humanities Requirement.
G. Davenport

4.973 Intermediate Motion Picture Production

Prereq.: 4.971
U (1)
4-6-2

Intermediate moviemaking with film and video, plus studio and cablecasting facilities. Planning and execution of individual or group projects. Emphasizes refinement of technique and theory, and encourages specialized application of movie media. Concentration on particular problems such as bio/autobiographical, space/time, performance, science movies. Possible use of cable or local broadcast television. May count toward Humanities Requirement. Permission of instructor required.
G. Davenport

4.977 Special Projects in Cable TV

(4.968)
Prereq.: Permission of Instructor
U (2)
Arr.

Supplementary work on individual or group basis. Registration subject to prior arrangement of subject matter and supervision by staff. Development of a significant project using the MIT cable TV system.
Staff

4.978 Independent Projects in Film/Video Production

Prereq.: Permission of Instructor
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 Moviemaking Workshop (A) (Revised Content and Unit)

Prereq.: Permission of Instructor
G (1)
8-12-4

Intensive advanced workshop in unscripted moviemaking. Combines a thorough review of sound, single and double system, super 8, and video technologies and production techniques with screening and discussing other filmakers' work. Following initial exercises in sound, super 8, and video, students complete two short but significant movies, one in super 8, one in video. Average cost of supplies $200 per student. Required of all entering graduate students in Film/Video section.
G. Davenport

4.982 Advanced Production: Problems in Editing (A)

Prereq.: 4.981
G (2)
4-6-2

Close analysis on a flatbed of editing techniques in student work in progress and significant work by other filmakers. Discusses theoretical problems. Students edit scenes shot by other filmakers as well as complete two movies of their own. Required of all second semester graduate students in Film/Video section.
R. Leacock

4.983 Visiting Artists Workshop (A)

Prereq.: 4.981
G (2)
Arr.

Advanced seminar sharing theoretical and technical problems of moviemaking approach, structure and subject development, and editing with visiting film/video makers, technical experts, fellow students, faculty, and staff. May include special workshops in group production or technical subjects. Final paper. Required of all graduate students in Film/Video section.
R. Leacock

4.984 Design Project in Film/Video Technology (A)

Prereq.: Permission of Instructor
G (1)
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 (A)

Prereq.: 4.981
G (2)
4-4-4

A direct approach to technical concerns of the independent filmmaker for all phases of film/video production including sound, super 8 and 16 mm film, video. Topics: lens and camera options, raw stocks, printing techniques; microphones and recording techniques, audio processing and mixing; lighting; basic electricity, electronics, and power systems; video carneras, recorders, and editing systems and options; film video transfers; field maintenance.
R. Leacock

4.988 Workshop in Elastic Movie Time (A) (Revised Content and Unit)

Prereq.: 4.982, 4.985
G (1)
6-8-2

Intensive workshop in electronic image, sound, and time manipulations exploring new movie forms. Participants use the Film/Video group's video editing and research facility to create works that expand and contract motion picture time. Projects involve multiple edits of two movies and a presentation of possible applications of elastic time: multiple-media performance events, interactive movies, personalized editing.
B. Bergery

4.989 Independent Projects in Motion Picture Production (A)

Prereq.: Permission of Instructor
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.: —
U (1)
3-0-6

Views and discusses movies particularly in light of technological innovation. Analyzes various film genres revealing the relation of the historical development of production technology to film form and content. Some elementary moviemaking exercises. Requires final paper. Lab fee. May count toward Humanities Requirement.
R. Leacock

4.999 Special Topics in Film History and Criticism (A)

Prereq.: 4.991
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.: —
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
U (1)
4-0-8

Presents theoretical principles of chemical bonding and molecular structure, and their application to the chemistry of all the elements of the periodic system.
D. Seyferth, M. S. Wrighton

5.04 Principles of Inorganic Chemistry II

Prereq.: 5.03
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.
M. S. Wrighton, S. J. Lippard

5.05 Principles of Inorganic Chemistry III

Prereq.: 5.03, 5.04
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. Emphasizes synthesis and reactivity, metal complexes with n-π acceptor ligands, organometallic chemistry, bioinorganic chemistry, and reactivity patterns of the heavier elements.
R. R. Schrock, S. J. Lippard

5.065 Advanced Inorganic Chemistry (A)

Prereq.: 5.03
G (2) **Next offered 1984-85**
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.
D. Seyferth

5.066 Introductory Bioinorganic Chemistry (Revised Content)

Prereq.: 5.03
G (1)
2-0-4

Emphasizes structural, spectroscopic, and functional properties of transition metals coordinated to proteins. Overviews metabolism, storage, toxicity, and catalytic roles of metal ions, followed by description of the principle methods useful in metallobiochemistry. Considers the principal types of metalloproteins. Students prepare and present library research papers on selected topics not covered in lecture.
W. H. Orme-Johnson

5.067 Inorganic Chemistry (A)

Prereq.: 5.03
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.
A. Davison

5.195 Interpretive Spectroscopy (A)

Prereq.: 5.42, 5.61
G (1)
3-0-6

Discusses spectrometric techniques and their application to identification of organic chemical compounds. Major emphasis on complementary use of infrared, nuclear magnetic resonance, and mass spectrometry. Also discusses instrumental and operational aspects of mass spectrometry.
G. A. Berchtold, W. R. Roush

5.310 Laboratory Chemistry

Prereq.: *5.41*
U (1, 2) LAB
2-8-2

Introduces 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. Enrollment limited to 100 students in Term 1 and to 180 students in Term 2.
Term 1: *R. A. Alberty*
Term 2: *R. A. Alberty, K. A. Nelson*

5.311 Introductory Chemical Experimentation

Prereq.: *5.41*
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.
R. A. Alberty, S. T. Ceyer

5.32 Intermediate Chemical Experimentation

Prereq.: 5.310 or 5.311, *5.42, 5.60*
U (2)
0-12-3

Experimental work more advanced than in 5.310 or 5.311 emphasizing 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.
R. R. Schrock, Staff

5.33 Advanced Chemical Experimentation

Prereq.: 5.32, *5.61*
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, K. A. Nelson

5.40 General Chemistry

Prereq.: —
U (1) SD
5-0-7

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.
A. Davison

5.41 Introduction to Structure, Bonding and Mechanism

Prereq.: —
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: *D. S. Kemp, K. B. Sharpless*
Term 2: *G. A. Petsko*

5.42 Organic Chemistry

Prereq.: 5.41
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.
G. A. Berchtold, F. D. Greene

5.43 Organic Chemistry

Prereq.: 5.42
U (2)
4-0-8

Studies reaction mechanisms emphasizing reactive intermediates, structure-reactivity relationships, and reactions of synthetic value.
R. L. Danheiser

5.50J Advanced Biochemistry (A) (Revised Content and Unit)

(Same subject as 7.75J)
Prereq.: 7.05
G (2)
4-0-8

See description under subject 7.75J.
G. M. Brown, C. T. Walsh

5.51 Advanced Organic Chemistry: Synthesis (A)

Prereq.: *5.53*
G (1)
3-0-6

Studies general methods and strategies for the synthesis of complex organic compounds.
S. Masamune, R. L. Danheiser

5.52 Advanced Biological Chemistry (New)

Prereq.: Permission of Instructor
G (1)
2-0-4

Concepts and methods of biochemistry, with emphasis on quantitative aspects of problem analysis.
Staff

5.53 Molecular Structure and Reactivity (A)

Prereq.: 5.32, 5.42
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
G (2) **Not offered 1984-85**
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.
Staff

5.55 Organic Chemistry: Natural Products (A)

Prereq.: 5.51
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
G (2)
3-0-6

Advanced topics of special current interest.
S. Masamune, W. R. Roush

5.57 Chemistry of Amino Acids, Peptides, and Proteins (A)

Prereq.: 5.42
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
G (1) **Next offered 1984-85**
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.
M. F. Roberts

5.59 Enzyme Physical Chemistry (New)

Prereq.: 5.62
G (2)
2-0-4

Biophysical approaches to mechanisms of enzyme-catalyzed reactions. Analyzes **kinetic** mechanisms from fit of algebraic models to steady-state and pre-steady-state rate data. Interprets structural and spectroscopic data to yield **chemical** mechanisms. Evaluates evidence on sources of rate enhancement. Thermodynamic profiles and evolution of enzyme mechanisms. Emphasizes use of physical methods, particularly with metalloenzymes. Examples mainly from major cellular oxidoreductive processes.
W. J. Orme-Johnson

5.60 Chemical Thermodynamics

Prereq.: *18.02*
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: *J. L. Kinsey, I. Oppenheim*
Term 2: *C. W. Garland, R. J. Silbey*

5.61 Physical Chemistry

Prereq.: 8.02, 18.02
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
U (2)
4-0-8

Elementary kinetic theory and statistical mechanics; transport properties of gases and liquids; rates of chemical reactions.
J. L. Kinsey, S. T. Ceyer

5.64J Biophysical Chemistry

(Same subject as 7.71J)
Prereq.: 5.60, 7.05
U (1)
4-0-8

See description under subject 7.71J.
G. A. Petsko, R. T. Sauer, P. R. Schimmel

5.65 Physical Chemistry of Macromolecular Solutions

Prereq.: 8.02, 5.60, 5.62
U (2)
2-0-4

Introduces 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
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.
M. F. Roberts

5.68 Kinetics of Chemical Reactions (A)

Prereq.: 5.62
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
G (1)
3-0-6

Reviews classical thermodynamics and introduces elementary statistical mechanics, with applications to simple physical and chemical systems.
C. W. Garland

5.72 Statistical Mechanics (A)

Prereq.: 5.70, 5.73, 18.075
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.
I. Oppenheim

5.73 Introductory Quantum Mechanics I (A)

Prereq.: 5.61, 8.03
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.
R. W. Field

5.74 Introductory Quantum Mechanics II (A)

Prereq.: 5.73, 18.075
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.
R. W. Field

5.76 Molecular Spectra and Molecular Structure (A)

Prereq.: 5.61 or 5.73 or 8.05
G (2) **Next offered 1984-85**
3-0-6

Atomic Spectra. Rotational, vibrational, and electronic spectra of diatomic and polyatomic molecules. Assignment of spectra. Structural parameters, molecular models, and effective Hamiltonian matrices. Breakdown of the Born-Oppenheimer approximation. Group Theory, selection rules, normal coordinates. Laser spectroscopy.
R. W. Field

5.80 Special Topics in Chemical Physics (A)

Prereq.: 5.70, 5.73
G (1, 2)
Arr.

Advanced topics of special or current interest. The specific areas announced in advance of each term.
Staff

5.82 Advanced Topics in Solid-State Chemistry (A)

Prereq.: 5.70, 5.73
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.

5.89 Special Problems in Chemistry for Undergraduates

Prereq.: —
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.: —
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.: —
G (1)
1-0-2

5.914 Seminar in Organic Chemistry (A)

Prereq.: —
G (2)
1-0-2

Discusses current journal publications in organic chemistry by graduate students and staff members.
Term 1: *R. L. Danheiser*
Term 2: *W. R. Roush*

5.915 Seminar in Analytical Chemistry (A)

Prereq.: —
G (1) **Next offered 1984-85**
1-0-2

5.916 Seminar in Analytical Chemistry (A)

Prereq.: —
G (2) **Next offered 1984-85**
1-0-2

Discusses topics of current interest in analytical chemistry by graduate students and staff members.
K. Biemann

5.931 Seminar in Physical Chemistry (A)

Prereq.: —
G (1)
1-0-2

5.932 Seminar in Physical Chemistry (A)

Prereq.: —
G (2)
1-0-2

Discusses 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.: —
G (1)
1-0-2

5.942 Seminar in Inorganic Chemistry (A)

Prereq.: —
G (2)
1-0-2

Discusses current research in inorganic chemistry by graduate students and staff.
Term 1: *D. Seyferth*
Term 2: *R. R. Schrock*

6 Electrical Engineering and Computer Science

Basic Undergraduate Subjects

6.001 Structure and Interpretation of Computer Programs

Prereq.: —
U (1, 2)
5-3-7

Control of complexity in large programming systems. 1) Building abstractions: computational processes; higher-order procedures; compound data; data abstractions.
2) Controlling interactions: generic operations; self-describing data; message passing; streams and infinite data structures. 3) Metalinguistic abstraction: interpretation of programming languages; machine model; compilation; embedded languages. Substantial weekly programming assignments are an integral part of the course. Students with no prior programming experience should consult instructor. Enrollment may be limited.
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
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. Enrollment may be limited.
S. D. Senturia, C. L. Searle, J. K. Roberge

6.003 Signals and Systems

Prereq.: 6.002; 18.03 or 18.700
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

6.004 Computation Structures[1] (New)

Prereq.: 6.001, 6.002
U (2)
4-3-8

Introduces architecture of digital systems, emphasizing structural principles common to a wide range of technologies. Multi-level implementation strategies; definition of new primitives (e.g., gates, instructions, procedures, processes) and their mechanization using lower-level elements. Analysis of potential concurrency; precedence constraints and performance measures; pipelined and multidimensional systems. Instruction set design issues; architectural support for contemporary software structures. Will replace 6.032.
S. A. Ward

6.012 Electronic Devices and Circuits

Prereq.: 6.002; 8.02 or 8.033
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
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; relation of quasistatic laws to the complete Maxwell's equations. Extensive use of engineering examples.
H. A. Haus, J. R. Melcher

[1]Either 6.032 or 6.004 will be offered Second Term 1983-84; consult Department.

6.014 Electrodynamics

Prereq.: 6.013
U (1, 2)
4-0-8

Plane waves in three dimensions; radiation from elementary electric dipoles, current distributions, and arrays; diffraction and interference. Waves on continuous transmission lines, periodic structures, and dielectric and metallic waveguides; propagation and evanescence; energy flow and impedance matching. Phase and group velocity. Natural frequencies and modes of closed electromagnetic structures; coupling to resonant structures, loaded and unloaded Q's. Examples taken from the fields of acoustics, optics, and microwaves.
J. A. Kong, D. H. Staelin

6.018 Statistical Mechanics and Thermodynamics

Prereq.: 3.091 or 5.40 or 5.41; 8.02
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

(Same subject as 2.791J, HST 541J)
Prereq.: 2.02 or 6.002 or 6.071; 8.02; 18.03
U (1)
4-2-6

Principles of mass transport, electrical signal generation, motility, and mechanical stability for biological membranes, cells, and tissues. Mass transport through membranes: diffusion, osmosis, chemically mediated, and active transport. Electric properties of cells: ion transport; equilibrium, resting, and action potentials. Intercellular communication: electrical and chemical junctions. Muscle contraction. Mechanics of connective tissue. For juniors and seniors.
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*
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. Emphasis on those systems, features, and devices that are most illuminated by the methods of physical sciences. 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
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

6.032 Computation Structures[1]

Prereq.: 6.001, 6.002
U (1, 2) **Not offered 1984-85**
4-0-8

Describes and analyzes computer architecture for the purpose of designing hardware capable of supporting desired software features. 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, language, data, and hardware structures. 6.071 may satisfy the 6.002 prerequisite; consult instructor. Will be replaced by 6.004.
S. A. Ward

6.033 Computer System Engineering

Prereq.: 6.032
U (1)
4-0-8

Topics on the engineering of computer software and hardware systems. Multilevel memory systems; naming and binding; privacy of information. Atomicity and coordination of parallel activities. Recovery and reliability. Networks and distributed systems. Limitations 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, D. P. Reed

6.034 Artificial Intelligence

Prereq.: 6.001
U (1) SD
4-0-8

Studies 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, logic, common sense, reasoning and representation.
P. H. Winston

6.035 Computer Language Engineering (Revised Unit)

Prereq.: 6.032, 6.170
U (2)
4-4-4

Analyzes issues associated with the implementation of higher-level programming languages. Fundamental concepts, functions, and structures of compilers. The interaction of theory and practice. Using tools in building software. Includes a substantial multi-person project on compiler design and implementation.
J. V. Guttag

6.036 Problem-Solving Paradigms

Prereq.: 6.034
U (2)
4-0-8

Investigates 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.: —
U (2)
3-0-6

Introduces 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
U (1, 2) SD
4-0-8

Modeling, quantification, and analysis of uncertainty. Formulation and solution in sample space. Random variables, transform techniques, simple random processes and their probability distributions, Markov processes, limit theorems, elements of statistical inference, and decision making under uncertainty. Interpretations, applications, and lecture demonstrations.
A. W. Drake

6.045J Computability, Automata, and Formal Languages

(Same subject as 18.420J)
Prereq.: 18.041 or 18.063
U (1, 2)
3-0-9

Introduces basic mathematical models of computation and the finite representation of infinite objects. Finite automata and regular languages. Pushdown automata and context-free languages. 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. Introduces mathematical logic.
C. E. Leiserson, M. Sipser

6.046 Introduction to Algorithms

Prereq.: 6.001, 18.063
U (1)
3-0-9

Techniques for the design and analysis of efficient algorithms emphasizing methods useful in practice. Broader coverage than 18.411 or 18.424. Topics: Sorting. Data structures for sets: lists, trees, hashing. Graph algorithms: shortest paths, depth-first search, matching, traveling salesman. NP-complete problems. Integer arithmetic: GCD's, primality testing, multiplication of large integers. Fast Fourier transform. Multiplication of polynomials. Dynamic programming. Linear programming. Parallel algorithms for expression evaluation.
R. L. Rivest

6.061 Modeling and Analysis of Electromechanical Devices

Prereq.: 6.002, 6.013
U (1) **Next offered 1984-85**
3-0-9

Fundamentals of energy-handling electric circuits and electromechanical apparatus. Modeling of magnetic field devices and description of their behavior using appropriate models. Simplification of problems using transformation techniques. Power electric circuits, magnetic circuits, lumped parameter electromechanics, elements of linear and rotating electric machinery. Modeling of synchronous, induction, and dc machinery.
J. L. Kirtley, Jr.

[1]Either 6.032 or 6.004 will be offered Second Term 1983-84; consult Department.

6.071 Introduction to Electronics

Prereq.: *8.02*, 18.01
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.: 6.003
U (1)
3-0-9

Introduces 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. Discusses some of the basic technological, economic and regulatory issues relating to telecommunications systems such as satellite systems and data networks. Outside speakers are invited to participate.
J. P. Ruina

Undergraduate Laboratory Subjects

6.100 Electrical Engineering and Computer Science Laboratory

Prereq.: —
U (1, 2, S)
Arr.

Individual experimental work at the undergraduate level related to electrical engineering and computer science not covered by other subjects offered by the Department. Student must initiate arrangements with a project supervisor and must file a proposal endorsed by the supervisor. Proposal must be approved by the Department. Written report must be submitted upon completion of the work. If 6.100 is to be used to satisfy the Departmental Laboratory Requirement, student must register for 12 units of laboratory credit in the term the work is done.
L. A. Gould

6.101 Introductory Electronics Laboratory

Prereq.: 6.002 or 6.071
U (1, 2) LAB
3-8-1

Introductory experimental laboratory involving design and construction of electronic analog and digital circuits. Introduces electrical measuring and display instrumentation. Studies 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
U (1, 2) LAB
3-7-2

Initial lecture format treats combinational logic, flip flops, counters, timing circuits, synchronization techniques, finite-state machines, and the design of more complicated digital systems using microprogramming techniques. This material, accompanied by problem sets and lab exercises, prepares students for the conception, design, and implementation of a complicated digital systems project of their choice: e.g., games, music, microcomputers, digital filters, bit-mapped displays, graphics. Enrollment limited to 200.
D. E. Troxel

6.114 Real-Time Computing and Control Laboratory

Prereq.: 6.001, 6.032
U (1, 2)
3-7-2

Effective use of mini- and micro-computer systems in laboratory and on-line applications. Software development using a combination of high-level and assemby language to achieve performance consistent with real-time needs. Input-output programming, interrupt systems, direct memory access (DMA), high-speed data acquisition, multi-tasking. Laboratory exercises involve open and closed loop control of physical devices, interactive graphics, and data acquisition.
F. F. Lee, B. R. Musicus

6.115 Microcomputer Project Laboratory

Prereq.: 6.111
U (1)
3-7-2

Explores the use of microprocessors as elements in larger systems. Lectures cover microprocessor architectures and assembly languages, LSI peripheral support chips, interfacing single-chip and special purpose microcomputers, design and debugging aids, communication strategies, and multiprocessor systems. Laboratory exercises include data acquisition, interrupt control, DMA. Major project: the design, construction, programming, and testing of a system using microprocessors as processing elements. Familiarity with assembly language required. Limited enrollment.
B. R. Musicus, F. F. Lee

6.141 Power Systems Project Laboratory

Prereq.: 6.002; *6.013*
U (1, 2) LAB
0-10-2

Introduces 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 Control of Energy Systems

Prereq.: 6.001, 6.003
U (2)
2-7-3

Microcomputer-based control system laboratory. Lectures: analysis and design of sampled-data control systems, microcomputer-based control system implementation, and energy system control objectives. Laboratory experiments and term project on design and hardware/software implementation of microcomputer-based control systems. Typical projects: control of ac and dc motors, gasoline engine, chopping regulator, heating sysem, and solar photovoltaic power generation. Limited to 25.
J. H. Lang, L. A. Gould, R. D. Thornton

6.150J Introduction to Microelectronic Technology

(Same subject as 3.083J)
Prereq.: 6.012
U (1, 2)
1-3-2

Introduces 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 6.151 or thesis work in the microelectronics field. Also available in IAP.
L. R. Reif, D. J. Edell, C. G. Fonstad, H. L. Tuller

6.151 Semiconductor Devices Project Laboratory

Prereq.: 6.150J, 6.720
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.
L. R. Reif

6.161 Modern Optics Project Laboratory

Prereq.: 6.013, 6.003
U (1) LAB
2-8-2

Lectures, laboratory exercises, and projects in modern optics. Topics: polarization properties of light. Reflection and refraction. Coherence and interference. Fraunhofer and Fresnel diffraction. Imaging and transforming properties of lenses. Spatial filtering. Coherent optical processors. Holography. Optical properties of materials. Spectroscopy. Lasers. Nonlinear optics. Electro-optic materials and devices. Optical detectors. Fiber optics and optical communication. Seniors may use this laboratory to find a thesis.
C. Warde

6.162 Image Transmission Systems Project Laboratory

Prereq.: 6.012
U (1, 2) LAB
0-12-0

Students use 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.: —
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.: 6.001
U (1)
3-6-3

Introduces 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.: —
U (1) LAB **Next offered 1984-85**
3-4-5

Introduces the methods used to measure human auditory abilities. Discusses auditory function, principles of psychoacoustic measurement, models for psychoacoustic performance and experimental 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.
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

Prereq.: 6.003; 18.03 or 18.031
U (1)
3-0-9

Introduces modern system theory; applications to control, communications, and operations research. Topics: recursive least-squares estimation; state-space models of discrete- and continuous-time multi-input-output systems; structure, behavior, and control of linear, time-invariant systems (controllability, observability, modes, transfer functions, compensators, root locus, state feedback, optimal regulation, observers, frequency-domain design); nonlinear systems (stability); basics of optimal control.
G. C. Verghese, S. K. Mitter

6.202 Introduction to Decision Making with Uncertainty

Prereq.: 6.041 or 18.440 or 18.313
U (2)
3-0-9

Introduces techniques for analyzing dynamic systems which are subject to random disturbances over time. Emphasizes 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
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
G (2)
3-0-9

Introduces 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)

Prereq.: 6.201 or 6.230 or 2.151 or 16.311; *6.432* or *2.152* or *16.371*
G (2)
3-0-9

Unified computer-aided design of multivariable feedback control systems using time- and frequency-domain concepts. The multivariable Nyquist stability criterion. Loop-shaping concepts using singular value plots: command-following, disturbance-rejection and robustness requirements. Characteristic loci methods. Model-based compensators and the robustified Linear-Quadratic-Gaussian design methodology. Multivariable robustness (gain and phase margins) using singular values. Extensive computer-aided homework.
M. Athans, G. Stein

6.251J Introduction to Mathematical Programming (A)

(Same subject as 15.081J)
Prereq.: 18.700
G (1, 2)
3-0-9

A first subject in mathematical optimization emphasizing both methodology and the underlying mathematical structures. Covers linear programming and related topics: the simplex method, duality theory, sensitivity analysis, network flow algorithms, decomposition, integer programming, and polyhedral geometry.
R. G. Gallager, J. B. Orlin

6.252J Nonlinear Programming and Discrete-Time Optimal Control (A)

(Same subject as 15.084J)
Prereq.: 18.700, *18.100*
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
G (2) **Next offered 1984-85**
3-0-9

Advanced topics; varying focus. Polynomial matrix descriptions of linear time-invariant systems; equivalence; internal and external properties. Fractional representations of transfer matrices; parametrization of stabilizing compensators; robustness; sensitivity. Output feedback. Decentralized control. Geometric theory of controlled-, conditionally- and almost-invariant subspaces. Multidimensional systems; systems over rings, groups and finite fields. Automata theory. Bilinear systems. Alternate years.
B. C. Levy, G. C. Verghese

6.254 Qualitative Theory of Dynamical Systems (A)

Prereq.: 6.230, 18.100
G (1) **Next offered 1984-85**
3-0-9

Introduces 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.
S. K. Mitter

6.255 Optimal Control Theory (A)

Prereq.: 6.230
G (2) **Next offered 1984-85**
3-0-9

Advanced topics in deterministic and stochastic optimal control theory. Topics: nonlinear control, the Pontryagin Minimum Principle, discrete and continuous time, static and dynamic games (Nash, Stackelberg, and Pareto solution concepts), team theory, optimal decentralized estimation and control, and large-scale systems. Applications and computational aspects also discussed. Alternate years.
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
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, systems reliability and maintenance, and congestion processes in communication networks.
R. C. Larson, A. W. Drake

6.263 Data-Communication Networks (A)

Prereq.: 6.041 or 18.313
G (1)
3-0-9

Modeling of the control processes in computer and data communication networks. Develops and utilizes elementary concepts from queueing theory, algorithms, linear and nonlinear programming to study the problems of line and network protocols, distributed algorithms, quasi-static and dynamic routing, congestion control, deadlock prevention, local networks, and radio and satellite multi-access schemes.
D. P. Bertsekas

6.264 Queueing Theory with Applications (A)

Prereq.: 6.262 or 6.432 or 15.973J or 18.445J
G (2) **Not offered 1984-85**
3-0-9

Introduces analysis of queueing systems, with applications in communications, computers, manufacturing, transportation and urban systems. Material presented varies, 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. Current research opportunities discussed. Alternate years.
P. A. Humblet, R. C. Larson

6.271 Introduction to Operations Research

Prereq.: Permission of Instructor
G (1)
3-0-9

6.272 Introduction to Operations Research

Prereq.: 6.271
G (2)
3-0-9

A two-term introduction to important techniques and problem formulations of operations research. Homework exercises with user-friendly, on-line computer programs. Emphasizes overall approach rather than mathematical theory. Topics: linear programming models and methods, network analysis, optimal sequential decision making, decision analysis, Markov models, queueing models, inventory theory, and simulation. Case studies developed on the computer.
R. C. Larson

6.281J Logistical and Transportation Planning Methods (A)

(Same subject as 1.203J, 11.526J, 13.665J, 15.078J, 16.76J, TPP 43J)
Prereq.: 6.431, 15.075
G (1)
3-0-9

See description under subject 1.203J.
R. C. Larson, A. I. Barnett, A. R. Odoni, H. N. Psaraftis

6.291 Seminar in Systems, Communications, and Control Research (A)

Prereq.: Permission of Instructor
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
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
U (2)
3-2-7

For undergraduates intending to study automatic control and feedback amplifier design. 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. Sampled-data in feedback systems. Previous laboratory experience assumed.
L. A. Gould

6.311 Telephony

Prereq.: 6.002 or 6.071 or 6.101
U (2) **Not offered 1984-85**
2-0-4

Reviews current telephone technology. Examines 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, crossbar, 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.
S. K. Burns

6.312 Acoustics

Prereq.: 6.002
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
G (2) **Not offered 1984-85**
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.
J. K. Roberge

6.332 Advanced Instrumentation Electronics (A)

Prereq.: 6.003
G (1)
3-0-9

Theory and practice of electronic transduction, circuits, and systems in modern instrumentation, with critical review of alternative implementations and engineering compromise. Emphasizes 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. Discusses feedback, pulse and timing circuits, digital-analog interfaces and microprocessor-controlled signal processors.
S. K. Burns

6.333 Electronic Circuits (A)

Prereq.: 6.003
G (2)
3-0-9

Theory, analysis, and design of linear and nonlinear electronic circuits emphasizing the use of computers to solve symbolic and numerical circuit problems. Topics: network representations and transformations; relations between time, frequency, and circuit domains; basic limitations and optimal design; sparse circuit methodology. Examples: amplifiers; oscillators; switching circuits; VLSI; feedback; circuit analogs for electromechanical systems.
R. D. Thornton, J. L. Wyatt

6.334 Power Electronics (A)

Prereq.: 6.012, 6.013
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. Active and passive filtering techniques. Emphasizes device limitations, circuit techniques, computer-aided analysis and design, and system control. Application examples include controlled rectifiers, high-frequency inverters, dc-dc conversion, motor drives, and battery electronics. Assumes background in elementary device physics.
J. G. Kassakian

6.335 Nonlinear Electrical Networks: Fundamental Theory and Simulation Techniques (A) (New)

Prereq.: 6.002; 6.201 or 6.230
G (1)
3-0-9

Rigorous fundamental approach to nonlinear network theory. Tellegen's theorem, elements of graph theory. Uniqueness, no-gain, reciprocity, sensitivity and extremum principles for resistive networks. Network differential equations. Monotonicity. Application to timing analysis in digital VLSI. Passivity. Brayton-Moser-Smale theory. Structurally stable oscillators. Numerical integration techniques for ordinary differential equations. Discusses sparsity, latency, macromodeling, and relaxation methods. Linear algebra required.
J. L. Wyatt

6.341 Digital Processing of Signals (A)

Prereq.: 6.003; 18.075 or 18.04; *6.041* or *6.431*
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.
A. V. Oppenheim

6.343 Digital Speech Processing (A)

Prereq.: 6.341
G (2) **Next offered 1984-85**
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.
V. W. Zue

6.344 Multidimensional Signal Processing (A)

Prereq.: 6.341
G (2) **Not offered 1984-85**
3-0-9

Representation, analysis, and design of multidimensional signals and systems. Multidimensional Fourier transform, z-transform, discrete Fourier transform, and fast Fourier transform algorithms. Multidimensional filter design and implementation. One-dimensional and multidimensional spectral estimation. Array processing. Image enhancement and restoration. Image coding. Alternate years.
J. S. Lim

6.361 Image Processing (A)

Prereq.: 6.003
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
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 multiproject 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 Design and Analysis of VLSI Circuits (A)

Prereq.: 6.012; 6.371 or 6.721
G (2)
3-0-9

Design and analysis of digital MOS VLSI circuits. Topics: methodology design; device and interconnect physics; noise and tolerancing; noise margins; worst-case design; logic-gate dynamics; delay optimization; specialized circuit forms; clocking; VLSI micro-architecture. Emphasizes analytical and CAD techniques for high-performance circuit design. Limited enrollment.
L. A. Glasser

Probabilistic Systems and Communication

6.431 Applied Probability

Prereq.: 18.02
G (1, 2)
4-0-8

Meets with 6.041. Requires the completion of additional advanced home problems.
A. W. Drake

6.432 Stochastic Processes and Applications (A)

Prereq.: 6.003; 6.041 or 6.431 or 18.313
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
G (1) **Not offered 1984-85**
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.
F. C. Schweppe

6.441 Transmission of Information (A)

Prereq.: 6.041 or 6.431 or 6.432 or 18.313
G (2)
3-0-9

Introduces 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.: 6.003; 6.041 or 18.313
G (1)
3-0-9

Fundamental principles underlying the transmission of digital data over noisy channels. 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. Elements of block and convolutional coding. Topics of current interest.
P. A. Humblet

6.452 Stochastic Filtering and Detection (A)

Prereq.: 6.230, 6.432
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
G (2) **Not offered 1984-85**
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. Alternate years.
J. H. Shapiro

6.454 Advanced Topics in Optical Communication Research (A)

Prereq.: Permission of Instructor
G (1) **Next offered 1984-85**
3-0-9

Discusses advanced topics and current research activities in optical detection, propagation, and communication. Material presented and detailed prerequisites vary from year to year. Term paper required. Alternate years.
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
G (1) **Next offered 1984-85**
3-0-9

Systems and techniques used in oceanographic data analysis. Temporal random processes, correlation and spectral analysis by indirect, DFT, and adaptive methods. Sonar, radar, echosounders, and seismic systems. Space/time random processes, frequency-wave number characterizations, array and spatial processing; applications in arrays for ambient noise and passive sonar, surface, and internal waves. Alternate years.
A. B. Baggeroer, R. C. Spindel (Woods Hole Staff)

Bioelectrical Engineering

6.501 Sound, Speech, Hearing

Prereq.: 6.003
U (1) **Not offered 1984-85**
3-0-9

Introduces 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.
K. N. Stevens, L. D. Braida

6.523J Computers and Patient Care

(Same subject as HST 550J)
Prereq.: —
G (2)
2-0-4

See description under subject HST 550J.
G. O. Barnett

6.524J General Physiology

(Same subject as 7.51J)
Prereq.: —
U (2) SD
3-0-9

See description under subject 7.51J.
J. Y. Lettvin

6.532J Sensory-Neural Systems (A)

(Same subject as 16.352J)
Prereq.: Permission of Instructor
G (1) **Not offered 1984-85**
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.
L. S. Frishkopf, C. M. Oman

6.541J Speech Communication (A)

(Same subject as 24.968J)
Prereq.: Permission of Instructor
G (2) **Next offered 1984-85**
3-0-9

Survey of structural properties of natural languages with special emphasis on the sound pattern. Physiology of speech production, articulatory phonetics. Acoustical theory of speech production; 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 prerequisite: mathematical background equivalent to 6.003. Alternate years.
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
G (1) **Not offered 1984-85**
2-2-8

Experimental investigations of speech processes. Topics: 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, e) identification and discrimination of speech-like sounds, and other topics. Recommended prerequisites: 6.501; 6.002 or 18.03. Alternate years.
D. H. Klatt, M. Halle

6.543 Natural Language Processing (A)

Prereq.: Permission of Instructor
G (1) **Not offered 1984-85**
3-0-9

Computational theories for the analysis of natural language. Studies 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.
J. Allen

6.551 Signal Processing by the Auditory System: Physiology (A)

Prereq.: 6.003, 6.023J
G (2) **Not offered 1984-85**
3-0-9

Physiological mechanisms involved in signal transmission and processing in the normal and pathological auditory system. Emphasizes the normal ear and brain stem with some discussion of higher brain levels. Background other than listed prerequisites may be accepted. Alternate years.
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
G (1) **Next offered 1984-85**
3-0-9

Studies behavioral aspects of human hearing in relation to current physiological knowledge. Examines performance in processing information from acoustic stimuli. Correlations between behavior and physiology reflecting the tono-topic organization and stochastic responses of the auditory system. Mathematical models of psychophysical relations incorporating quantitative knowledge of physiological transformations by the peripheral auditory system. Discusses related research on diagnosis and aids for partially deaf. Alternate years.
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
G (1)
3-0-9

Conduction, diffusion, convection in electrolytes; fields in heterogeneous media; electrical double layers; Maxwell stress tensor and electrical forces in physiological systems. Fluid and solid continua: equations of motion useful for porous, hydrated media. Case studies: membrane transport; electrode interfaces; electrical, mechanical, and chemical transduction in tissues; electrophoretic, electro-osmotic flows; diffusion/reaction; ECG. Electromechanical interactions in biomaterials and cells; examples from orthopaedic research.
A. J. Grodzinsky

6.562J Ultrasound: Physics, Biophysics and Technology (A)

(Same subject as 2.76J, HST 530J)
Prereq.: Permission of Instructor
G (1) **Next offered 1984-85**
4-1-7

See description under subject 2.76J.
F. R. Morgenthaler, P. P. Lele

6.565J Measurements in Medicine and Biomedical Research (A except VI)

(Same subject as HST 581J)
Prereq.: 6.003, 6.022J, 6.041
G (2)
2-5-5

See description under subject HST 581J.
R. G. Mark, E. D. Trautman

Electrodynamics

6.601 Fields, Forces, and Motion

Prereq.: 6.013
U (1)
3-0-9

Electromechanical interactions in lumped-parameter and continuum systems. Integral and differential electromagnetic laws, including motion. Lumped electrical and mechanical elements: thermodynamics of discrete electromechanical coupling, equations of motion. Synchronous and induction rotating machines. Linear and nonlinear transducers, transient and steady-state dynamics; electromechanical time constants. Field transformations, dc rotating machines, magnetic diffusion and charge relaxation in moving conductors. Electromagnetic force densities and stress tensors.
J. R. Melcher

6.611 Introduction to Optical Electronics

Prereq.: 6.013, 6.003
U (2)
3-0-9

Introduces 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. Discusses specific applications.
J. H. Shapiro

6.631 Optics and Optical Electronics (A)

Prereq.: 6.014 or 8.07
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. Propagation of spherical and Gaussian-spherical beams. Thin film and "fiber" waveguides. Device applications of electro-optic effect and nonlinear optics.
H. A. Haus, S. Ezekiel

6.632 Advanced Electromagnetic Theory (A)

Prereq.: 6.014 or 8.03
G (1)
3-0-9

A first-year graduate subject on electromagnetic field theory emphasizing 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
G (2) **Next offered 1984-85**
3-0-9

Intended for first-year graduate students and seniors whose interest is in the interaction of electromagnetic fields with charged particles, plasmas, and continuous media. Wave propagation in media with temporal and spatial dispersion. General stability criteria and techniques for identifying and classifying wave-type instabilities. 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. Alternate years.
A. Bers

6.634 Nonlinear Optics (A)

Prereq.: 6.014 or 8.07
G (2)
3-0-9

Nonlinear optical phenomena emphasizing applications, techniques, and devices. Nonlinear polarization: harmonic generation, frequency conversion, optical Kerr effect, self-phase modulation, wavefront conjugation. Pulse propagation in nonlinear media. Applications to fiber optics. Nonlinear laser spectroscopy. Picosecond pulse generation and measurement techniques.
E. P. Ippen

6.635 Topics in Electrodynamics (A)

Prereq.: 6.014 or 6.632 or 8.07
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

6.638 Electrical and Optical Processes in Gases (A)

Prereq.: 8.03, 8.211
G (2) **Not offered 1984-85**
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.
C. M. Cooke

6.641 Microwave Circuits (A)

Prereq.: 6.014
G (2) **Not offered 1984-85**
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.
R. L. Kyhl

6.642 Antennas and Radiation (A)

Prereq.: 6.014
G (2) **Next offered 1984-85**
3-0-9

General theory of radiation and its application to the analysis of representative types of antennas; emphasizes the design of antenna arrays, microwave reflectors, and lenses. Alternate years.
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
G (1)
3-0-9

See description under subject 8.613J.
A. Bers, K. Molvig, M. Porkolab

6.652J Introduction to Plasma Physics II (A)

(Same subject as 8.614J, 22.612J)
Prereq.: 6.651J or 8.613J or 22.611J; 18.075
G (2)
3-0-9

See description under subject 22.612J.
A. Bers, R. C. Davidson,K. Molvig

6.653J MHD Theory of Magnetic Fusion Systems I (A)

(Same subject as 22.615J)
Prereq.: 6.651J or 22.611J, or 8.613J
G (1)
3-0-9

See description under subject 22.615J.
R. R. Parker, J. P. Freidberg

6.661 Receivers, Antennas, and Signals (A)

Prereq.: 6.014
G (1) **Next offered 1984-85**
3-0-9

Detection and measurement of radio and optical signals encountered in astronomy, radar, and communications. Statistical analysis of signal processing systems, including radiometers, spectrometers, interferometers, and digital correlation systems. Matched filters and ambiguity functions. 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.
D. H. Staelin

6.662J Radar Astronomy, Astrometry, and Geodesy (A) (New)

(Same subject as 12.620J)
Prereq.: 6.014 or 8.03; 18.075
G (1) **Not offered 1984-85**
3-0-9

See description under subject 12.620J.
D. H. Staelin, G. H. Pettengill, C. C. Counselman

6.671 Continuum Electromechanics I (A)

Prereq.: 6.013; 6.601 or 2.03J
G (2)
3-0-9

Quasistatic field dynamics. Transfer relations as an approach to field descriptions. Electromagnetic forces, force densities and stress tensors including magnetization and polarization. Classification of energy-conversion processes. Charge migration and relaxation, and magnetic diffusion and induction interactions with material motion. Introduction to electromechanics of continua. Temporal and spatial modes. Method of characteristics. Varied applications.
J. R. Melcher

6.672 Continuum Electromechanics II (A)

Prereq.: 6.671
G (1) **Next offered 1984-85**
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, magnetohydrodynamic and electrohydrodynamic pumps and generators, physiochemical systems, heat transfer, continuum feedback control, electron beam devices, and plasma dynamics. Alternate years.
J. R. Melcher

6.683 Operation and Planning of Electric Power Systems (A)

Prereq.: Permission of Instructor
G (2) **Next offered 1984-85**
3-0-9

Electric power system generation, transmission distribution at a regional (e.g., New England) level. Customer interaction and feedback. Integration of diverse physical, economic, and social phenomena covering time frames ranging from seconds to years. Methods of control, analysis, design, and decision making for such large-scale systems. Special consideration of small distributed generation, rates and load management, and the impact of microprocessors. Alternate years.
F. C. Schweppe

6.685 Dynamics of Electric Machines (A)

Prereq.: 6.061 or 6.601
G (2) **Next offered 1984-85**
3-0-9

Treatment of transformers, electromechanical transducers, rotating and linear electric machines. Lumped-parameter electromechanics of interaction. Consideration of the basic machine types: dc, 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.
J. L. Kirtley, Jr.

6.687J Case Studies in Energy, Technology, Economics, and Management (New)

(Same subject as 22.85J)
Prereq.: —
G (2)
3-0-9

See description under subject number 22.85J.
D. C. White, M. M. Miller

Solid-State Materials and Devices

6.720 Semiconductor Devices (Revised Unit)

Prereq.: 6.012
U (1)
4-0-8

The physics, modeling, fabrication, and application of selected semiconductor devices. Emphasis on devices in integrated circuit contexts. Introduces use of the energy band viewpoint. 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 heterostructures.
C. G. Fonstad

6.721 Contemporary Digital MOS Circuits

Prereq.: 6.032
U (1)
3-0-9

Reviews and elaborates models of MOS transistors. Discusses scaling effects on device performance. Overview of organization and operation of contemporary MOS integrated circuits, especially microprocessors and static and dynamic RAMs. Uses circuit techniques to optimize speed/power tradeoffs. Systemic influences on device architectures and circuits.
R. E. Zippel

6.725 Solar Energy Systems

Prereq.: 6.002 or 6.071 or 2.02
U (1)
3-0-9

Examines energy conversion systems, primarily solar. Topics: solar radiation, blackbody radiation; photovoltaic power generation including theory, materials, devices; systems analysis of solar heating, cooling, and hybrid electrical-thermal combinations; flat plate collectors, heat mirrors, heat transfer; alternate energy sources including photochemical, hydro, wind, and tidal power; energy storage systems. Guest lectures on topics of intensive current research. Elementary knowledge of thermodynamics helpful.
G. W. Pratt, Jr., R. D. Thornton

6.731J Physics of Solids I (A except VIII)

(Same subject as 8.231J)
Prereq.: 8.04 or 8.211; 6.018
G (1)
4-0-8

See description under subject 8.231J.
M. Kastner

6.732J Physics of Solids II (A)

(Same subject as 8.500J)
Prereq.: 6.731J
G (2)
4-0-8

Second term of a sequence presenting basic concepts of the quantum theory of solids. Emphasizes simple physical models. Topics: electronic structures, dynamics of electrons in solids, Fermi surfaces, transport phenomena in metals and semiconductors; optical properties of metals, semiconductors and insulators; lattice modes; magnetic phenomena in solids such as paramagnetism, diamagnetism, ferromagnetism, resonance studies in a magnetic field; superconductivity.
M. S. Dresselhaus

6.734J Application of Group Theory to the Physics of Solids (A)

(Same subject as 8.513J)
Prereq.: 6.731J
G (1) **Next offered 1984-85**
3-0-9

Group theory techniques: mathematical background, representation theory, character tables, basis functions, point groups, space groups, 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. Alternate years.
M. S. Dresselhaus, G. F. Koster

6.741J Theory of Solids I (A)

(Same subject as 8.511J)
Prereq.: 6.732J
G (1)
3-0-9

See description under subject 8.511J.
D. Adler, J. D. Joannopoulos

6.742J Theory of Solids II (A)

(Same subject as 8.512J)
Prereq.: 6.741J
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
G (1) **Not offered 1984-85**
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.
D. Adler

6.751 Quantum Electronics (A)

Prereq.: 6.731J or 8.05
G (2)
3-0-9

Basic phenomena of quantum electronics including development of background quantum mechanics and optical properties of solids. Quantization of 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, picosecond switches and pulse generation, optical logic gates. Fiber optics.
G. W. Pratt, Jr.

6.753 Microwave Magnetics (A)

Prereq.: 6.014 or 6.601
G (2) **Not offered 1984-85**
3-0-9

Introduces 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. Electromagnetic quantum-mechanical exchange and elastic channels of power flow. Alternate years.
F. R. Morgenthaler

6.754 Signal Processing with Coherent Wave States in Crystals (A)

Prereq.: 6.014, 6.003
G (2) **Next offered 1984-85**
3-0-9

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. Signal characteristics and processing methods currently used in modern radar and spread-spectrum communications. Propagation of bulk and surface waves of electromagnetic, ultrasonic, and magnetostatic varieties; application to signal processing systems. Guest lecturers with expertise in industrial state-of-the-art techniques. Alternate years.
F. R. Morgenthaler

6.761J Electronic Materials (A)

(Same subject as 3.46J)
Prereq.: 3.02 or 3.71J or 22.071J or 22.71J
G (1)
2-0-6

See description under subject 3.46J.
H. C. Gatos

6.762 Dielectric and Optical Materials and Devices (A)

Prereq.: 6.013
G (2) **Not offered 1984-85**
3-0-9

Devices dependent on polarization rather than transport. Tensor properties and crystal symmetry. Nonlinear dielectrics: ferroelectrics, parametric amplification. Elasticity. Coupled effects: pyro- and piezo-electricity. Optical properties: waves in anisotropic crystals; indicatrix; electro-optics, photoelasticity, optical modulators; beam deflectors. Nonlinear optics: frequency doubling; parametric conversion; photorefractive effects. Alternate years.
D. J. Epstein

6.763 Applied Superconductivity (A)

Prereq.: 6.013 or 8.07
G (1)
3-0-9

Phenomenological approach to superconductivity surveying large-scale and small-scale applications. Electrodynamics of superconductors, London's model, flux quantization. Type II superconductors, upper critical fields, pinning, critical state model. Josephson Junctions and superconducting quantum devices, equivalent circuits and analogs, computers. Brief overview of superconducting materials and microscopic theory. Some background in solid-state physics helpful.
T. P. Orlando

6.771 Physics of Semiconductor Devices (A)

Prereq.: 6.720, 6.018
G (1)
3-0-9

The physical basis of semiconductor device operation. Quantum mechanics of free particles; energy bands in semiconductors; Fermi-Dirac statistics; equilibrium properties of semiconductors; electrochemical potential; generation-recombination mechanisms; Boltzmann transport equation; ambipolar transport; p-n junctions; MOS capacitors and field-effect transistors; Gummel approach to bipolar devices; space-charge recombination; Zener and avalanche breakdown; high-level injection; bipolar transistor. Some background in quantum mechanics is desirable.
S. D. Senturia

6.772 Integrated Circuit Devices and Processes (A)

Prereq.: 6.771
G (2)
3-0-9

Silicon integrated circuit technology. Theory and practice of IC fabrication and device design emphasizing their relation to circuit performance. Topics: materials and fabrication processes; large-signal models for bipolar and field-effect transistors; components and circuit building blocks for modern digital ICs; circuit 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
G (2) **Not offered 1984-85**
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 ultrahigh-speed transistors, including the permeable base transistor. Alternate years.
A. L. McWhorter

6.774 Physics of Microelectronic Fabrication (A)

Prereq.: 6.720 or 6.771; 6.150J
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. Refractory metal silicides, plasma and reactive ion etching, laser/electron beam processing. Technological limitations on integrated circuit design and fabrication. VLSI fundamentals.
L. R. Reif

6.775 Design of Analog MOS LSI (A)

Prereq.: 6.301
G (1)
3-0-9

A detailed exposition of the principles involved in designing analog circuits in MOS LSI. Device physics, small signal and large signal models. Biasing. Basic circuit building blocks. Operational amplifier design. Large signal considerations. Principles of switched capacitor networks. Applications: fully integrated filters, comparators, A/D and D/A converters, PCM encoders and decoders; other signal processing circuits. A comprehensive design project is a required part of the subject. Limited enrollment.
D. A. Antoniadis

6.776J Plasma Processing in Integrated Circuit Fabrication (A) (New)

(Same subject as 10.616J)
Prereq.: Permission of Instructor
G (2) **Next offered 1984-85**
3-0-9

Studies glow discharge properties and processes as applied to integrated circuit fabrication. The physics and chemistry of nonequilibrium plasmas. Emphasizes the plasma kinetics and plasma-surface interactions. Extensively reviews plasma etching processes, sputter deposition, and plasma assisted chemical vapor deposition for the fabrication of VLSI devices. Alternate years.
L. R. Reif, H. H. Sawin

6.777J Implantable Microelectronic Instrumentation (A) (New)

(Same subject as HST 583J)
Prereq.: Permission of Instructor
G (1)
2-3-7

See description under subject HST 583J.
D. J. Edell

6.781 Submicrometer Structures Technology (A)

Prereq.: —
G (2)
3-1-8

Surveys techniques to fabricate and analyze submicrometer structures, with applications. Reviews optical and electron microscopy. Surface characterization, preparation, and measurement techniques. Resist technology. Optical projection holographic, X-ray, ion, and electron lithography. Aqueous, ion, and plasma etching techniques. Lift-off, film growth, and electroplating. Ion implantation. Applications in microelectronic devices, optical devices, graphoepitaxy and X-ray optics. Undergraduates with permission of instructor.
H. I. Smith

6.791 Special Topics in the Solid State and Its Application (A)

Prereq.: —
G (1)
3-0-9

6.792 Special Topics in the Solid State and Its Application (A)

Prereq.: —
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

6.801 Machine Vision (New)

Prereq.: 6.003
U (1)
3-0-9

Deriving a symbolic description of the environment from an image. Understanding physics of image formation. Image analysis as an inversion problem. Binary image processing and filtering of images as preprocessing steps. Recovering shape, lightness, orientation and motion. Using constraints to reduce the remaining ambiguity. Photometric stereo and extended Gaussian sphere. Applications to robotics; intelligent interaction of machines with their environment.
B. K. P. Horn

6.802 Robot Manipulation (New)

Prereq.: 6.001, 8.01, 18.02
U (2)
3-0-9

Introduces kinematic, dynamic, and spatial constraints on robot motion. Basic considerations in design and application of robot systems. Solving kinematics of robot manipulators. Planning trajectories subject to position, velocity, and acceleration constraints. Using rigid-body dynamics in the control of robots. Controlling force and compliance in manipulation. Survey of basic issues in robot programming. Development of algorithms for automatic synthesis of robot programs.
T. Lozano-Perez

6.821 Concepts in Modern Programming Languages (A)

Prereq.: Permission of Instructor
G (1)
4-0-8

Core graduate subject in programming languages. Programming language concepts and design, with emphasis on abstraction mechanisms. Denotational semantics. Functional and imperative languages. Procedure call and parameter passing mechanisms. Generic and polymorphic definitions. Abstract data types. Efficiency issues. 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.
J. V. Guttag, B. H. Liskov

6.823 Computer System Architecture (A)

Prereq.: Permission of Instructor
G (2)
3-0-9

Evolution of computer architecture emphasizing relationship of hardware organization and systems programming to structure of application programs and languages in which they are expressed. Schemes for addressing, protecting, creating, and storing data and procedure objects in computer systems storage. Processor design and programming issues in high performance, vector, and multiprocessor systems. Assumes undergraduate knowledge of programming languages and computer systems.
Arvind

6.824 Artificial Intelligence (A)

Prereq.: Permission of Instructor
G (1)
3-0-9

Intensive introduction to central issues of constructing intelligent systems. Historical trends in AI research: generality in problem solving, role of particular knowledge. Formalisms for knowledge representation: predicate logic, semantic networks, "frame" systems, production rules. Problem-solving techniques: goal-directed behavior, natural deduction, resolution, production system architectures, reasoning about control, planning, dependency-directed control, constraints, truth maintenance. Expects working knowledge of LISP.
P. Szolovits, R. Davis, H. E. Shrobe

6.830 Program Semantics and Verification (A)

Prereq.: 6.821, 6.045J
G (2)
3-0-9

Mathematical approaches to defining semantics of simple programming languages: denotational, operational, and axiomatic semantics. Formal systems for program verification: soundness and completeness. Logics of programs, type theory, lambda calculus. Further topics selected from: semantics and verification of complex languages with concurrent and parallel constructs; current verification technology.
A. R. Meyer

6.835 Theory of Concurrent Systems (A)

Prereq.: 6.035, 6.033
G (1)
3-0-9

Studies 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. Study of Communicating Sequential Processes. "Lazy" and "eager" evaluators. Laws for communicating parallel processes. Proof techniques based on partial orders of events.
C. E. Hewitt

6.837 Data Base Management Systems (A)

Prereq.: Permission of Instructor
G (1)
3-0-9

Design, implementation, and use of modern data base management systems, with emphasis on practical issues. Data models, data description languages, data manipulation languages. Conceptual schemas and representations of data base semantics. Feature analysis of existing systems. File structures, access methods, query processing. Data base system architecture with case studies. Integrity, concurrency, security. Interface to teleprocessing monitors; transaction processing and report writing. Distributed data bases.
M. Hammer

6.840J Theory of Computation (A)

(Same subject as 18.427J)
Prereq.: 6.045J or 18.511
G (1)
3-0-9

See description under subject 18.427J.
A. R. Meyer, M. Sipser

6.845 Topics in Computer Systems Research (A)

Prereq.: Permission of Instructor
G (2)
3-0-9

Seminar on a selected research topic in the engineering of computer systems. Emphasizes software and hardware as a single system, and case studies of actual system implementations. Usually includes extensive reading in journals, discussion and preparation of reports. Content varies from year to year. Typical topics: information protection, design of physically distributed systems, and performance analysis. See instructor for topic to be offered. Limited enrollment.
J. H. Saltzer

6.847 Dataflow Computer Systems (A)

Prereq.: 6.001, 6.032
G (1)
3-0-9

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; data and demand-driven execution models; streams and managers; dataflow program graphs; the unraveling-interpreter. Static and dynamic dataflow architectures; reduction machines.
Arvind, J. B. Dennis

6.851J Algorithms (A)

(Same subject as 18.437J)
Prereq.: 18.700, 18.063; 6.046 or 18.424 or 18.411
G (2)
3-0-9

Design and analysis of fast and optimal algorithms for sorting and searching, graph problems, network flow, and related problems. Computations with polynomials, integers, and matrices. Algorithms for linear programming and applications. Polynomial-time computability and NP-completeness.
R. L. Rivest, R. Kannan

6.856 Algebraic Manipulation (A)

Prereq.: 6.821, 18.063
G (2) **Next offered 1984-85**
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.
J. Moses, R. E. Zippel

6.863 Natural Language and the Computer Representation of Knowledge (A)

Prereq.: 6.034
G (2)
3-0-9

Relationship between computer representation of knowledge and the structure of natural language. Emphasizes development of the analytical skills necessary to judge the computational implications of grammatical formalisms, and uses concrete examples to illustrate particular computational issues. Efficient parsing algorithms for context-free grammars; augmented transition network grammars. Models for the semantics of English relevant to symbolic computation. Question answering systems; computer acquisition of syntactic knowledge.
R. C. Berwick

6.866 Machine Vision (A) (New)

Prereq.: Permission of Instructor
G (1)
3-0-9

Intensive introduction to the process of generating a symbolic description of the environment from an image. Students expected to attend the 6.801 lectures as well as occasional seminar meetings on special topics. Material presented in 6.801 is supplemented by reading from the literature. Students required to prepare a paper analyzing research in a selected area.
B. K. P. Horn

6.867 Robot Manipulation (A) (New)

Prereq.: Permission of Instructor
G (2)
3-0-9

Intensive introduction to the planning and control of robot motion. Students expected to attend the 6.802 lectures as well as occasional seminar meetings on special topics. Material presented in 6.802 is supplemented by reading from the literature. Students required to prepare a paper analyzing research in a selected area.
T. Lozano-Perez

6.868 Topics in Artificial Intelligence (A)

Prereq.: Permission of Instructor
G (1)
3-0-9

Seminar on selected, currently active research topics in artificial intelligence. One or two topics covered in depth each term. 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 6.824
G (2) **Next offered 1984-85**
3-0-9

Development of programs containing a significant amount of knowledge about their application domain. Topics: 1) theories of human problem solving, 2) identification, representation, and dissemination of expert knowledge, and 3) technological problems arising from attempts to mechanize expertise (including program architecture, human-machine natural language dialogue, and automatic programming). Case studies in applied mathematics, management, medicine, and software, plus term project building an expert system. Alternate years.
P. Szolovits

6.875 Cryptography and Cryptanalysis (A)

Prereq.: 18.063, 6.045J, 18.05
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.
R. L. Rivest

6.880J Perspectives on Computers and Society (A)

(Same subject as STS 633J)
Prereq.: Permission of Instructor
G (1)
3-0-9

Seminar on the interface between computers and society. Topics 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.
J. Weizenbaum

6.891-6.899 Special Topics in the Computer Sciences (A)

Prereq.: Permission of Instructor
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.
P. Elias

Special Subjects

6.901 Inventions and Patents

Prereq.: 14.02
U (1)
3-0-6

School-Wide Elective Subject. Description given at end of this chapter on SWE page.
R. H. Rines

6.910 Special Studies in Electrical Engineering and Computer Science

Prereq.: —
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. Student is responsible 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.: —
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.: —
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
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.: —
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.: —
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.: —
U (1)
3-0-9

School-Wide Elective Subject. Description given at end of this chapter on SWE page.
R. T. Lund, D. P. Hoult, H. S. Marcus

6.931 Development of Inventions and Creative Ideas (A)

Prereq.: 14.002
G (2)
3-0-9

Role of the engineer as patent expert and as technical witness in court and patent interference and related proceedings. Rights and obligations of engineers in connection with 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 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
G (2)
4-0-8

See description under subject 17.486J.
J. P. Ruina, G. W. Rathjens

6.933J Telecommunication Technology and Policy (A) (New)

(Same subject as 17.740J)
Prereq.: Permission of Instructor
G (1)
3-0-9

See description under subject 17.740J.
M. A. Sirbu, I. D. Pool

6.936 Entrepreneurship

Prereq.: —
G (2)
4-0-5

School-Wide Elective Subject. Description given at end of this chapter on SWE page.
D. G. Jansson

6.938 Engineering Risk-Benefit Analysis (A)

Prereq.: 18.02
G (2)
3-0-6

School-Wide Elective Subject. Description given at end of this chapter on SWE page.
A. W. Drake, A. R. Odoni

6.941J Current Issues in Engineering

(Same subject as 1.485J, 3.562J, 13.682J, 22.87J)
Prereq.: —
G (2)
3-0-6

See description under subject 1.485J.
T. H. Lee

6.942J Cases and Projects in Engineering Management (A)

(Same subject as 1.486J, 3.563J, 13.683J, 22.88J)
Prereq.: 6.941J
G (1)
3-1-5

See description under subject 1.486J.
T. H. Lee

6.951 Graduate Industrial Practice

Prereq.: 6.922
G (1, 2, S)
0-12-0

Provides academic credit for a 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
G (1, 2, S)
0-12-0

Provides academic credit for graduate students who require an additional term at the company 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
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.: —
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.: —
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.: —
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.: —
G (1, 2)
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.: —
G (1, 2)
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.: —
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.: —
U (1, 2, S)
Arr.

Extended participation in the work of a faculty member or research group, including independent study of the literature, direct involvement in the group's research, and project work under an individual faculty member. 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. An initial letter of intent and a summary report must be submitted to 6.UR coordinator. Grading P/F only.
R. D. Thornton

6.ThU Undergraduate Thesis

Prereq.: —
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.: —
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.: —
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

7.01 General Biology

Prereq.: —
U (1, 2) SD
4-0-8

Part 1: Molecular biology using examples from work done with bacteria, viruses, and eukaryotic cells; introduction to enzymes, biochemical energetics, biosynthesis of macromolecules, cellular control systems, and genetics. Part 2: Cell biology including structure of eukaryotic cells, cell membranes, and immunity. Part 3: Evolution of animals, plants, and complex processes in multicellular organisms. Part 4: Higher organism physiology emphasizing the structure and function of the nervous system.
Term 1: *V. M. Ingram*
Term 2: *S. E. Luria, D. E. Housman*

7.011 Introduction to Experimental Biology

Prereq.: 7.01 or 7.05
U (1, 2) LAB
2-8-4

Application of experimental techniques in biochemistry, microbiology, and cell biology. Emphasizes integrating factual knowledge with understanding the design of experiments and data analysis to prepare the students for research projects.
J. M. Buchanan, B. J. Meyer, A. Torriani-Gorini

7.03 Genetics

Prereq.: 7.01 or 7.05
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. Permission of instructor required.
H. R. Horvitz, E. R. Signer

7.031 Experimental Microbial Genetics

Prereq.: 7.011
U (2) LAB **Not offered 1984-85**
2-16-6

Laboratory project in microbiology and genetics. Enrollment limited.
G. C. Walker

7.04 Cell and Developmental Biology

Prereq.: 7.03, 7.05
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.
R. O. Hynes

7.041 Experimental Cell Biology

Prereq.: 7.011
U (1) LAB **Next offered 1984-85**
2-16-6

Laboratory investigation dealing with animal cells. Enrollment limited.
D. E. Housman

7.05 General Biochemistry

Prereq.: 5.41
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. Solomon, P. R. Schimmel*

7.051 Experimental Biochemistry

Prereq.: 7.011, 7.05
U (2) LAB **Next offered 1984-85**
2-16-6

Laboratory project in biochemistry. Enrollment limited.
Staff

7.06 Metazoan Cell Biology

Prereq.: 7.01 or 7.05
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. Emphasizes biochemistry and electron microscopic anatomy.
S. Penman

7.11 Biology Teaching

Prereq.: —
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

7.15 Experimental Molecular Biology: Biotechnology I

Prereq.: 7.011, 7.03, 7.05
U (1) LAB
2-16-6

Laboratory project applying recombinant DNA and other modern genetic techniques to problems in prokaryotic genetics. Cloning of genes from a variety of prokaryotic and lower eukaryotic organisms, and characterization of the cloned genes for structure and function.
L. P. Guarente

7.16 Experimental Molecular Biology: Biotechnology II

Prereq.: 7.011, 7.03, 7.05
U (2)
2-16-6

Laboratory methodology and theoretical basis for cloning and manipulation of genes in eukaryotic organisms. Mammalian cell culture, biological assays with mammalian cells, isolation of hybridomas that secrete monoclonal antibodies, and cloning and expression of genes in eukaryotic organisms.
R. C. Mulligan, N. H. Hopkins, P. A. Sharp

7.21 Microbial Physiology

Prereq.: 7.05
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
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
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
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.
D. Baltimore, P. A. Sharp, N. H. Hopkins

7.27 Regulation of Gene Expression (A) (Revised Content)

Prereq.: 7.03, 7.05
G (2)
4-0-8

Studies molecular mechanisms responsible for the regulation of gene expression in bacteria, bacterial viruses, and eukaryotic microorganisms.
B. Magasanik, L. P. Guarente

7.28 Nucleic Acid Biochemistry: Replication and Repair of DNA and the Biosynthesis of RNA and Proteins (A) (New)

Prereq.: 7.03, 7.05
G (1)
3-0-9

Genome structure and function, emphasizing regulation of chromosome metabolism and protein synthesis in both prokaryotes and eukaryotes.
A. J. Varshavsky

7.30 Method and Logic in Molecular Biology (A)

Prereq.: Permission of Instructor
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, F. Solomon

7.32 Analysis of Differentiation and Development

Prereq.: 7.05
G (2)
2-0-4

Graduate discussion seminar examining 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.
H. R. Horvitz, G. R. Fink

7.33 Genetics for Graduate Students (A) (New)

Prereq.: Permission of Instructor
G (1)
4-0-8

Principles of genetics, including Mendelian systems and prokaryotic genetics. Application of principles to biological function, including regulation and development. Mechanisms of recombination, mutation, and evolution. Discussion of original scientific papers and review of problem sets and exams supplement lectures.
D. Botstein, G. R. Fink

7.36 Advanced Neurophysiology (A)

Prereq.: 7.06
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.: —
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.: —
G (1, 2)
Arr.

Advanced problems in biological oceanography with assigned reading and consultation.
(Woods Hole Staff)

7.43 Phytoplankton Ecology (A) (Revised Content)

Prereq.: Permission of Instructor
G (1) **Next offered 1984-85**
3-0-6

Overview of major algal classes, physiological processes, and large scale systems as they relate to phytoplankton in the marine environment. Attention to interactions of environmental parameters (light, temperature, nutrients, trace metals, physical factors) on the growth and distribution of phytoplankton. Discusses multidisciplinary programs and modeling. Emphasizes current problems in the field through lectures, readings, and discussions. Students evaluate selected papers and present a seminar.
(Woods Hole Staff): D. Anderson, P. Glibert

7.44 Ecology of Oceanic Zooplankton

Prereq.: 7.43
G (1) **Not offered 1984-85**
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. Opportunity for student participation in presenting material and in structuring portions of the course.
(Woods Hole Staff): T. J. Cowles

7.45 Benthic Ecology (A)

Prereq.: Permission of Instructor
G (1) **Next offered 1984-85**
3-0-6

Aspects of the ecology of marine benthos. Includes communities, with consideration of sampling, life histories, population dynamics, biotic interrelationships, zoogeography, diversity, and evolution. Emphasizes 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.
(Woods Hole Staff): J. F. Grassle

7.46 Topics in Physiology and Biochemistry of Marine Animals (A)

Prereq.: Permission of Instructor
G (1) **Not offered 1984-85**
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.
(Woods Hole Staff): J. J. Stegeman, J. M. Capuzzo

7.491 Research in Biological Oceanography (A)

Prereq.: —
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.: —
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

7.53 Laboratory in Biological Electron Microscopy (Revised Unit)

Prereq.: Permission of Instructor
G (2)
2-2-5

Introduces the use of visualization techniques for studying biological problems. Operation of the transmission and scanning electron microscopes. 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. Limited to 16 students.
J. A. King, E. R. Hartwieg

7.54J Human Physiology (New)

(Same subject as 20.022J)
Prereq.: 7.05
U (1)
3-0-9

Comprehensive course in human physiology emphasizing the molecular basis and applied aspects of organ function and regulation in health and disease. Material covered includes a review of cell structure and function as well as the mechanisms by which the endocrine and nervous systems integrate cellular metabolism. Special emphasis on examining the cardiovascular, pulmonary, gastrointestinal, and renal systems.
M. F. Holick, M. Krieger, R. D. Rosenberg

7.60 Cell Biology (A)

Prereq.: 7.06
G (1)
4-0-8

Advanced subject covering the structure and function of eukaryotic cells, emphasizing 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, R. A. Weinberg

7.62 Tumor Biology (A)

Prereq.: 7.05
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
G (2)
4-0-8

Discusses mammalian immune system emphasizing 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.
T. Imanishi-Kari, S. Tonegawa

7.64 Cell Matrix Biology

Prereq.: 7.05
G (2)
2-0-4

The structuring and ordered maintenance of extracellular space by cells in tissues and organs. How and what cells contribute to matrices, how matrices direct biosynthetic and replicative activities of constituent cells, and how matrices serve as substrates for constituent cells and for cells which live on their surfaces. The structure, biosynthesis, and processing and assembly of collagens. The diversity of collagen genes, integrated matrix structure, and matrix modeling and remodeling in development, wound healing, and regeneration.
E. Bell

7.66 Cell Surfaces (A)

Prereq.: 5.58, 7.05
G (2) **Next offered 1984-85**
2-0-4

Considers 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.
R. O. Hynes

7.71J Biophysical Chemistry

(Same subject as 5.64J)
Prereq.: 5.60, 7.05
U (1)
4-0-8

Nucleic acids: structures and the forces which stabilize them. Polymer statistics relating to the properties of long nucleic acid chains. Supercoiling. Hydrodynamic behavior as a function of conformation. Melting of double-stranded DNA and RNA: the helix-coil transition. Renaturation kinetics and Cot curves. Proteins: thermodynamics and kinetics of protein folding. Forces stabilizing three-dimensional structure. Hydrophobic effects and water structure. Prediction of structure from amino acid sequence. Enzyme kinetics and allosteric systems. Interactions with nucleic acids.
P. R. Schimmel, R. T. Sauer, G. A. Petsko

7.73 General Immunology

Prereq.: 7.05
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

7.75J Advanced Biochemistry (A) (Revised Unit)

(Same subject as 5.50J)
Prereq.: 7.05
G (2)
4-0-8

Major metabolic pathways for the synthesis of amino acids, coenzymes, lipids and steroids emphasizing enzyme mechanisms, regulation, and coenzyme-catalyzed reactions. Oxidative phosphorylation and photosynthesis.
G. M. Brown, C. T. Walsh

7.77 Structure, Function, and Assembly of Biological Macromolecules (A)

Prereq.: 7.05
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. Symmetry principles in macromolecular organization. The structure and assembly of viruses, ribosomes, and other organelles. Emphasizes the relationship of structure to biological function.
U. L. RajBhandary, R. T. Sauer

7.78 Seminar in Lipid and Carbohydrate Biochemistry (A)

Prereq.: 7.05
G (2) **Next offered 1984-85**
2-0-4

Discusses recent research in the area of complex lipids and carbohydrates. Lipid topics include phospholipids, prostaglandins, and steroids. In the carbohydrate area emphasizes 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
G (2)
3-0-9

Examines in depth 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, genome organization, genetic recombination, and gene function as developed in microbial systems. Subject designed to establish familiarity with literature and patterns of thought in the field and develop ability of critically evaluating papers. Undergraduates who have taken 7.03 and 7.21 admitted with permission of instructor.
M. S. Fox

7.90 Special Problems in Biology for Undergraduates

Prereq.: —
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.: —
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.: —
G (1)
Arr.

7.942 Research Problems (A)

Prereq.: —
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
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.: —
U (1, 2)
Arr.

Undergraduate research opportunities in physics. For further information contact the Departmental UROP Coordinator.
A. Lazarus

8.01 Physics I

Prereq.: —
U (1, 2)
5-1-6

Introduces 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. Heat and an introduction to kinetic theory.
A. P. French, J. G. King

8.012 Physics I

Prereq.: —
U (1)
5-1-6

Elementary mechanics, presented at greater depth than in 8.01. Newton's laws, concepts of momentum, energy, angular momentum, rigid body motion, non-inertial systems. Uses elementary calculus freely. Concurrent registration in a math subject more advanced than 18.01 is recommended.
J. S. Whitaker

8.013J Physics I

(Same subject as HST 500J)
Prereq.: —
U (1)
5-1-6

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 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.
Staff

8.02 Physics II

Prereq.: 8.01 or 8.012 or 8.013J; 18.01
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.
H. Enge, P. Joss

8.021 Physics II

Prereq.: 8.01 or 8.012 or 8.013J; 18.01
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.
Staff

8.022 Physics II

Prereq.: 8.012
U (2)
5-1-6

Parallel to 8.02, but at a mathematically more advanced level. Some knowledge of vector calculus assumed. Maxwell's equations, in both differential and integral form. Electrostatic and magnetic vector potential. Properties of dielectrics and magnetic materials.
Staff

8.023J Physics II

(Same subject as HST 501J)
Prereq.: 8.01 or 8.012 or 8.013J; 18.01
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; electrocardiography. Nernst-Planck equation; diffusion potentials; Debye shielding; electrophoresis of cells and proteins. Electrodes. Bioelectricity: cell membrane potentials. Magnetic fields; Lorentz force, Ampere's and Biot-Savart's laws. Faraday's law of induction; LC circuits. Maxwell's equations; electromagnetic waves.
Staff

8.03 Physics III

Prereq.: 8.02 or 8.021 or 8.022 or 8.023J; 18.02
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; wave solutions to Maxwell's equations; polarization; Snell's Law, interference, Huygens' principle, Fraunhofer diffraction, gratings.
K. U. Ingard

8.04 Quantum Physics I

Prereq.: 8.03 or 6.014, 18.03
U (1, 2) SD
5-0-7

Experimental basis of quantum physics: Photoelectric effect, Compton scattering, photons, Franck-Hertz experiment, the Bohr atom, electron diffraction, 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.
Staff

8.05 Quantum Physics II

Prereq.: 8.04 or 8.211
U (1, 2)
5-0-7

Reviews 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. Discusses real physical examples at each stage.
A. N. Berker

8.06 Mechanics II

Prereq.: 8.03
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.: —
U (1)
4-0-8

Surveys 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.
E. Moniz

8.08 Statistical and Quantum Physics

Prereq.: 8.05
U (2)
4-0-8

Introduces 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.
M. Baranger

Undergraduate Laboratory and Special Project Subjects

8.11 Physics Project Laboratory I

Prereq.: —
U (1) LAB
1-6-5

8.12 Physics Project Laboratory II

Prereq.: —
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. Machine shop facilities available. Not usable as a restricted elective for physics majors.
L. Osborne

8.13 Experimental Atomic Physics I

Prereq.: 8.04 or 8.211
U (1)
0-6-9

8.14 Experimental Atomic Physics II

Prereq.: 8.04 or 8.211, *8.05*
U (2)
0-6-9

About 6 fundamental laboratory experiments carried out each term, covering most aspects of modern physics relating to names such as Rutherford, Franck-Hertz, Hall, Ramsauer, Doppler, Fraunhofer, Faraday, Mossbauer, Compton, Stern-Gerlach. Stresses basic experimental techniques and data analyses, and written and oral presentation of experiment results. Second term requires knowledge of quantum mechanics at the 8.05 level.
R. Yamamoto

8.18 Special Problems in Undergraduate Physics

Prereq.: —
U (1, 2)
Arr.

Opportunity for undergraduates to engage in experimental or theoretical research under the supervision of a staff member. Specific approval required in each case.
G. F. Koster

8.19 Readings in Physics

Prereq.: —
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 required in each case.
G. F. Koster

Undergraduate Elective Subjects

8.20 Introduction to Special Relativity

Prereq.: 8.01, 18.01
U (2) SD
2-0-7

Analyzes time stretching, Lorentz contraction, limiting speed of light, solutions to the twin paradox using invariance of the interval. Lorentz transformation, and space-time diagrams. Analyzes particle collisions, interactions, transformations, creations, and annihilations using conservation laws and the energy-momentum 4-vector. Examples from MIT research projects. Puzzles and paradoxes. Briefly discusses the theory of gravitation (general relativity). Primarily for first- and second-year students.
E. F. Taylor

8.206J Public Controversies on the Control of Technology

(Same subject as STS 413J)
Prereq.: —
U (2)
2-0-7

See description under subject STS 413J.
B. T. Feld, C. Weiner

8.211 Introduction to Quantum Physics

Prereq.: 18.03, 8.02
U (1) SD
5-0-7

Introduces quantum physics with application to atoms, molecules, and solids. Emphasizes failures of classical physics, experimental basis for quantum mechanics, and an understanding of the Uncertainty Principle. Applies Schroedinger's theory to the free particle, tunneling, the harmonic oscillator, and the hydrogen atom. Discusses Pauli Exclusion Principle, many-electron atoms, and quantum theory of ionic and covalent bonding. 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
U (1)
4-0-8

First term of a sequence presenting basic concepts of the quantum theory of solids. Emphasizes simple physical models. Topics: periodic structure and symmetry of crystals; diffraction; reciprocal lattice; chemical bonding; 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.
M. Kastner

8.236 Topics in Quantum Theory of Matter

Prereq.: 8.05
U (2) **Not offered 1984-85**
3-0-9

Introduces 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
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. Laser oscillators. Excitation mechanisms in gaseous and solid-state lasers. Raman effect and nonlinear optics. Laboratory demonstrations. Requires familiarity with Maxwell's equations and the Schroedinger equation.
M. S. Feld, A. Javan

8.243 Modern Optics

Prereq.: 8.03
U (1) SD **Next offered 1984-85**
3-0-9

Ray matrices, reflection and refraction at dielectric interface. Fresnel equations, Gaussian beams, optical resonators. Fiber optics. Propagation in anisotropic media, optical activity, electro-optics and magneto-optic effects. Propagation in nonlinear media, effects of second- and third-order nonlinear susceptibility. Interference, Michelson and Fabry-Perot interferometers, Fourier transform spectroscopy, multi-layer films. Fraunhofer and Fresnel diffraction. Diffraction gratings. Fourier optics, spatial filtering, holography.
R. L. Aggarwal

8.251 Physics of Noise and Fluctuations

Prereq.: 8.04
U (1) **Not offered 1984-85**
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. Discusses modern experimental techniques for the study of thermal fluctuations. Quantum effects. Information theory. Fluctuations in living systems.
T. J. Greytak

8.263 Physics of Fluids

Prereq.: 8.03
U (1) SD **Next offered 1984-85**
3-0-9

Introduction to the physics of fluids. Emphasis on phenomena rather than mathematics. Topics: physical properties of liquids, gases, plasmas dynamics waves, and turbulence.
K. U. Ingard

8.272 Introduction to Nuclear Physics

Prereq.: 8.05 or 8.211
U (2)
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. Discusses modern experimental techniques and research in progress at MIT.
E. Moniz

8.274 Introduction to Particle Physics

(8.273)
Prereq.: 8.05
U (2)
4-0-8

High-energy accelerators and particle detectors. Particles and their classification. Quarks. Four classes of fundamental forces and the corresponding carriers of the forces. Symmetries and conserved quantities. High energy e^+e^-, pp, $\overline{p}p$ and lepton-proton interactions. Observations of charm and beauty and current search for new quarks, leptons, and the weak bosons.
Staff

8.282 Introduction to Astrophysics and Astronomy

Prereq.: *8.02*, 18.01
U (2) SD
3-0-9

Quantitative introduction to physics of the Galaxy and the universe as determined from a variety of astronomical observations 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. Prior knowledge of astronomy not necessary. Not usable as a restricted elective by physics majors.
Staff

8.284 Modern Astrophysics

Prereq.: *8.05*
U (2)
3-0-9

Applications of physics to fundamental processes which occur in celestial objects and in the interstellar medium, e.g., synchrotron radiation, thermal bremsstrahlung, inverse Compton effect. Applications to the Galaxy, main sequence stars, neutron stars, radio galaxies, supernovae, pulsars, the "big bang" universe. Observational data discussed.
Staff

8.287J Observational Techniques of Optical Astronomy

(Same subject as 12.117J)
Prereq.: Any subject in Astronomy or Astrophysics
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, limitations 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 Physics of the Solar System (Revised Content)

(Same subject as 12.131J)
Prereq.: *8.03*
U (1) SD
3-0-9

See description under subject 12.131J.
G. H. Pettengil, C. C. Counselman, J. L. Elliot

8.293J Dynamical Astronomy

(Same subject as 12.115J)
Prereq.: 18.03
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. Emphasizes throughout applications to actual problems, both historical and current, rather than on mathematical theory *per se*.
C. C. Counselman

8.299 Physics Teaching

Prereq.: —
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.: —
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.
R. Weiss

Graduate Subjects

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
G (2)
4-0-8

Basic principles of electromagnetic theory: Maxwell's equations; vector and scalar potentials; conservation laws, methods in electro- and magnetostatics. 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
G (1)
4-0-8

8.322 Quantum Theory II (A)

Prereq.: 8.321
G (2)
4-0-8

A two-semester subject on quantum theory, stressing principles: uncertainty relation, 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. Variational and perturbation approximations. Systems of identical particles and applications. Time-dependent perturbation theory. Scattering theory: phase shifts, Born approximation. The quantum theory of radiation. Second quantization and many-body theory. Relativistic quantum mechanics of one electron.
R. Jackiw

8.323 Relativistic Quantum Field Theory (A)

Prereq.: 8.322
G (1)
3-0-9

Classical field theory, canonical quantization, and Dirac field. Interacting fields, perturbation theory, Feynman graphs. Symmetries. Renormalization. Calculations in quantum electrodynamics.
E. Farhi

8.333 Statistical Mechanics I (A)

Prereq.: 8.321
G (1)
4-0-8

8.334 Statistical Mechanics II (A)

Prereq.: 8.333
G (2)
4-0-8

Thermodynamics: work and heat, temperature and entropy. Basic postulates of statistical mechanics, classical and quantum mechanics. Open systems: canonical and grand canonical distributions and free energy minimum principle. Applications to real and model systems: Fermi and Bose gases, photon gas, lattice vibrations, Van der Waal gases. Fluctuation-dissipation theorem. Monte Carlo methods. 8.334 a continuation of 8.333. Superfluidity. Elementary excitations in Bose and Fermi systems. Broken symmetry and phase transitions: scaling description and the application of the renormalization group to critical phenomena.
8.333: *F. Villars*
8.334: *P. A. Lee*

8.361 Quantum Theory of Many-Particle Systems (A)

Prereq.: 8.322, 8.333
G (1) **Next offered 1984-85**
3-0-9

Introduces general many-body theory applicable to low temperature, nuclear, and solid-state physics. Reviews 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.
Staff

8.371 Advanced Mathematics for Physicists I (New)

Prereq.: 18.101
G (1)
3-0-9

8.372 Advanced Mathematics for Physicists II (New)

Prereq.: 8.371
G (2)
3-0-9

A year course in modern mathematical techniques with specific application to physics. Topics: set and measure theory (application to statistical mechanics); fibre bundles (application to gauge theories); loop expansions (Green-Graebert corrections to deterministic processes); negative feedback and VLSI systems (strange attractors in field theory and cardiac dysrhythmias). Offered when sufficient student demand is demonstrated.
J. E. Young

8.381, 8.382 Selected Topics in Theoretical Physics (A)*

Prereq.: Permission of Instructor
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.: Permission of Instructor
G (1, 2)
Arr.

Reading, consultation, and original investigation on a problem in theoretical physics.
Staff

8.399 Physics Teaching (A)

Prereq.: Permission of Instructor
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
G (1) **Next offered 1984-85**
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
G (1, 2) **Not offered 1984-85**
3-0-9

Atom-radiation field interactions: resonance vs transition rate viewpoints, dressed atoms for intense fields, momentum exchange, and multi-photon processes (including 4-wave mixing). Coherence effects: quantum beats, level crossing spectroscopy, and superradiance. Methods of laser spectroscopy. Atom-atom interactions: interatomic forces, diatomic molecules, elastic and inelastic collisions, atom-molecule collisions (energy transfer). Emphasizes semiclassical methods and relationship of continuum and bound behavior.
D. E. Pritchard

8.422 Survey of Atomic Physics (A)

Prereq.: 8.05
G (2)
3-0-9

Surveys basic problems and contemporary research. Topics: the interaction of atoms with radiation; resonance and resonance techniques; spontaneous, stimulated and inhibited emission; masers; the spectroscopy of hydrogen; the Lamb shift and the anomalous electron moment; the fundamental constants; highly excited atoms; atoms in strong fields. Some discussion of experimental techniques.
D. Kleppner

8.442 Statistical Optics and Spectroscopy (A)*

Prereq.: 8.05, *8.08*
G (2) **Not offered 1984-85**
3-0-9

Discusses light as a statistical process and describes 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
G (1) **Not offered 1984-85**
3-0-9

Develops 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.
M. S. Feld, A. Javan

8.452 Seminar in Optical and Infrared Lasers (A)

Prereq.: 8.451
G (2) **Next offered 1984-85**
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.
M. S. Feld, A. Javan

8.481, 8.482 Selected Topics in Physics of Atoms and Radiation (A)*

Prereq.: 8.321
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.: Permission of Instructor
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
G (2)
4-0-8

See description under subject 6.732J.
M. S. Dresselhaus

8.511J Theory of Solids I (A)

(Same subject as 6.741J)
Prereq.: 8.231J
G (1)
3-0-9

First term of a theoretical treatment of the physics of solids. Concept of elementary excitations. Symmetry: translational, rotational, and time-reversal invariances: theory of representations. Energy bands: APW, OPW, pseudopotential and LCAO schemes. Survey of electronic structure of metals, semimetals, semiconductors, and insulators. Excitons. Critical points. Response functions. Interactions in the electron gas.
J. D. Joannopoulos, D. Adler

8.512J Theory of Solids II (A)

(Same subject as 6.742J)
Prereq.: 8.511J
G (2)
3-0-9

See description under subject 6.742J.
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
G (1) **Next offered 1984-85**
3-0-9

See description under subject 6.734J.
G. F. Koster, M. S. Dresselhaus

8.532 Physics of Semiconductors (A)

Prereq.: 8.231J or 8.05
G (2)
3-0-9

Theoretical and experimental exposition of the electrical, optical, and magnetic properties of semiconductors. Topics: Energy bands, emphasizing $\vec{\kappa} \cdot \vec{p}$ theory; cyclotron resonance; magnetotransport; interband and intraband optics, impurity states; elementary excitations, phonons, excitons, polaritons, plasmons, electron-hole drops; nonlinear spectroscopy, two-photon absorption, Raman scattering; two-dimensional systems, superlattices, quantum wells, quantized Hall effect; physics of devices, i.e., tunneling, electron transfer, avalanche, lasers.
B. Lax, R. L. Aggarwal

8.562 Correlations and Critical Behavior in Condensed Matter (A)

Prereq.: 8.511J, 8.333
G (2) **Next offered 1984-85**
3-0-9

Views condensed matter physics through space- and time-dependent correlation functions measured by scattering spectroscopy. Treats in detail experimental techniques of x-ray, light, electron, and neutron scattering. Theoretical development is strongly phenomenological to elucidate physical behavior with minimal mathematical complexity. Uses conservation laws, broken symmetry, and the fluctuation-dissipation theorem to illustrate the interconnection between apparently diverse systems with special attention to behavior near phase transitions.
J. D. Litster

8.581, 8.582 Selected Topics in the Theory of Solids (A)*

Prereq.: 8.512J
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.: Permission of Instructor
G (1, 2)
Arr.

Advanced problems in the physics of the solid state, with assigned reading and consultation.
Staff

8.613J Introduction to 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
G (1)
3-0-9

Introduces 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. MHD models; simple equilibrium and stability analysis. Two-fluid

hydrodynamic plasma models; wave propagation in a magnetic field. Introduces kinetic theory; Vlasov plasma model; electron plasma waves and Landau damping; ion-acoustic waves; streaming instabilities.
A. Bers, K. Molvig, M. Porkolab

8.614J Introduction to Plasma Physics II (A)

(Same subject as 6.652J, 22.612J)
Prereq.: 6.651J or 8.613J or 22.611J; 18.075
G (?)
3-0-9

See description under subject 22.612J.
R. C. Davidson, A. Bers, K. Molvig

8.621J Plasma Kinetic Theory (A)

(Same subject as 22.64J)
Prereq.: 8.613J
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
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 Radio Frequency Heating of Plasmas and Nonlinear Effects (A)

Prereq.: 8.613J
G (2)
3-0-9

Comprehensive theory of electromagnetic waves in a magnetized plasma. Effects of finite temperature including 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, with applications to radio-frequency heating of fusion plasmas (ECRH, ICRH, LHH). RF current drive in tokamaks. Parametric instabilities. Discusses relevant experimental results.
M. Porkolab

8.641 Physics of High Temperature Plasmas I (A)

Prereq.: 8.613J
G (1) **Next offered 1984-85**
3-0-9

8.642 Physics of High Temperature Plasmas II (A)

Prereq.: 8.613J
G (1) **Not offered 1984-85**
3-0-9

Basic concepts of plasmas, with temperatures of thermonuclear interest, relevant to fusion research and to astrophysics. Microscopic transport processes due to inter-particle collisions and to collective modes (e.g., microinstabilities). Relevant macroscopic transport coefficients (electrical resistivity, thermal conductivities, particle "diffusion"). Runaway and slide-away regimes. Magnetic reconnection processes and their relevance to experimental observations. Radiation emission from inhomogeneous plasmas. Conditions for thermonuclear burning and ignition (D-T and "advanced" fusion reactions, plasmas with polarized nuclei). Role of "impurity" nuclei. "Finite-β" (pressure) regimes and ballooning modes. Convective modes in configuration and velocity space. Trapped particle regimes. Nonlinear and explosive instabilities. Interaction of positive and negative energy modes. Each subject can be taken independently.
B. Coppi

8.681, 8.682 Selected Topics in Fluid and Plasma Physics (A)*

Prereq.: 8.613J
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.: Permission of Instructor
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
G (1)
3-0-9

Introduces 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.
Staff

8.712 Nuclear Physics II (A)

Prereq.: 8.711
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.
Staff

8.721 High-Energy Nuclear Physics (A)*

Prereq.: 8.712
G (1) **Not offered 1984-85**
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. Offered when sufficient interest is demonstrated.
W. Bertozzi

8.751 Theory of Nuclear Structure (A)

Prereq.: 8.322
G (1) **Next offered 1984-85**
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, time permitting. Unified theory of nuclear reactions; theory of the optical potential.
E. L. Lomon

8.781, 8.782 Selected Topics in Nuclear Theory (A)*

Prereq.: 8.751
G (1, 2)
3-0-9

Presents 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.: Permission of Instructor
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
G (2)
4-0-8

Introduces phenomenology of particle properties and interactions, stressing experimental results. Classification by quantum numbers. Isospin concept, symmetries; conservation laws. Particle detectors and techniques. Accelerators. Quark model, color symmetry, Dirac equation, and QED. V-A theory. Conservation-Violation; Parity, etc., experiments. K-mesons, associated production, puzzles, mixing, regeneration, CP-violation.
J. G. Branson

8.811 Particle Physics II (A)

Prereq.: 8.810
G (1)
3-0-9

Resonances, data, and models. Elementary symmetries SU (2)-SU (6). Photoproduction and inelastic e-p scattering experiments. Parton — quark picture. Tests. e^+e^- storage rings. Neutrino physics; charged and neutral currents. Unification of electromagnetic and weak interactions. Z_o Searches. $p\bar{p}$ — colliders. Physics phenomena at extremely high energies.
U. J. Becker

8.871, 8.872 Selected Topics in Theoretical Particle Physics (A)*

Prereq.: 8.323
G (1, 2)
3-0-9

Presents 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
G (1, 2)
3-0-9

Presents 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.: —
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 (A)

Prereq.: 8.05, 8.08
G (2)
3-0-9

Size and time scales in astrophysics. Stellar structure equations and survey of stellar evolution. Degenerate stars and interacting binary stars. Radiative transfer, line formation, spectroscopy of interstellar medium. The equilibrium of stellar systems and the distribution of stars in our galaxy. Introduces cosmology.
L. Cowie, S. Tremaine

8.912 Intermediate Theoretical Plasma Physics (A)

Prereq.: 8.613J
G (1) **Next offered 1984-85**
3-0-9

Provides a unified theoretical connection among topics covered in Physics 8.613J, 8.641, 8.642, 8.913, 8.914, and 8.621J. Draws significant physical examples from material described under 8.641, 8.642 and 8.913, 8.914. Devotes special attention to relationships between different theoretical descriptions of plasmas: to the ideal MHD approximation, multi-fluid approximations, guiding center approach and "drift" (quasi-kinetic) approximation, the Vlasov and Fokker-Planck equations, the analysis transport processes of in trapped particle regimes.
B. Coppi

8.913 Physics of Space Plasmas I (A)

Prereq.: Permission of Instructor
G (2) **Next offered 1984-85**
3-0-9

8.914 Physics of Space Plasmas II (A)

Prereq.: Permission of Instructor
G (2) **Next offered 1984-85**
3-0-9

For students interested in space physics, astrophysics, and plasma physics in general. Magnetospheres of rotating magnetized planets, ordinary stars, neutron stars, and black holes. Pulsar models: processes for slowing down, particle acceleration, and radiation emission; accreting plasmas and x-ray stars; stellar winds; heliosphere and solar wind: relevant magnetic field configuration, measured particle distribution in velocity space and induced collective modes; stability of the current sheet and collisionless processes for magnetic reconnection; theory of collisionless shocks; solitons; Ferroaro-Rosenbluth sheet; solar flare models; heating processes of the solar corona; earth's magnetosphere (auroral phenomena and their interpretation, bow-shock, magnetotail, trapped particle effects); relationship between gravitational (galactic) plasmas and electromagnetic plasmas. Each subject can be taken independently.
B. Coppi

8.921 Stellar Structure and Evolution (A)

Prereq.: 8.910
G (1) **Not offered 1984-85**
3-0-9

Observable stellar characteristics; overviews observational information. Principles underlying calculations of stellar structure interiors. Physical processes in stellar interiors; properties of matter and radiation; radiative, conductive, and convective heat transport; nuclear energy generation; nucleosynthesis; neutrino emission. Protostars; the main sequence, and the solar neutrino flux; advanced evolutionary stages; variable stars; planetary nebulae, supernovae, white dwarfs, and neutron stars; close binary systems; abundance of chemical elements. Permission of instructor required.
P. C. Joss

8.922 Physics of the Galaxy (A)

Prereq.: 8.910
G (2) **Not offered 1984-85**
3-0-9

Observations of the distribution of stars, clusters, gas, and dust in the galaxy. Theory of the equilibrium of stellar systems: Vlasov equation, Fokker-Planck equation, Jeans' theorem and the third integral. Introduces spiral structure theory. Interstellar clouds, evolution of supernova envelopes, star formation, and the energy budget of the interstellar medium. Permission of instructor required.
L. Cowie, S. Tremaine

8.923 High Energy Astrophysics (A)

Prereq.: 8.910
G (1) **Next offered 1984-85**
3-0-9

Observation and theory of high energy phenomena in astrophysics. Reviews special relativity. Synchrotron radiation. Compton processes. Bremsstrahlung radiation. Coherent radiation processes. Radio pulsars. Cosmic rays-origin, acceleration and confinement. Supernovae. Shock waves. X-ray sources–spherical and disk accretion, diffuse x-ray emission. Quasars and Seyfert galaxies. Permission of instructor required.
C. Alcock

8.942 Cosmology (A)

Prereq.: Permission of Instructor
G (2)
3-0-9

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 to variability of physical laws. First and last states. Some knowledge of relativity expected. 8.962 recommended though not required.
P. Morrison

8.962 General Relativity and Gravitation (A)*

Prereq.: 8.07
G (2)
3-0-9

Special relativistic electrodynamics and hydrodynamics. Principle of equivalence. Tensor calculus for general coordinate systems. Riemannian geometry. Gravitational field. Einstein field equations. The Einstein action. Schwarzschild solution. Solar system spaces. Robertson-Walker metric and cosmography. Standard cosmological model. The early universe. Black holes.
Staff

8.981, 8.982 Selected Topics in Astrophysics (A)*

Prereq.: Permission of Instructor
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.: Permission of Instructor
G (1, 2)
Arr.

Advanced problems in astrophysics with assigned reading and consultation.
Staff

8.ThG Graduate Physics Thesis (A)

Prereq.: —
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.: —
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.: —
U (1)
4-0-5

Considers the organization and development of human mental life and behavior. Explores cognition, emotions, and action in terms of their biological roots, psychological manifestations, and social extensions. Reviews basic findings in sensation, perception, learning, memory, personality, and motivation, and examines controversies about "human nature," mental illness, IQ tests, brain/mind relations.
S. L. Chorover, J. M. Wolfe

9.01 Neuroscience and Behavior

Prereq.: 9.00 or 9.62J
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.
G. E. Schneider

9.014J The Human Nervous System: The Neurosciences I (A)

(Same subject as 20.511J, HST 130J)
Prereq.: Permission of Instructor
G (1)
6-3-6

See description under subject HST 130J.
W. J. H. Nauta, E. Bizzi, N. Geschwind, A. M. Graybiel, A. North, S. Palay, V. Chan Palay, A. Rossier, T. Sabin, P. H. Schiller, H. R. Tyler, R. J. Wurtman

9.015J The Neurosciences II (A)

(Same subject as 20.512J)
Prereq.: Permission of Instructor
G (2)
6-0-9

See description under subject 20.512J.
R. A. North, R. J. Wurtman, M. J. Baum, S. Corkin, G. E. Schneider

9.018J Pathophysiology of the Nervous System (A)

(Same subject as 20.518J, HST 131J)
Prereq.: 9.016J
G (2)
3-0-6

See description under subject HST 131J.
N. Geschwind, M. A. Moskowitz

9.019 Topics in Neuropsychology (A)

Prereq.: Permission of Instructor
G (2) **Next offered 1984-85**
2-3-7

Introduces current research on the effects of brain disease on human behavior. Lectures by neuropsychologists, neurologists, and psychiatrists, emphasizing specific neural mechanisms underlying memory, attention, language, perception, spatial abilities, motivation, and emotion. Also includes hemispheric specialization and the role of neurotransmitters and hormones in brain diseases. Laboratory sessions include demonstrations of behavioral testing methods and presentations of patients. Alternate years.
S. Corkin, Guest Lecturers

9.02 Nature, Nurture, and the Individual Brain

Prereq.: 9.01
U (2) **Next offered 1984-85**
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. Human cognitive and emotional systems and sources of variability. Alternate years.
N. Geschwind, P. H. Schiller, G. E. Schneider

9.021 Topics in Brain and Behavior (A)

Prereq.: Permission of Instructor
G (2) **Not offered 1984-85**
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 final test during the last class. Alternate years.
S. Corkin, A. M. Graybiel

9.022 Topics in Neuroanatomy (A)

Prereq.: 9.014J
G (2) **Next offered 1984-85**
3-0-6

Recent findings and functional concepts dealing with neurotransmitter systems and internal organization of central nervous system. Seminar sessions in which participants take turns leading class discussions on the readings and presenting reports on special topics. Alternate years. Permission of instructor required.
A. M. Graybiel

9.023 Principles of Neuronal Growth

Prereq.: Permission of Instructor
G (2) **Not offered 1984-85**
3-0-6

Topics in developmental neurobiology selected according to interests of students and staff. Possibilities: neuronal proliferation and migration, growth cones and axonal elongation, competition among terminating axons, stages in axonal or dendritic growth as defined by morphology or biochemistry, transplants as experiments in developmental mechanisms or as therapy for adult brain damage, aberrant axonal growth as a cause of behavior disorders. Requirements include readings in recent literature and class participation and reports. Alternate years.
S. Jhaveri, G. E. Schneider

9.036 The Visual System (A)

Prereq.: Permission of Instructor
G (1) **Not offered 1984-85**
3-0-6

Reviews the current neurophysiological and neuroanatomical research literature on the mammalian visual system. Alternate years.
P. H. Schiller

9.05 Psychotechnology: Scientific and Ethical Issues in Behavior Control

Prereq.: —
U (2) **Next offered 1984-85**
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. Discusses biomedical and psychotechnological approaches to delinquency, drug addiction, and other social problems in terms of their alleged scientific bases, scope, power and limitations. Emphasizes throughout questions bridging the traditional gap between science/technological/social policy. Alternate years.
S. L. Chorover

9.051 Human Nature and Sociobiology (A)

Prereq.: Permission of Instructor
G (2) **Next offered 1984-85**
3-0-6

Critical survey of attempts to account for human social behavior in terms of evolutionary and psychobiological mechanisms. The "nature vs. nurture" controversy and its influence from ancient times to the present. Particular emphasis on motivation, territoriality, aggression, competition, cooperation, etc. and alleged implications for laissez-faire and planned economic systems, conformity and deviance, social stability and social change. Readings in scholarly and popular sources. Alternate years.
S. L. Chorover

9.30 Animal Behavior

Prereq.: 9.00
U (1)
3-0-6

Reviews basic concepts in the study of animal behavior. Examines the natural history of selected species (e.g., felids, canids, and cephalopods). Contributions of environment and heredity to the shaping of behavior. Inquires into the contribution of behavior to meeting requirements for individual and species survival. Analyzes selected problems including animal communication, navigation, sexual behavior, aggression, defense, perception and learning.
A. Hein

9.35 Sensation and Perception

Prereq.: 9.00 or 9.62J
U (2)
3-0-6

Surveys the mechanisms and models of sensory processes and neural systems underlying perception in humans and other animals. Discusses basic properties of vision, hearing, smell, touch, and taste. 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 count toward Humanities Requirement *only* by students concentrating in Psychology; see Department for details.
R. Held, J. M. Wolfe

9.351 Advanced Seminar on Sensation and Perception

Prereq.: Permission of Instructor
G (2)
4-0-8

Reads, discusses, and criticizes current theory and experiments bearing on topics selected according to interests of participants. Different topics each year. Sample topics: perception of form, motion, and space; sensorimotor interaction; relevant neural processes; theoretical models, comparisons among species; and developmental approaches.
R. Held, J. M. Wolfe, S. Ullman, P. Schiller

9.36 Natural Computation and Control

Prereq.: 18.02
U (1)
3-0-6

Objects differ widely from each other as well as among themselves in terms of their appearance and behavior in a natural environment. These differences are limited, however, by the natural and physical properties of the world. Recognizing these constraints allows us to understand how different objects may be represented and manipulated. Examples stress the computation of visual aspects of a scene, although useful acoustic and tactile representations are also included. May *not* count toward Humanities Requirement.
W. A. Richards, P. H. Winston, C. L. Searle

9.362 Problems in Natural Computation (A)

Prereq.: Permission of Instructor
G (1)
4-0-8

General survey of the field of Natural Computation is provided by 9.36 lectures, which students are expected to attend and complete. This basic material is supplemented by readings and in-depth study of a particular problem. Term paper required.
W. A. Richards

9.370 Control of Movement in Biological and Robotic Systems (A)

Prereq.: Permission of Instructor
G (1)
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.
E. Bizzi, J. Hollerbach

9.372 Movement: Mechanisms and Models (A)

Prereq.: 9.370
G (1, 2)
3-0-6

Research seminar directed at surveying basic concepts and methods in the study of the vertebrate motor system. Reviews current investigations on neural integration in movement control emphasizing spinal cord, cerebellar and cortical mechanisms; arm trajectory formation, physiology, and biomechanics; eye-head and eye-hand coordination; manipulation. Permission of instructor required for students without 9.370 background.
E. Bizzi

9.380 Vision Algorithms and Psychophysics (A)

Prereq.: Permission of Instructor
G (2)
3-0-6

Seminar on the theory of visual information processing and applying algorithmic techniques to vision by humans or machines. Discusses interactions between psychophysics of human vision, computational studies, and machine vision. Topics include properties of light, sampling and interpolation, edge detection, motion, stereo, and neuronal hardware.
S. Ullman, T. Poggio

9.39J Human Factors in Design

(Same subject as 2.18J, 22.088J)
Prereq.: Permission of Instructor
U (2)
3-1-8

See description under subject 2.18J.
A. Hein, T. B. Sheridan, D. D. Lanning

9.401 Survey of Cognition and Perception

Prereq.: Permission of Instructor
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 9.62J or 9.90; and one other subject in Psychology
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

9.59 Psychology of Language and Communication

Prereq.: 9.62J or 24.900J
U (1)
3-0-6

Studies language processes in light of contemporary linguistic theory: systematic examination of core problems of language production and perception. Stresses methodological implications of psycholinguistic experiments and theory.
M. F. Garrett

9.591 Seminar in Psychology of Language and Communication I (A)

Prereq.: 9.59 or 9.901
G (1)
3-0-6

Reads, discusses, and criticizes selected topics. Emphasizes 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. Permission of instructor required for students without 9.59 or 9.901 background.
J. A. Fodor, M. F. Garrett

9.592 Seminar in Psychology of Language and Communication II (A)

Prereq.: Permission of Instructor
G (2)
3-0-6

Advanced topics in psycholinguistics, emphasizing current studies of language production and language disorders. A research paper required as part of this subject.
M. F. Garrett

9.601J Seminar on Language Acquisition (A)

(Same subject as 24.949J)
Prereq.: Permission of Instructor
G (2) **Not offered 1984-85**
3-0-6

Reading and discussion of current theory and data concerning language acquisition. Emphasizes learning of syntax and morphology, and especially research relating syntactic theory and learnability theory to empirical studies of children's linguistic abilities.
S. Pinker

9.62J Introduction to Cognitive Science

(Same subject as 24.116J)
Prereq.: —
U (1)
3-0-9

Surveys 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. Emphasizes clear formulation of questions and theoretical criteria of adequacy. Examines specific proposals in response to these questions.
D. N. Osherson

9.632 Formal Learning Theory (A) (New)

Prereq.: 9.62J
G (1)
3-0-9

Introduces the mathematical theory of learning and language acquisition. Applications to machine learning. Rigorous development of automata-theoretic models and general limitation results. Permission of instructor required for students without 9.62J background.
D. N. Osherson

9.65 Cognitive Processes

Prereq.: —
U (2)
3-0-6

An introduction to human information processing and learning; topics include the nature of mental representation and processing; the architecture of memory; pattern recognition; imagery and mental codes; concepts and prototypes; reasoning and problem solving.
M. C. Potter, S. Carey

9.651 Cognitive Processes (A)

Prereq.: Permission of Instructor
G (2) **Not offered 1984-85**
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. Alternate years.
M. C. Potter

9.652 Seminar in Cognitive Development (A)

Prereq.: Permission of Instructor
G (1)
3-0-6

Critical survey of selected topics. Emphasizes 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

9.68 Affect: Biological, Psychological, and Social Aspects of "Feelings"

Prereq.: 9.00
U (2) **Not offered 1984-85**
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. Alternate years.
S. L. Chorover

9.70 Social Psychology

Prereq.: —
U (2)
3-0-6

Examines 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

Prereq.: 9.00 or 9.62J
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.
A. Hein

9.90 Human Development: Individual and Social Perspectives

Prereq.: —
U (2)
3-0-6

Examines psychological processes and structures from a developmental perspective. The evolution of individual personality and social awareness treated first, followed by an overview of leading theories of cognitive growth. Gives special attention to the perceptual, cognitive, and affectional systems operative in the human infant; links the organization of these immature systems 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)

Prereq.: Permission of Instructor
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. Consult R. Held.

9.91, 9.92 Topics in Psychology

Prereq.: 9.00 or 9.62J and any other two subjects in Psychology
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
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 M. C. Potter.

9.921 Research in Psychology (A)

Prereq.: 9.901
G (1)
Arr.

9.922 Research in Psychology (A)

Prereq.: 9.901
G (2)
Arr.

9.923 Research in Psychology (A)

Prereq.: 9.901
G (S)
Arr.

Guided research under the sponsorship of individual members of the faculty. Ordinarily restricted to candidates for the doctoral degree in psychology. Consult M. C. Potter

10 Chemical Engineering

10.UR Undergraduate Research

Prereq.: —
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.: —
U (2) SD
3-0-6

Introduces 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 Engineering Systems

Prereq.: 18.02, 8.01
U (1) SD
3-0-9

School-Wide Elective Subject. Description given at end of this chapter on SWE page.
B. Schumacker

10.13 Mass and Energy Processing

Prereq.: *18.02*
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; 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.
C. M. Mohr

10.14 Chemical Engineering Thermodynamics

Prereq.: 10.13
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.
R. C. Reid, H. Brenner, J. W. Tester

10.17 Air Pollution Fundamentals

Prereq.: 5.41, 18.02
U (2) SD
2-0-4

Introduces the causes, effects, and control of air pollution emphasizing 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
U (2)
3-0-6

Studies processes for making industrial chemicals as systems. Explores 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
U (2)
2-8-2

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. Working in small teams students are assigned projects preferably relating to ongoing research programs. Enrollment limited. Permission of instructor required.
J. M. Beér

10.21 Structures and Properties of Matter

Prereq.: 5.41, 5.62
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.
U. W. Suter

10.25 Industrial Chemistry and Chemical Process Pathways (A)

Prereq.: 5.41, 10.14, 10.37
G (1)
3-0-6

Chemical and engineering principles involved in creation and operation of viable industrial processes. Topics: analysis of process chemistry by p-pathways (i.e., radical, ionic, and pericyclic reactions of organic syntheses) and d-pathways (i.e., catalysis by transition metal complexes). Use of reaction mechanisms for inference of co-product formation, kinetics, and equilibria: process synthesis logic related to reaction selectivity, recycle, separations. Illustrations drawn from current and contemplated commercial practice.
P. S. Virk

10.26 Chemical Engineering Laboratory

Prereq.: 5.41, 10.14, 10.302, 10.37
U (1)
2-8-2

Laboratory projects in the areas of applied chemical research and unit operations. Emphasizes 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
U (1)
3-0-6

Introduces 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. Introduces boundary layer theory.
R. A. Brown, J. F. Brady

10.302 Transport Processes

Prereq.: 10.13, 10.301
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, H. H. Sawin

10.32 Separation Processes

Prereq.: 10.14, 10.302
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.
T. A. Hatton

10.33 Analytical Treatment of Chemical Engineering Processes (A)

Prereq.: 10.301, 18.03
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 and partial differential equations. Solution of these equations by analytical methods.
R. C. Armstrong

10.331 Nonlinear Analysis in Chemical Engineering

Prereq.: 10.33
G (2)
3-0-6

Emphasizes both classical and modern methods for analyzing nonlinear ordinary and partial differential equations arising in reaction engineering and transport phenomena. Topics: elementary stability theory and bifurcation analysis of steady states; introduction to time periodic phenomena; numerical methods for tracking multiple-steady and time-periodic states.
R. A. Brown

10.34 Numerical Methods Applied to Chemical Engineering (A)

Prereq.: 10.33
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
G (2) **Next offered 1984-85**
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
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.
M. Kramer

10.36 Process Design

Prereq.: 10.302, 10.32
U (2)
3-0-6

Presents and discusses real process design problems, with case studies in chemical processing and petrochemicals. Emphasizes conception and invention of processes, as well as analysis and economic balances, to specify optimum design and operating conditions. Discusses a variety of cases throughout the term.
C. M. Mohr

10.37 Chemical Kinetics and Reactor Design

Prereq.: 10.13, 10.301
U (2)
3-0-6

Introduces design of commercial chemical reactors emphasizing synthesis of chemical kinetics, transport phenomena. Topics: Kinetics and Equilibrium — elementary steps, transition state theory, multi-step reactions and multiple paths, network algebra. Ideal Reactors — batch, plug flow, well-stirred; residence time distributions. Transport in Reactors — heat and mass transfer, diffusion to and within catalyst particles. Reactor design — role of reaction pathway and thermochemistry; reactor size; modeling of performance.
P. S. Virk

10.38 Analysis and Simulation of Chemical Processing Systems (A)

Prereq.: 10.302, 18.03
G (2)
2-2-4

Introduces techniques for computer-aided analysis of chemical processing systems. Development of mathematical models to describe dynamic and steady-state process behavior. Numerical methods for solving resulting systems of nonlinear differential and optimization problems. Numerical techniques for solving the resulting nonlinear programming problems. Students gain experience in solving case study problems on the computer. Assumes knowledge of FORTRAN programming.
L. B. Evans

10.381 Computer-Aided Process Design (A)

Prereq.: 10.302, 10.32
G (1)
2-0-7

Use of the computer for steady-state process simulation and design with the aid of the ASPEN software system. Modeling the flowsheet, selection of thermophysical property models, use of data regression to fit constants in models, unit operation models, development of specialized models for chemical reactors, cost estimation, and economic evaluation. Techniques for convergence of recycle streams and design specifications. Students gain experience in the use of ASPEN to solve case study problems.
L. B. Evans

10.39 Energy Technology (A)

Prereq.: 10.13, 10.14
G (2)
3-0-6

Studies the factors determining the choice of energy technologies and their individual design and performance features. Considers energy supply-demand patterns, economics, efficiency of resource utilization, and environmental and social effects. Gives special emphasis 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
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, H. Brenner, J. W. Tester

10.42 Advanced Thermodynamics (A)

Prereq.: 10.40
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, H. Brenner, J. W. Tester

10.48J Gas-Solid Reactions (A)

(Same subject as 3.551J)
Prereq.: 3.55, 10.50
G (2) **Not offered 1984-85**
3-0-6

See description under subject 3.551J.
J. Szekely

10.49J Biomedical Transport Phenomena (A)

(Same subject as HST 521J)
Prereq.: 10.301, 10.302
G (2)
2-0-5

Applies the principles of transport phenomena to the analysis of selected physiological processes and the design of artificial internal organs and extracorporeal devices. Reviews 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, emphasizing artificial kidneys and cardiopulmonary assist devices.
C. K. Colton, W. M. Deen

10.50 Heat and Mass Transfer (A)

Prereq.: 10.302
G (1)
4-0-8

Analyzes diffusive and convective transport of heat and mass. Exact and approximate analytical solutions to steady-state and transient diffusion or conduction problems. Fundamentals of momentum transfer. Forced and free convection of heat and mass in laminar flow, including laminar and boundary layers. Heat and mass transfer in turbulent fluids. Simultaneous heat and mass transfer in problems with phase changes or chemical reactions.
R. A. Brown, W. M. Deen, J. Brady

10.51 Macromolecular Hydrodynamics (A)

Prereq.: 10.301
G (2) **Not offered 1984-85**
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.
R. C. Armstrong

10.52 Mechanics of Fluids (A)

Prereq.: 10.50
G (2)
3-0-6

Advanced course in fluid and continuum mechanics. Content may vary, drawing from such topics as low Reynolds number hydrodynamics, Brownian motion, suspension mechanics, flow in porous media, multiphase/particulate flow, ideal fluid theory, laminar boundary-layer theory, stability theory, and turbulence.
J. F. Brady, H. Brenner

10.54 Advanced Topics in Heat and Mass Transfer (A)

Prereq.: 10.50
G (2)
3-0-6

Generalized Taylor dispersion theory with applications to chromatographic separation processes and flow and dispersion in porous media. Mixing at the macroscopic and microscopic levels, emphasizing scale-up of industrial processes, including chemical reaction phenomena. Transport problems in evaporation, dissolution, and crystallization in liquid-solid and vapor-solid systems. Applies stability and kinematic wave theory to transport processes in multi-phase/particulate systems.
J. Brady, H. Brenner, T. A. Hatton, J. W. Tester

10.565 Seminar in Separation Processes for Biochemical Products (A)

Prereq.: —
G (1)
2-0-4

Focuses on the fundamental problems of separation operations important to the recovery of products from biological processes. Biotechnology is placing new demands on chemical engineers to separate both large and small molecule weight molecules from aqueous media. Lectures cover membrane filtration, chromatography, centrifugation, electrochemical separation, and other techniques.
C. K. Colton, C. L. Cooney

10.57J Polymer Processing (A)

(Same subject as 2.820J)
Prereq.: 10.301
G (2) **Next offered 1984-85**
3-0-9

Reviews physicochemical, mechanical, and rheological properties of polymers. Surveys processing techniques. Modeling, analysis, and scale-up of extrusions, molding, thermoforming, calendering, and mixing. 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.
R. C. Armstrong, L. Erwin, T. Gutowski

Biochemical Engineering

10.59J Biochemical Engineering (A)

(Same subject as 20.811J)
Prereq.: Permission of Instructor
G (1)
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

10.591J Biochemical Engineering Laboratory (A)

(Same subject as 20.812J)
Prereq.: 20.811
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

10.60 Heterogeneous Catalysis and Catalytic Processes (A)

Prereq.: 5.62 or 10.37
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

Applied Chemistry

10.613J Solid-State Surface Science (A)

(Same subject as 3.22J)
Prereq.: 10.40 or 3.20
G (2) **Next offered 1984-85**
3-0-6

See description under subject 3.22J.
R. M. Latanision, H. H. Sawin

10.615 Integrated Circuit Processing (A)

Prereq.: Permission of Instructor
G (1)
3-0-6

Introduces the basic process techniques used in silicon monolithic integrated circuits. Reviews fundamental solid-state chemistry and physics. Introduces 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

10.616J Plasma Processing in Integrated Circuit Fabrication (A) (New)

(Same subject as 6.776J)
Prereq.: Permission of Instructor
G (2) **Next offered 1984-85**
3-0-9

See description under subject 6.776J.
H. H. Sawin, L. R. Reif

10.641 Molecular and Morphological Engineering of Polymers (A)

Prereq.: 5.42, 5.62
G (1)
3-0-6

Introduces structure and properties of polymers. Describes macromolecular architecture and morphologies of solid polymers. Polymer surfaces and interfaces. Properties covered include thermal transitions, transport properties, solid-state mechanical behavior. Also discusses the effects of various non-polymeric additives.
R. E. Cohen

10.642 Molecular and Phenomenological Interpretation of Polymer Viscoelasticity (A)

Prereq.: 5.60 or 5.62
G (2) **Not offered 1984-85**
2-0-7

Theory and phenomenology of linear viscoelastic behavior of polymers. Material functions and their interconversion, model representation, time-temperature equivalence. Reviews molecular theories. Introduces nonlinear viscoelasticity.
R. E. Cohen

10.65 Chemical Reactor Engineering (A)

Prereq.: 10.37
G (1, 2)
3-0-6

Applies chemical kinetics to development and improvement of industrial processes. Nonideal 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.
J. Wei, M. Kramer

10.651J Fluidization (A)

(Same subject as 2.65J)
Prereq.: Permission of Instructor
G (1) **Not offered 1984-85**
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. Analyzes non-catalytic gas-solid reactions. Applications to heat exchangers and fluidized-bed combustors.
A. F. Sarofim, L. R. Glicksman

10.655 Multiphase Chemical Reactors (A)

Prereq.: 10.37
G (2)
3-0-6

Mass transfer with simultaneous chemical reaction in gas-solid, gas-liquid, and gas-liquid-solid systems. Analyzes contacting patterns and of mass and energy effects in multiphase chemical reactors including slurry-type reactors, trickle beds, and fluidized beds. Attention 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
G (2) **Not offered 1984-85**
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.
R. C. Armstrong, R. E. Cohen

10.67 Polymer Science Laboratory (A) (Revised Unit)

Prereq.: Permission of Instructor
G (2)
1-8-3

Acquaints students with a selection of techniques employed in the synthesis and characterization of polymeric materials. Experiments chosen for practical importance and instructional value. Studies 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 welcome.
U. W. Suter, R. E. Cohen

10.681 Physical Chemistry of Polymers (A)

Prereq.: 5.60 or 10.14 or 10.40
G (1)
3-0-6

Chain conformation statistics. Elements of rubber elasticity theory. Statistical thermodynamics of the "liquid lattice." Applications to polymer-solvent and polymer-polymer miscibility, swelling of cross-linked polymers, melting point depression. Theory and methods of molecular weight determination (osmotic pressure, viscometry, light scattering, gel permeation chromatography). Response of isolated polymer chains to shear and to extensional flows.
E. W. Merrill

10.682 Structure and Shape of Macromolecules (A)

Prereq.: Permission of Instructor
G (2) **Not offered 1984-85**
3-0-6

Structure, configuration, conformation of macromolecules. Spectroscopic observation of structure, configuration of synthetic chains, and importance of polymerization mechanisms. Statistics of copolymerization. Chain conformation: principles and advanced statistical mechanical treatments. Role of structure, configuration in determining conformation. Experimental observation of conformation and shape in general, in solution, amorphous bulk, and crystalline polymers. Scattering of radiation.
U. W. Suter

10.691 Synthesis of Polymers (A)

Prereq.: 5.42
G (2)
3-0-6

Studies synthesis of polymeric materials emphasizing interrelationships of chemical pathway, process conditions, and "microarchitecture" of molecules produced. Chemical pathway: anionic, radical, condensation, ring-opening, etc. Process conditions: bulk, solution, emulsion, suspension, gas phase, batch vs continuous fluidized bed, etc. "Microarchitecture": tacticity, molecular weight distribution, sequence distributions in copolymers, "errors" in chains such as branches, head-to-head addition, peroxide incorporation.
E. W. Merrill

10.70 Principles of Combustion (A)

Prereq.: Permission of Instructor
G (1)
3-0-6

Basic concepts and applications of combustion: flame propagation in premixed gas mixtures, laminar burner flames, turbulent flames, enclosed and swirling jet flames, flame stabilization, heterogeneous combustion of fuel droplets and particles. Diffusional and chemical kinetics, pollutant formation and destruction in flames. Coal combustion systems: stoker, pulverized coal, fluidized combustion of coal.
J. M. Beer

10.72 Seminar in Air Pollution Control (A)

Prereq.: 10.302
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. 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
G (1)
2-0-4

Seminar covering topics in combustion and fuel conversion related to current research interests.
Fuels Laboratory Faculty

10.74J Radiative Transfer (A)

(Same subject as 2.58J)
Prereq.: 10.302 or 2.51
G (1) **Next offered 1984-85**
3-0-9

Principles of thermal radiations and their application to engineering heat transfer problems. Basic laws of thermal radiation. Radiative properties of surfaces. Radiant interchange among surfaces separated by a transparent medium. Thermal radiation characteristics of gases and particle clouds. Radiative interchange through absorbing, emitting, and scattering media. Application to furnaces, high-temperature processing, pyrometry, insulation, and solar energy.
A. F. Sarofim, L. Glicksman

10.75 Principles of Fuel Conversion (A)

Prereq.: 10.302, 10.37
G (1)
3-0-6

Basic features and classification of gasification and liquefaction processes applied to fossil fuels and biomass. Chemical and physical properties of natural and synthetic fuels. Thermodynamic and chemical equilibrium in multicomponent and multiphase C-H-O systems. Kinetics and mechanisms of gas reactions with solid carbon. Diffusion and reaction in porous solids with transient properties.
J. B. Howard

10.801 Entrepreneurship

Prereq.: —
G (2)
4-0-5

School-Wide Elective Subject. Description given at end of this chapter on SWE page.
D. G. Jansson

10.802J Invention

(Same subject as 2.941J, 16.671J)
Prereq.: —
G (1)
3-0-6

See description under subject 2.941J.
J. P. Longwell, A. D. Carmichael, D. G. Jansson, W. R. Markey

10.803 Introduction to Technology and Law

Prereq.: —
U (1)
3-0-9

School-Wide Elective Subject. Description given at end of this chapter on SWE page.
J. D. Nyhart

10.804 Government and the Chemical Process Industries (A)

Prereq.: —
G (2)
3-0-6

Examines the 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; government support for R&D and innovation; rationales for, function of, and alternatives to environmental, health, safety, and energy regulation; responsibilities of the individual professional. Seminar format.
C. T. Hill

10.805J Technology, Law, and the Working Environment

(Same subject as TPP 35J)
Prereq.: Permission of Instructor
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. Toxic Substances Control Act, state worker's compensation and 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, L. B. Evans

10.806 Management in Engineering

Prereq.: —
U (1)
3-0-9

School-Wide Elective Subject. Description given at end of this chapter on SWE page.
R. T. Lund, D. P. Hoult, H. S. Marcus

10.808 Thermoeconomics (A)

Prereq.: Permission of Instructor
G (1)
3-0-6

New method for optimum design of thermodynamic system. A plant is divided into separate zones and a miniature economy is erected governing the buying/selling of generalized availability from one zone to another. Proper transfer prices for interzonal trading are found from the Lagrangian of the system guaranteeing that local optima coincide with plant optimum. Lectures cover generalized availability analysis, Lagrangian prices and their determination, methods of calculation for real systems, computational techniques in thermodynamic analysis.
J. P. Longwell, W. M. Rohsenow, M. Tribus

10.816 Engineering Risk-Benefit Analysis (A)

Prereq.: 18.02
G (2)
3-0-6

School-Wide Elective Subject. Description given at end of this chapter on SWE page.
A. W. Drake, A. R. Odoni

School of Chemical Engineering Practice

10.82 (10.80, 10.81, 10,82, 10.83) School of Chemical Engineering Practice — Albany Station

Prereq.: Permission of Instructor
G (1, 2, S)
0-12-0

Conducted at General Electric Company plants of their Noryl Plastics Division at Selkirk, NY, and Silicone Products Division at Waterford, NY. Group problem assignments conducted at plant sites involve 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 Master's thesis; see section on School of Chemical Engineering Practice for details. Enrollment limited and subject to plant availability.
J. W. Tester

10.84 (10.85, 10.86, 10.87) School of Chemical Engineering Practice — Bethlehem Station (A)

Prereq.: Permission of Instructor
G (1, 2, S)
0-12-0

Conducted at Bethlehem Steel Corporation's Steel Plant and Research Laboratories in Bethlehem, PA. Group problem assignments involve process metallurgy, coke manufacture and by-product recovery, water and air treatment for environmental control, energy conservation, and process control and simulation. Credit granted in lieu of Master's thesis; see section on School of Chemical Engineering Practice for details. Enrollment limited and subject to plant availability.
J. W. Tester

10.88 (10.89) School of Chemical Engineering Practice — Brookhaven Station (A)

Prereq.: Permission of Instructor
G (S)
0-12-0

Conducted at Brookhaven National Laboratory, Upton, NY. Group problem assignments emphasizing application of chemical engineering to synthetic hydrocarbon fuels and alternate energy resources, electrochemistry, environmental science, and nuclear technology. Credit granted in lieu of a Master's thesis; see section on School of Chemical Engineering Practice for details. Enrollment limited and subject to plant availability.
J. W. Tester

General

10.90 Experimental Research Problem (A)

Prereq.: Permission of Instructor
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.: —
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
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
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
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
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
G (1)
2-0-4

10.992 Seminar in Chemical Engineering (A)

Prereq.: Permission of Instructor
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 Development and Design

Prereq.: —
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, seminars review cases from contemporary practice, current theories of design, and theories of form and professional role.
D. Frenchman

11.002 Introduction to Public Policy Analysis and Government Action

Prereq.: —
U (1)
3-0-9

Presents, through case study exercises, major analytic techniques of public policy analysis: determinant and probabilistic models; cost-benefit analysis; decision analysis; linear programming. Class sessions organized in order of main tasks of policy analyst: of alternatives, implementation, evaluation. Compares alternative approaches to public policy analysis. Same subject as 11.500.
S. T. Buckle, L. G. Buckle

11.003 Planning and Applied Social Research I

Prereq.: *11.007J, 14.01*
U (1)
4-0-8

Concerned with these questions: What theories from the social sciences are applicable to the design, implementation, or evaluation of public policies and programs? How good should such theories be? What theories of social science do current public policies and programs presume? How good are these theories?
A. Fleisher

11.004 Planning and Applied Social Research II

Prereq.: 11.003
U (2)
4-0-8

Develops an understanding of the reasons why public-sector programs and policies sometimes fail and sometimes succeed. Emphasizes theories of implementation, intervention, and regulation and concepts of the public interest. Contrasts alternative theories of social change and conflict management. Develops the skills needed for effective intervention in a variety of planners' roles. Students build personal theories of action. Same subject as 11.503J.
L. G. Buckle, S. T. Buckle

11.005 Urban Social Structure and Process

Prereq.: —
U (2) HUM-D
3-0-6

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. Examines ethnic and racial relationships in the US. May count toward Humanities Requirement.
G. Marx

Fundamentals of Applied Social Research

11.007J Politics and Public Policy

(Same subject as 17.201J)
Prereq.: —
U (1, 2) HUM-D
3-0-9

See description under subject 17.201J.
G. T. Marx, M. Lipsky, D. A. Stone

11.008J Urban Economics

(Same subject as 14.51J)
Prereq.: 14.01
U (2)
3-0-6

See description under subject 14.51J.
W. C. Wheaton

11.012 Institutions and Communities

Prereq.: 11.005 or 11.007J
U (1)
3-0-6

Structure, behavior, and processes of change in communities and formal organizations. Emphasizes formulation and implementation of public policies. Background in communities and organizations for students interested in planning or design. Perspectives on communities and organizations as environments for planners, designers, and policy analysts, and as objects of interventions. Organizational and community theories using case study materials from housing, health, urban design and development, and law. May count toward Humanities Requirement. Same subject as 11.448.
Y. Camyd-Freixas

11.013J American Urban History I

(Same subject as 21.412J)
Prereq.: —
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. Focuses on readings and discussions. May count toward Humanities Requirement.
R. M. Fogelson

11.014J American Urban History II

(Same subject as 21.413J)
Prereq.: —
U (2)
3-0-6

Reads about and discusses 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 count toward Humanities Requirement.
R. M. Fogelson

11.015 Models and the Metropolis

Prereq.: 18.01, 18.02
U (1) SD
3-0-9

The science in social science, thinking about complex systems. Making models, their contribution to knowing, their interplay with experiment, their place in deciding policy. Usually draws materials from problems in urban studies and planning but the local interests of the students can also be accommodated.
A. Fleisher

11.016 Introduction to Technology and Environmental Analysis

Prereq.: —
U (1)
3-0-6

Comparative analysis of technological impacts on natural resources and the environment. Case studies of oil drilling, coal mining, power plant, dam, agricultural, automobile, and architectural impacts on national and global air, water, land, plant, and animal resources and marine environments. Analytic frameworks include natural science, economic, political, problem solving, and design approaches. May count toward Humanities Requirement.
M. Klapp

Specialization in Environmental Planning

11.122 Environmental Policy and Regulation

Prereq.: —
U (1)
3-0-9

Analyzes rationales for government intervention to protect the environment. Reviews policy instruments available to promote environmental quality including standards, taxes, marketable rights, and liability rules. Meets with 11.361. May count toward Humanities Requirement for undergraduates.
L. S. Bacow

11.123 Environmental Quality Assessment

Prereq.: 18.02 or 8.02; 11.016
U (2) SD
3-2-7

The estimation of changes in the environment from human activities; qualities of the built environment; externalities and societal interventions, population interactions, and species diversity; relation of standards to technological capabilities, societal choice, and regulatory schema.
A. Fleisher

Specialization in Neighborhood and Community Planning

11.131 The Urban Neighborhood (Revised Unit)

Prereq.: —
U (2) HUM-D
3-0-9

Covers theories, studies, and policy issues concerning the urban neighborhood. Reviews neighborhood theory from the neighborhood unit to neighborhood territoriality; examines methods for studying neighborhoods, including research design and participant observation. Considers issues of policy such as municipal decentralization, neighborhood abandonment, and maintaining public safety in the neighborhood. May count toward Humanities Requirement.
Y. Camayd-Freixas

11.139 Introduction to Community Development

Prereq.: —
U (2)
3-0-6

Surveys basic policy issues surrounding community development. Lectures deal with actual community development activities in urban and rural settings. Overall strategy is to synthesize theories of development through use of actual cases. Material covered is especially relevant for students interested in planning practice. May count toward Humanities Requirement.
F. S. Jones

Specialization in Planning for Developing Countries

11.143 Urban and Regional Planning in Developing Countries

Prereq.: —
U (2)
2-0-7

Problems of cities and regions in developing countries in relation to national economic and social development policies. Stresses case studies and comparative analysis. Requires paper. May count toward Humanities Requirement.
L. Rodwin

11.144 Urban and Regional Economic Issues in Developing Countries

Prereq.: 14.74
U (1)
2-0-7

Examines and analyzes a range of urban and regional problems in developing countries with emphasis on public policy. Discusses theoretical and methodological problems associated with the planning of balanced regional development, along with appropriate institutional arrangements for linking national and regional plans. Analyzes urban economic problems focusing on housing, public utilities, social services, transport, land use, and employment. May count toward Humanities Requirement.
A. M. Strout

Specialization in Public Policy, Urban Management, and Law

11.165 Law and Public Policy

Prereq.: —
U (2) HUM-D
3-0-9

Introduces law, organized around the theme of how the law shapes, influences, and constrains the design and implementation of policy. Examines relationship between courts and line agencies. Analyzes how courts differ from other policy-making institutions. Includes basic legal research.
L. S. Bacow

11.166 Legal Institutions and Social Change

Prereq.: —
U (2)
3-0-6

Analyzes unique characteristics and problems of legal institutions, especially issues most strongly affecting the conduct and reform of legal regulatory processes. Brief history of reform in the American judiciary. Current controversies and the values underlying them. Evaluates the alternatives for judicial reform, with development of theory of change in legal institutions.
S. T. Buckle, L. G. Buckle

Laboratories

11.185J Design with Microclimate

(Same subject as 4.071J)
Prereq.: 8.01, 18.01
U (1) LAB
3-6-3

See description under subject 4.071J.
T. E. Johnson

11.188 Laboratory in Research Methods

Prereq.: Permission of Instructor
U (2) LAB **Next offered 1984-85**
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 ideas, test hypotheses, and generate data. Interplay of model and experiment, in manipulation of numerical and categorical data, in exercise of various modes of inference, and in measurement of their worth. Several individual and group projects. Students must have taken at least one subject in statistics or probability before enrolling. Required of all Course XI majors.
J. Ferreira, Jr.

Tutorials, Fieldwork, and Internships

11.UR Undergraduate Research

Prereq.: —
U (1, 2)
Arr.

Undergraduate research opportunities in Urban Studies and Planning. For further information consult the Departmental Coordinators.
J. Ferreira, Jr.

11.191 Undergraduate Tutorial in Urban Studies

Prereq.: —
U (1)
3-0-6

11.192 Undergraduate Tutorial in Urban Studies

Prereq.: —
U (2)
3-0-6

Reading and discussion of special topics in urban studies. By arrangement with individual members of the staff.
J. Ferreira, Jr.

11.193 Preparation for Undergraduate Thesis

Prereq.: —
U (1, 2)
Arr.

Selects thesis subject, defines method of approach, and prepares preliminary thesis outline. Independent study, supplemented by frequent individual conference with staff members.
J. Ferreira, Jr.

11.194 Special Topics in Urban Studies and Planning

Prereq.: —
U (1, 2)
Arr.

11.195 Special Topics in Urban Studies and Planning

Prereq.: —
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.
J. Ferreira, Jr.

11.196 Urban Fieldwork and Internships

Prereq.: —
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.
J. Ferreira, Jr.

11.197J State and Local Government Internships

(Same subject as 17.351J)
Prereq.: —
U (1, 2)
3-0-9

See description under subject 17.351J.
M. W. Weinberg

Graduate Subjects

Core Subjects and Methods Modules

11.200 Planning and Institutional Processes

Prereq.: Permission of Instructor
G (1)
4-4-8

Basic paradigms and theories of planning practice. Evaluates historical and current developments in planning with special emphasis on the institutional setting of planning in American society. Lectures, case studies, and comparative analyses explore the changing roles of the planner and the key dilemmas in planning practice. Focuses on strategies of institutional intervention and implementation. Taught in conjunction with 11.210 and 11.220. Restricted to first year M.C.P. students.
L. C. Keyes

11.210 Political Economy for Planners

Prereq.: Permission of Instructor
G (1)
4-2-6

Introduces political economy for planners, emphasizing economic institutions and structural analysis of standard economic theory and public policy grounded in that theory. Models of individual and aggregative economic behavior, institutional analysis of economic power, introduces Marxian political economy. Topics vary (e.g., poverty and discrimination, changing urban form, industrial location). Some recitation sessions in conjunction with 11.200 and 11.220. Restricted to first-year M.C.P. students.
B. Harrison

11.216 Writing for Public Policy and Planning (New)

Prereq.: —
G (2)
2-1-1

Optional Methods Module. Counts toward the M.C.P. Methods Requirement. Strategies for organizing and expressing ideas in writing. Students draft and redraft projects of their own choice while sharpening their awareness of the writing process through exercise and feedback. Techniques for structuring analytical presentations, making use of intuition, anticipating reader response, and editing for academic or professional audiences. Limited to 15.
L. Dunlap

11.217 Bargaining and Negotiation

Prereq.: —
G (1)
2-1-1

Optional Methods Module. Counts toward the M.C.P. Methods Requirement. Introduces methods and formal theory of bargaining and negotiation. Analyzes ways in which procedure, structure of bargaining situation, preferences of negotiators, and tactics of bargainers can lead to the success or failure of negotiations. Uses case study and gaming materials in class. Permission of instructor required.
L. E. Susskind

11.218 Market Analysis in Development

Prereq.: 11.210
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.
L. Sagalyn

11.219 Library Research Methods

Prereq.: —
G (1)
2-1-1

Teaches planning students skills needed to access library information while in school, and later as practicing professionals. Problem-oriented; learn by doing. Class time spent discussing and practicing appropriate methodologies for researching specific topics of interest. Examples of resources covered: periodical indices, government documents, the US Census, computerized literature searching, and the union catalogue.
R. Gregory

11.220 Quantitative Reasoning and Statistical Methods for Planning

Prereq.: Permission of Instructor
G (1)
4-2-6

Develops logical, empirically based arguments using statistical techniques and analytic methods. Covers elementary statistics, probability, and other types of quantitative reasoning useful for description; estimation, comparison, and explanation. Emphasizes the use and limitations of analytical techniques in planning practice. Taught in conjunction with 11.200 and 11.210. Restricted to first-year M.C.P. students.
M. Schuster

11.222 Decision Analysis for Planning

Prereq.: 11.220
G (2)
2-1-1

Optional Methods Module. Counts toward the M.C.P. Methods Requirement. Analytical approaches to decision making and policy analysis when uncertainty is a central issue. Emphasizes decision trees, preference measurement, social choice problems, and determining an appropriate level of formal analysis. Includes analysis and critique of planning cases.
J. Ferreira, Jr.

11.223 Graphic Methods for Analysis

Prereq.: —
G (1)
2-1-1

Optional Methods Module. Counts toward M.C.P. Methods Requirement. Module covers four basic techniques of visualization: drawing, photography, video, and visual design in print. Provides planning students with a condensed introduction to visual communication techniques and the issues surrounding their use. Class sessions devoted to presentations, lectures, and instruction.
G. A. Hack

11.224 Urban and Environmental Impact Assessment

Prereq.: 11.220
G (2)
2-1-1

Optional Methods Module. Counts toward the M.C.P. Methods Requirement. Methods for predicting and evaluating impact of development, stressing predictive techniques for use by public officials without formal training in quantitative modeling, graphic and other nonquantitative techniques as an aid to 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 Community Change

Prereq.: 11.220
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. Focuses on understanding the behavior of individual households and businesses and incorporating that understanding into various predictive techniques. Offers hands-on experience with actual data sets and computer methods. No computer experience necessary.
D. L. Birch

11.226 Cost-Benefit Analysis for Planning

Prereq.: 11.220
G (1)
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. Explores underlying rationales of various cost-benefit precepts and tools. Permission of instructor required.
A. M. Strout

11.227 Formal Models for Public Policy Analysis

Prereq.: 11.220
G (1)
2-1-1

Optional Methods Module. Counts toward the M.C.P. Methods Requirement. Uses and limitations of formal models for analyzing public policy issues. Emphasizes model formulation and evaluation (rather than the mathematics of "solving" models). Includes simulation (difference equation and "cohort-survival" models), optimal resource allocation (linear programming), and probabilistic models (queueing problems).
J. Ferreira, Jr.

11.228 Survey Research Methods

Prereq.: 11.220
G (2)
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. Discusses strategies for introducing surveys of different types into public policy debates. Permission of instructor required.
S. T. Buckle, L. G. Buckle

11.229 Case Study and Field Research Methods

Prereq.: —
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. Emphasizes when and how to frame case studies, case study selection, generalizing from a small set of cases, and drawing policy inferences from case studies. Analyzes and prepares case studies.
R. K. Yin

Intermediate Methods Subjects

11.230 Workshop in Institutional Analysis

Prereq.: 11.200
G (2)
4-0-8

Basic theories of institutional behavior, structure, and change for planners. Emphasizes institutions that 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 is on application of institutional perspectives to practice-related issues.
D. Schon, L. C. Keyes

11.232 Microeconomic Analysis for Planners (A)(Revised Unit)

Prereq.: 11.210, 11.231
G (2)
4-0-8

Systematic survey of microeconomic theory and mathematical methods used to develop that theory. For students of economic analysis skills — at an intermediate level. Teaches calculus and other mathematical tools in parallel with microeconomic theory. Emphasizes examples and applications of the theory to planning problems.
W. C. Wheaton

11.233 Qualitative Analysis in Public Policy and Planning

Prereq.: Permission of Instructor
G (2)
2-4-6

Optional Methods Module. Counts toward M.C.P. Methods requirement. Uses of qualitative methods in exploring issues of public policy and planning. Interviewing and group papers. Analyzes the connection between qualitative analysis and broader issues of political economy. Topics selected each year. Research can be used in developing M.C.P. or Ph.D. thesis.
L. R. Peattie

11.234 Laboratory in Data Analysis for Planners (A)

Prereq.: 11.220 or 18.057
G (2)
3-6-3

Hands-on experience analyzing social science data of interest to planners using statistical computer packages. The methodological focus is on hierarchical models: regression and analysis of variance for metric data; and logit, ordit, and loglinear models for categorical data. Requirements include five short data analyses and a term paper. Counts for two modules toward M.C.P. Methods Requirement.
A. Fleisher

Environmental Planning and Design

11.240 Images of Cities

Prereq.: —
G (2)
2-0-7

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. Includes readings from literature, history, philosophy, and selected films. Open to qualified seniors as well as graduate students.
L. Rodwin

11.252 Legal Regulation of the Use and Development of Land

Prereq.: —
G (2) **Next offered 1984-85**
3-0-9

Analyzes 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.
L. Bacow

11.301J Introduction to Urban Development and Design

(Same subject as 4.736J)
Prereq.: Permission of Instructor
G (1)
3-0-9

See description under subject 4.736J.
D. Frenchman

11.311J Problem Setting in Environmental Programming (A)

(Same subject as 4.745J)
Prereq.: Permission of Instructor
G (2)
3-0-9

See description under subject 4.745J.
E. Robbins

11.313J Urban Settlements in Developing Countries (A)

(Same subject as 4.753J)
Prereq.: Permission of Instructor
G (2)
3-0-6

Critically analyzes 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. Draws case materials of industrialized housing, aided self-help sites and services, and squatter and speculative settlements from capitalist, socialist, and mixed economies.
L. R. Peattie

11.320 History of the Physical Environment of Urban America

Prereq.: —
G (2)
3-0-6

Reads and discusses the history of selected features of the physical environment of urban America. Features considered are parks, romantic cemeteries, dumbbell tenements, romantic suburbs, civic centers, superblocks, and shopping centers. Students undertake independent historical research projects.
R. M. Fogelson

11.325 Understanding the Development Process (A)

Prereq.: 11.200
G (2)
4-0-8

Examines urban and suburban developments of varied size and complexity, emphasizing housing, using cases. Develops a conceptual framework which facilitates analyzing each development, and understanding the interrelationships between the disciplines involved, the impact of policies chosen and their implementation over a period of time.
F. S. Jones

11.328J Community, Class and Race: A Social Perspective (A)

(Same subject as 4.766J)
Prereq.: —
G (2) **Next offered 1984-85**
3-0-6

See description under subject 4.766J.
E. Robbins

11.330J Theory of City Form (A)

(Same subject as 4.747J)
Prereq.: 4.736J or 11.301J
G (2)
3-0-6

See description under subject 4.747J.
J. Beinart

11.331J International Cases in Urban Planning and Design (A) (New)

(Same subject as 4.763J)
Prereq.: Permission of Instructor
G (2)
3-0-6

See description under subject 4.763J.
J. de Monchaux

11.332J Urban Design (A)

(Same subject as 4.163J)
Prereq.: Permission of Instructor
G (2)
Arr.

See description under subject 4.163J.
I. Halasz, W. L. Porter

11.333 Urban Aesthetics (New)

Prereq.: —
G (1)
3-0-9

Focuses on the form and meaning of the urban landscape, its role in communicating about its inhabitants, popular visions of the beautiful cities, programs which have tried to improve city appearance and their results. Legal, economic, and cultural issues in improving the appearance of urban areas.
G. A. Hack

11.334 Environmental Ecology and Natural Resource Management

Prereq.: —
G (2)
3-0-6

Analyzes scientific and engineering information for purposes of setting environmental standards and regulatory policy. Issues include differences among ecological, engineering, and economic models; measurement, assessment, and certainty; sufficient expertise; information access and overload; and extrapolation from poor or biased data. Cases cover multiple-use, siting, pollution, and design problems.
M. Klapp

11.336J Site Planning

(Same subject as 4.744J)
Prereq.: —
G (2)
1-8-3

Introduces basic considerations in site planning and provides practice in their applications to housing development. Examines physical aspects of environmental planning such as earth moving, microclimate, vegetation, and behavioral aspects such as social uses of public space. Comprehensive analysis of existing housing sites supplements work with simulation models and design exercises.
D. Lee

11.360 Community Growth and Land Use Planning

Prereq.: Permission of Instructor
G (1)
3-0-6

Seminar and fieldwork on applying methods of planning, control for growth and land use. Approaches to the design of intervention strategies, chiefly at the municipal level. Reads and discusses 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)

Prereq.: 11.210 or 14.01
G (1)
3-0-9

See description under subject 11.122.
L. S. Bacow

11.362 Land Use and Environmental Policy Implementation (A)

Prereq.: 11.360
G (2)
3-0-6

Analyzes 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 prepare in-depth case studies of land use policy reforms and policy implementation strategies.
L. E. Susskind

11.364 Environmental Dispute Resolution

Prereq.: Permission of Instructor
G (2)
3-0-6

Introduces methods and formal theories of negotiation, mediation, and compensation as techniques to resolve environmental disputes. Examines ten current EPA cases involving rule making, permitting, and enforcement. Includes disputes over power plant siting, energy conversion from oil to coal, and sewage treatment standards. Considers specific bargaining tactics and their strategic implications.
L. E. Susskind, M. Wheeler

11.365J Coastal Zone Management (A)

(Same subject as 13.98J)
Prereq.: Permission of Instructor
G (2)
3-3-6

See description under subject 13.98J.
J. T. Kildow

11.370 Theories of Settlement Patterns (New)

Prereq.: —
G (1)
3-0-6

Examines locational theories and empirical evidence related to human settlement patterns and associated phenomena. Includes the spatial location of regional growth, size distribution of cities, migration patterns, area location of economic and noneconomic activities and gravity modeling of spatial flows of goods and services. Requires an analytical term paper or empirical project.
A. M. Strout

11.380J Urban Transportation Planning (A)

(Same subject as 1.252J)
Prereq.: Permission of Instructor
G (2)
3-0-6

See description under subject 1.252J.
R. A. Gakenheimer

11.384J Transportation and Infrastructure in Developing Countries (A) (Revised Content)

(Same subject as 1.254J)
Prereq.: Permission of Instructor
G (1)
3-0-6

Analysis and planning for transportation, water supply, sewerage, and other services in developing countries, especially urban areas. Major policy and planning issues in growth and rehabilitation of systems. Political and cultural factors in service decision making. institutional arrangements, coordination with other sections, integration of planning and programming. Overview of technical methods: demand analysis, technology tradeoffs, evaluation procedures, simple policy analysis techniques, management information systems.
R. A. Gakenheimer, M. L. Manheim

Community and Economic Development

11.410J Urban Economic Analysis I (A)

(Same subject as 1.283J, 14.573J)
Prereq.: 14.04 or 14.03
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. Analyzes 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
G (2)
3-0-9

See description under subject 14.574J.
W. C. Wheaton

11.413 Social Aspects of Development (A)

Prereq.: Permission of Instructor
G (1)
2-0-7

Seminar discusses the social and cultural aspects of economic development and planning in developing countries. Considers strategies with respect to urban growth, city planning, education, family policy 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

11.417J Planning in Socialist Countries (A)

(Same subject as 4.767J)
Prereq.: Permission of Instructor
G (1)
3-0-6

Introduces political economy of development strategies of the USSR, Eastern Europe, Yugoslavia, People's Republic of China, and Cuba. Examines significant debates leading to or emerging from experiences with three approaches to planning: administrative, indicative, and participative. Emphasizes links between planning, as well as between planning, design, and building. Requires participation in study groups.
R. Bon, K. R. Polenske

11.420J Neighborhood Planning (A)

(Same subject as 4.743J)
Prereq.: 11.200, 11.210, 11.220; or 4.144
G (2)
3-0-6

Techniques of neighborhood planning. Class organized around issues commonly faced by planners working at the neighborhood scale. Professional techniques: how to define information needs; how to get and use the data; mapping; zoning; surveying physical conditions, and resident attitudes and behavior; alternative methods of allocating resources among neighborhood units; approaches to citizen involvement.
P. L. Clay

11.431 Financial Analysis in Real Estate

Prereq.: —
G (1)
4-0-8

Concepts and tools of financial analysis, methods of financing, sources of capital for real estate development. Covers capital cost, pro forma, leverage, tax shelter, and investment analysis. Case application: multifamily housing, office buildings, rehabilitation, specialty retail center. Examines financial institutions, mortgage markets, revenue bond financing, in particular credit policy.
L. Sagalyn

11.432 Urban Land Development (A)

Prereq.: 11.431, 11.450
G (2)
2-0-7

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. Considers optimal use and price of land, market demand for kind of space developed, design and type of structure, the framework of zoning and building codes, minimum rent levels.
P. David

11.435 Introduction to Economic Development Planning in the US (A) (Revised Unit)

Prereq.: 11.210 or 14.64 or 14.671 or 14.74
G (2)
3-0-6

Theoretical foundations of economic development processes in capitalist economics. Dependent development and internal colonialism. History of economic development policy in the US since the New Deal. Interregional/international conflicts over development policy. Critical assessment of plans for community economic development, city or state-level programs, national policies for "reindustrialization."
B. Harrison

11.436 Labor Markets and the Organization of Work (A) (Revised Unit)

Prereq.: 11.210 or 14.01
G (1)
3-0-6

Neoclassical and Marxian economic theories of labor market structure: human capital, screening and credentialism, queueing, dual/segmented markets, labor theory of value, and occupational stratification by race and gender. Issues in measurement and policy evaluation. Development since the 19th century of theories about the changing organization of work (the "labor process").
B. Harrison

11.437 Financing Community Economic Development (New)

Prereq.: —
G (2)
3-0-9

Examines role of capital in the economic development process, capital access problems of small, minority, and community-based businesses, and government options for overcoming these problems. Emphasizes role and operation of public-sector finance institutions. Presents and critiques case studies of interventions by development finance agencies. Student projects analyze either a specific intervention or the operation of a particular agency.
B. Daniels

11.441 Issues and Strategies in Community Development

Prereq.: —
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
G (2)
Arr.

Continuation of 11.441. Discusses and analyzes case studies presented by Community Fellows. Emphasizes preparation of written reports. Permission of instructor required.
M. H. King

11.445 Community Development in Urban Neighborhoods

Prereq.: Permission of Instructor
G (2)
3-0-6

Politics of community-oriented economic development, focusing on minority areas of large cities. The problems of increasing political and economic power of ghetto residents.
M. H. King

11.448 Systems, Networks, and Neighborhoods (New)

Prereq.: —
G (2)
3-0-6

Introduces planning students to "systems thinking," techniques, and strategies of structural intervention. Social networks at the neighborhood level. Provides a grounding in social systems and network theory. Models of community organization, a process approach to planned change in organizations, collaborative network development strategies in human services, and applications in community development planning. For M.C.P. students looking for skills in community development. Same subject as 11.012.
Y. Camayd-Freixas

11.450 Housing Issues and Policy

Prereq.: —
G (1)
2-0-7

Introduces 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 give students a working familiarity with the elements of the housing system, a sense of current policy issues, and historic context from which those policies have emerged.
L. C. Keyes

11.451 Housing Practicum (A)

Prereq.: 11.450
G (2)
4-0-8

Focuses on actual housing problems in conjunction with a governmental or community client. Collaborative interaction with other students and 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.
P. L. Clay

11.455 Housing for Populations with Special Needs

Prereq.: —
G (2)
2-2-6

Explores housing for population groups with special needs. Includes single parent families, elderly, physically and mentally handicapped. Assumes that our current understanding of housing must be redefined to satisfy future changes in population, family, and life-style characteristics. Emphasizes housing and social policy; its evolution and prospect for the future. Also examines strategies for environmental and participatory design.
M. L. Joroff

11.461 Planning and Urban and Regional Growth in Developing Countries (A)

Prereq.: 11.210
G (1)
Arr.

Examines ideas of planning in relation to urban growth issues and policy options. Covers problems of diagnosis and implementation of these policy options mainly in Third World countries; and technical and political, national and sub-national, sectoral and intersectoral, and rural and urban aspects of these problems. Uses Socratic analysis, role playing, case studies, and empirical analysis in evaluation. Requires extended readings and paper.
L. Rodwin

11.462 Housing Problems, Goals, and Policies in Developing Countries

Prereq.: —
G (2)
2-0-7

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. Concerned with price and subsidy policy and linkages between housing and national development strategies. Examined from several standpoints, including paradigms of the mixed economy and of Marxism.
L. Rodwin

11.468 The Implementation of Metropolitan Planning in Developing Countries

Prereq.: Permission of Instructor
G (2)
3-0-9

Emphasizes 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. Analyzes cases of planning and decision making, the study of "terms of relevance" for planning services, and the programming of urban infrastructure. Conducted jointly with Harvard School of Design.
R. A. Gakenheimer

11.481 Regional Economic Accounts, Theories, and Techniques (A)

Prereq.: 14.03, 14.04
G (2)
3-0-9

Surveys the basic accounting frameworks, theories, and techniques used in regional and multiregional economic analyses. Emphasizes the aspects of each relevant to their use in program impact and distribution studies. Uses problem sets to illustrate the different accounts, theories, and techniques.
K. R. Polenske

11.482 Applications of Regional Economic Theory (A)

Prereq.: 11.481
G (1)
3-0-9

Critically examines the use of multiregional accounts and models for regional development analysis, including applications of economic base, regional growth, general equilibrium, and inter-regional trade models. Gives special attention to the use of regional input-output models and to current regional analyses being made of transportation, energy, fiscal, income distribution, and employment problems. Some foreign regional studies also included. Permission of instructor required.
K. R. Polenske

11.483 Workshop in Regional Economic Planning in Developing Countries (A)

Prereq.: 11.417, 11.481
G (2)
3-0-9

Analyzes regional economic plans for particular developing countries giving consideration to the link between regional and national planning strategies. Uses specific data and materials from capitalist and socialist countries for case studies. Permission of instructor required.
K. R. Polenske

11.484 Social Cost-Benefit Analysis of Projects and Programs

Prereq.: —
G (2)
3-3-6

Practical introduction to theory and practice of project analysis and evaluation. Develops quantitative skills through case study or practice. Problem-solving emphasis on cost and benefit valuation (both economic and non-economic) and on considerations of time, space, scale, externalities, multiple-objectives, risk and uncertainty, and indirect benefits and costs. Examines usual institutional setting and practical influences of analytical procedures or project design and selection.
A. M. Strout

11.485 Rural Development: Agriculture and Industry in the Regional Context

Prereq.: —
G (2) **Next offered 1984-85**
2-0-7

Role of nonmetropolitan, largely rural areas in regional development and problems of ensuring that rural development leads to equitable improvements in rural welfare. Emphasizes agricultural growth and transformation and the prospects for rural industrialization, largely in the developing countries. Social and political as well as economic aspects or rural development. Considerable student participation, especially in working with case study materials from Africa, Latin America, Asia and, occasionally, from the US or Europe.
A. M. Strout

11.487 Practicum in Area Planning for Developing Countries (A)

Prereq.: 11.461, 11.413, 11.481
G (1) **Next offered 1984-85**
4-4-8

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 clients provides an opportunity to develop and apply professional planning skills. Topics change yearly but may include issues of development, regional growth strategies, urban-rural relationships. Permission of instructor required.
A. M. Strout

Public Policy

11.500 Introduction to Public Policy and Management

Prereq.: —
G (1)
4-0-8

Introduces the theory and practice of public policy formulation and implementation. Emphasizes applications and limitations of public policy analysis. Examines theories of public policy implementation for their implications for effective management in the public sector. Same subject as 11.002.
S. T. Buckle, L. G. Buckle

11.502 Seminar in Program Design (A)

Prereq.: Permission of Instructor
G (2) **Next offered 1984-85**
2-0-7

Advanced seminar in planning methods for selected areas of urban social policy. Emphasizes 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

11.503J Implementation (A)

(Same subject as TPP 42J)
Prereq.: 11.200, 11.230 or TPP 11J, TPP 12J
G (2)
2-0-7

Explores problems of implementation by comparing case studies and contemporary theories. Examines four theories of why programs fail: ineffective management control; inherent resistance to change in bureaucracies; poor negotiation with interest groups; inadequate interpersonal relations among implementors. Emphasizes building useful guidelines for reform; students consider strategies in light of their professional practice. Same subject as 11.004.
L. G. Buckle, S. T. Buckle

11.506 Theory of Action Seminar (A)

Prereq.: 11.230
G (2)
3-3-3

Students examine own theories of intervention. Discusses theories of action drawn from the work of Argyris and Schon, Vickers, Bateson, Simon, and others. Students prepare cases of own actual past or proposed future interventions and then examine them in terms of the frameworks suggested above. Sessions on the analysis and criticism of student scenarios, and practice in discovering, inventing, and producing alternative interventions. Permission of the instructor required.
D. A. Schon

11.510 Seminar on Sociological Aspects of Policy Research

Prereq.: —
G (2)
3-0-6

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

11.511J Big Decisions (New)

(Same subject as STS 620J)
Prereq.: —
G (2)
2-0-7

Describes and evaluates large projects and entrepreneurial endeavors in the public and private sectors, including infrastructure and social and technological policies. Historical, humanistic, and religious models; social and natural science pictures. Discontinuity, fluctuation, risk, shock crisis, doom, sacrifice, and violation of taboo; decision and marginal analysis, efficient resource allocation, and maximizing. Failure, and recovery from mistakes. Ethics of big decisions.
M. H. Krieger

11.514 Social and Demographic Aspects of Public Policy in Urban Communities (A)

Prereq.: Permission of Instructor
G (1)
3-0-6

Focuses on the social structure differentiation and metropolitan communities. Helps students understand issues of program design and public policy and community development that have a territorial basis. Gives special attention 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 — Fiscal Federalism (A)

Prereq.: 11.210
G (1)
4-0-8

Theory and application of economic analysis to problems and behavior of state and local governments. Topics include property tax incidence, municipal bond markets, public expenditure theory, fiscal impact of land use, intergovernmental grants and state equalization policies.
W. C. Wheaton

11.521 Policy Analysis of Social Service Systems (A) (Revised Unit)

Prereq.: 11.210, 11.220
G (1)
3-0-6

Emphasizes models and measures used to design and evaluate social service programs. Particular attention to housing, health, and social insurance contexts and to the treatment of risk and equity issues using, for example, Lorenz curves, Gini coefficients, and utility functions.
J. Ferreira, Jr.

11.523 Evaluation of Public Programs (A)

Prereq.: 11.521
G (2) **Next offered 1984-85**
2-0-7

Evaluations characterized and compared as to methodology, scale and scope, sponsorship, audience, and feasibility. Considers experimental design and related statistical issues. Analyzes political, social, economic, and institutional contexts of evaluation. Examines several evaluations drawn from health, housing, and criminal justice as case studies.
R. C. Larson

11.526J Logistical and Transportation Planning Methods (A)

(Same subject as 1.203J, 6.281J, 13.665J, 15.078J, 16.76J, TPP 43J)
Prereq.: 6.431, 15.075
G (1)
3-0-9

See description under subject 1.203J.
A. I. Barnett, R. C. Larson, A. R. Odoni, H. N. Psaraftis

11.527 Computers and Public Management (New)

Prereq.: Permission of Instructor
G (1)
3-0-9

Introduces data-intensive, computer-implemented methods for improving public management. Topics: forecasting, scheduling, and modeling aides for public managers; design and implementation experiences with Management Information Systems and Decision Support Systems. Draws case studies from New York City and elsewhere. Hands-on computer workshop in integral part.
R. C. Larson

11.550 Conflict, Dispute Resolution, and Negotiation in the Public Sector

Prereq.: 11.200, 11,230
G (2)
3-0-6

Investigates social conflict and organizations that process disputes in public sector. While theoretical aspects of conflict are considered, focuses on the operation, organization, and roles of dispute-processing agencies. Bases comparisons among agencies on their processes and consequences for participants and societies. Explores strategies for more effective design and use of dispute-processing agencies.
S. T. Buckle, L. G. Buckle

11.551 Comparative Issues in Planning (New)

Prereq.: —
G (2)
2-1-1

An intensive examination of how planning issues are dealt with in Europe and the US. Topic varies from year to year.
L. E. Susskind, P. Laconte

11.562 Housing Analysis and Public Policy (A)

Prereq.: 11.210, 11.450
G (2)
2-0-7

Economic and institutional factors affecting housing with applications to policy analysis. Reviews housing concepts, market dynamics, impacts of racial discrimination on market behavior. Examines different modes of housing policy: tenure choice, market segmentation, and distributional analysis. Evaluates several modes of intervention — tax expenditures, regulation, credit aids — using examples of Federal, state, and local government housing policy.
L. Sagalyn

Doctoral Seminars

11.800 Doctoral Seminar I (A)

Prereq.: Permission of Instructor
G (1)
3-0-9

11.801 Doctoral Seminar II (A)

Prereq.: Permission of Instructor
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, M. Rein

11.803 The Theory and Practice of Planning (New)

Prereq.: 11.200
G (1)
3-0-9

Advanced seminar for masters and doctoral students. Historical and comparative analyses of the best known plans, planners, and planning theories in the US and Europe. Reviews and critiques prevailing approaches to practice. Analyzes planning successes and failures at local, metropolitan, and regional levels. Emphasizes the persistent gap between theory and practice. Departmental students only. Enrollment limited to 15. Permission of instructor required.
L. E. Susskind

11.850 Social Research Methods (New)

Prereq.: —
G (2)
3-0-9

Introduces methods and process of social research. Explores various methods — surveys, case studies, comparative research, social area analysis. Emphasizes development of research designs, selection of appropriate methods, and use of primary and secondary data. For Ph.D. students or permission of instructor required.
P. L. Clay, J. Ferreira, Jr.

11.900 Doctoral Proseminars (A)

Prereq.: Permission of Instructor
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.
G. A. Hack

Tutorials, Research, and Fieldwork Subjects

11.901 Research Seminar: Topics in Urban Studies and Planning (A)

Prereq.: Permission of Instructor
G (1)
3-0-6

11.902 Research Seminar: Topics in Urban Studies and Planning (A)

Prereq.: Permission of Instructor
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.
G. A. Hack

11.911 Reading Seminar in Urban Studies and Planning (A)

Prereq.: Permission of Instructor
G (1)
Arr.

11.912 Reading Seminar in Urban Studies and Planning (A)

Prereq.: Permission of Instructor
G (2)
Arr.

Reading and discussion of special topics in urban studies and planning.
G. A. Hack

11.932 Preparation for Thesis (A)

Prereq.: —
G (1, 2)
Arr.

Selects thesis subject, defines method of approach, and prepares preliminary thesis outline. Independent study, supplemented by frequent individual conference with staff members. Restricted to doctoral candidates.
G. A. Hack

11.941-11.948 Special Studies in Urban Studies and Planning (A)

Prereq.: —
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.
G. A. Hack

11.962 Urban Fieldwork and Internships (A)

Prereq.: Permission of Instructor
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.
G. A. Hack

11.981 Graduate Tutorial

Prereq.: —
G (1)
Arr.

11.982 Graduate Tutorial

Prereq.: —
G (2)
Arr.

Planned programs of individual instruction. Students and faculty members must make arrangements prior to the beginning of the term.
G. A. Hack

12 Earth and Planetary Sciences

Undergraduate Subjects

12.UR Undergraduate Research

Prereq.: —
U (1, 2)
Arr.

Undergraduate research opportunities in Earth and Planetary Sciences.
Staff

12.002 The Earth and the Planets

Prereq.: —
U (2) SD
2-0-4

Introduces comparative study of the planets and the earth. Properties of planetary atmospheres, surfaces, interiors, magnetic fields. Reviews data from new space missions.
M. N. Toksöz

12.01 Geological Processes, Features, and History

Prereq.: —
U (1) SD
3-4-5

Introductory course in geology. Major rock-forming minerals, rock-forming processes, and rock types. Geologic structures and relationships observable in the field. Geologic time scale, dating of rocks by fossil and radiometric methods. Movement of sediment and development of landforms by moving water, wind, and ice. Crustal processes and evolution in terms of global plate tectonics; surveys geologic history of the continents. Laboratory work on minerals and geologic mapping techniques. Two non-required weekend days of field trips.
J. B. Southard, J. G. Sclater

12.011 Sedimentary Processes: Rivers

Prereq.: 12.01
U (1) **Not offered 1984-85**
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.
J. B. Southard

12.012 Sedimentary Processes: Glaciers

Prereq.: 12.01
U (2) **Not offered 1984-85**
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.
J. B. Southard

12.013 Sedimentary Processes: The Wind

Prereq.: 12.01
U (1) **Next offered 1984-85**
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.
J. B. Southard

12.014 Sedimentary Processes: Coastlines

Prereq.: 12.01
U (2) **Next offered 1984-85**
1-0-3

Waves and currents in the shallow ocean; 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.
J. B. Southard

12.016 Sediments and Sedimentary Rocks

Prereq.: 12.01
U (2)
2-2-2

Texture of clastic sediments. Sedimentary minerals. Petrology and classification of sandstones, shales, conglomerates. Modern carbonate depositional environments and sediments; petrology of ancient carbonates. Briefly treats other sedimentary rocks: chert, ironstone, evaporites, coal. Primary sedimentary structures. Lithification and diagenesis. Principles and techniques of interpreting modern depositional environments. Laboratory work on petrology and classification of major rock types using hand specimens and thin sections. One weekend field trip.
J. B. Southard

12.02 Chemistry and Physics of Minerals and Rocks

Prereq.: —
U (1) SD
3-4-5

Introduces geochemistry, mineralogy, and petrology. Properties of common rock-forming minerals: their crystal chemistry, structures, and stabilities. Evolution of igneous, sedimentary, and metamorphic rocks and of associated ore deposits. Laboratory work focuses on identification and paragenesis of the most significant minerals and rock types. Two field trips during laboratory classes.
R. G. Burns

12.03 Structural Geology

Prereq.: 12.01
U (1)
3-3-6

Introduces mechanics of rock deformations. Discusses and interprets faults, folds, structural features of igneous and metamorphic rocks, and superposed deformations. Introduces 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

(Same subject as 1.384J, 2.742J, 3.095J)
Prereq.: —
U (1)
3-0-6

See description under subject 3.095J.
J. F. Elliott, R. G. Burns, H. H. Einstein, C. R. Peterson

12.051 Field Geology I

Prereq.: 12.02, *12.03*
U (1)
2-2-2

Introduces techniques of geological field study. Several weekend field exercises provide practical experience in preparation for 12.052. Presents in addition some introductory material on the regional geology of the locale of 12.052.
B. C. Burchfiel

12.052 Field Geology II

Prereq.: 12.051, 12.03
U (J, 2)
Arr.

During January, practices methods of modern geological field study 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. 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.
B. C. Burchfiel

12.061 Petrology I

Prereq.: 12.02
U (1)
3-6-3

Principles of optical mineralogy emphasizing use of petrographic microscope for identification of minerals in rock thin sections and mineral grain mounts. Introduces thermodynamics of heterogeneous phase equilibria and its application to experimental and natural rock systems. Introduces experimental silicate systems. Surveys igneous rocks, emphasizing distribution, composition, mineral associations, origin and relationship to tectonic environment.
T. L. Grove, F. S. Spear

12.062 Petrology II

Prereq.: 12.061
U (2)
3-6-3

Continuation of 12.061. Introduces 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

Prereq.: 12.02
U (2) LAB
2-6-4

Introduces 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. Laboratory projects utilize these techniques to solve specific geologic problems. Limited to 12.
F. A. Frey, R. G. Burns, S. R. Hart, T. L. Grove

12.07 Chemistry and Physics of the Earth

Prereq.: 8.02, 18.03
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 geophysical structure of mid-ocean ridges and island arcs; structure, composition and dynamics of the mantle; and the evolution of the Earth's crust and mantle.
S. R. Hart, S. C. Solomon

12.091-12.094 Special Problems

Prereq.: —
U (1, 2)
Arr.

Reading, laboratory, or fieldwork in Earth and Planetary Sciences. Requires written report.
Staff

12.095 Teaching Earth and Planetary Sciences

Prereq.: Permission of Instructor
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
U (1)
3-0-9

Surveys 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

12.105 Introduction to Field Geophysics (Revised Unit)

Prereq.: 18.03
U (1) **Next offered 1984-85**
2-3-4

Introduces geophysical field techniques and instruments. Describes 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.
P. Molnar, T. R. Madden

12.106 Geophysics Field Study

Prereq.: 12.105
U (J, 2) **Next offered 1984-85**
Arr.

Applies geophysical field techniques and data interpretation to studying 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 ssismic, 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.
P. Molnar, T. R. Madden

12.109 History of Astronomy and Astrophysics: 1609–1982 (New)

Prereq.: An Introductory Course
U (1) SD
3-0-9

Requires some background in astronomy. Traces astronomical and astrophysical discoveries, ideas, and principles from Galileo to the present day, emphasizing the 20th century. Topics: history of the telescope and accessories, x-ray sources, quasars, theories of origin of the solar system and star systems. Opportunities for sundial making and telescopic observations at Wallace Observatory.
W. H. Pinson

12.110 Applied Astronomy and Celestial Navigation

Prereq.: —
U (2) SD
3-2-7

Introduces spherical astronomy. Applied celestial navigation, using a programmable calculator. Participants become proficient with sextant, theodolite, and small telescopes. Topics: coordinate systems, transformations, and timekeeping; elliptic motion and Kepler's equation; determining geographical position; making an ephemeris for Halley's comet and Pallas; apparent motion of the Moon. Trips to Wallace Observatory; opportunities in photography and photometry.
W. H. Pinson

12.113 Astronomy: Stars and Galaxies

Prereq.: —
U (1) SD
3-2-7

Introduces stellar and galactic astronomy. Math and physics oriented with problem sets. Sundial-making project and telescopic observations. Topics: binaries, stellar interior equations and evolution; white dwarfs, neutron stars, and black holes; variable stars; quasars and active galaxies; expanding universe. Opportunities in celestial photography and photoelectric photometry. Lab hours to be arranged. Trips to Wallace Observatory.
W. H. Pinson

12.114 Astronomy: Solar System

Prereq.: —
U (2) SD
3-2-7

The "Golden Age of Solar System Exploration" has culminated in an incredible amount of information, which is presented in this course. Also covers classical planetology. Projects and activities include making a sundial; using the Sky Survey Atlas; opportunities in celestial photography and photometry. Topics: coordinates and transformations; comet models; impact craters; meteorites and solar system origin theories; planetary atmospheres; satellites. Lab hours to be arranged. Trips to Wallace Observatory.
W. H. Pinson

12.115J Dynamical Astronomy

(Same subject as 8.293J)
Prereq.: 18.03
U (2) SD
3-0-9

See description under subject 8.293J.
C. C. Counselman

12.117J Observational Techniques of Optical Astronomy

(Same subject as 8.287J)
Prereq.: One Course in Astronomy or Astrophysics
U (1) LAB
3-4-5

See description under subject 8.287J.
J. L. Elliot

12.118 Project in Optical Astronomy (New)

Prereq.: 12.117J
U (J, 2)
Arr.

Students select an observing project to be carried out at one of MIT's observatories or another facility, depending on telescope and instrument scheduling constraints. Regular seminar meetings discuss the observations, data analysis, and interpretation of the results. Requires a written report on the project. Permission of instructor.
L. M. French, J. L. Elliot

12.121 Exploration of the Solar System

Prereq.: 8.03
U (2)
3-0-9

Surveys instrumental techniques and strategy underlying remote measurements of the solar system. A description of optical, ultraviolet, infrared, radio, radar and particle detectors as applied both from the ground and from spacecraft to determine the properties of planets, satellites, and rings. Role of occultation techniques and two-frequency propagation paths as a means of studying the solar corona, interplanetary plasma and planetary atmospheres.
G. H. Pettengill, J. L. Elliot

12.131J Physics of the Solar System (Revised Content)

(Same subject as 8.291J)
Prereq.: *8.03*
U (1) SD
3-0-9

Physical study of the solar system: its evolution, composition, present configuration, and dynamics. A general description of the solar system is followed by a detailed discussion of its current dynamics emphasizing resonances and tidal evaluation. Devotes specific attention to compositions of the surfaces and interiors of terrestrial planets, giant planets, their satellites and rings, and minor planets and comets.
G. H. Pettengill, C. C. Counselman, J. L. Elliot

12.20J Environmental Chemistry of the Ocean-Atmosphere System

(Same subject as 19.05J)
Prereq.: —
U (1)
3-0-9

The earth's air and water. Factors controlling both the steady-state composition of the ocean and atmosphere and its response time to perturbations. Global and regional balances of water, C, O_2, H, S, and N_2. Cycle of aerosols and the role of precipitation as a removal process. Effect of weathering on river composition. Use of isotopes as tracers. Effect of anthropogenic activity on natural cycles.
Prerequisite: Institute Science Requirement or the equivalent.
J. M. Edmond, R. E. Newell

12.21 Physics of the Ocean

Prereq.: 8.03, 18.03
U (2) SD **Not offered 1984-85**
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.
C. C. Eriksen

12.221-12.229 Project Studies in Oceanography

Prereq.: —
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

Graduate Subjects

12.ThG Graduate Thesis (A)

Prereq.: —
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.
Staff

Geology and Geochemistry

12.301, 12.302 Seminar in Geology and Geochemistry (A)

Prereq.: 12.02
G (1)
2-0-4

Fall seminar on topics of current interest in geology and geochemistry. Required background preparation for students taking predoctoral general examinations in these subjects.
S. R. Hart, Staff

12.311 Seminar in Regional Tectonics (A)

Prereq.: 12.31
G (1, 2)
3-0-6

Applies techniques of tectonic synthesis to study the roles of particular orogenic belts in global plate tectonics. Treats different applications 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, P. Molnar

12.32 Mechanics of Sedimentary Processes (A)

Prereq.: 1.05
G (2) **Not offered 1984-85**
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. Sediment gravity flows; sorting of sediments by particle size and density. Interpretation of primary structures and toxtures in modern and ancient sedimentary deposits on the basis of sediment-transportation mechanics.
J. B. Southard

12.33 Petroleum Geology

Prereq.: Permission of Instructor
G (1, 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. Consult department.
Staff

12.34 Mineral Deposits

Prereq.: Permission of Instructor
G (1, 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. Consult department.
Staff

12.355 Seminar in Rock Mechanics (A)

Prereq.: —
G (1, 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
G (2) **Next offered 1984-85**
3-0-6

Reviews 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.
W. F. Brace

12.385-12.399 Special Problems in Geology-Geochemistry (A)

Prereq.: —
G (1, 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); *Staff* (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).

12.401 Meteorites: From Stones to Stars (New)

Prereq.: 12.02
U (2)
2-0-2

Discusses various classification schemes for meteorites based on metamorphic, chemical, and isotopic criteria; early chronology of the solar system and cosmochronology based on long- and short-lived isotopes; chemical composition of meteorites and its relationship to other solar system objects; condensation theory; nucleosynthesis and the isotopic composition of meteorites; the origin of cosmic rays and solar wind and their record in meteorites; ancient sun activity and ancient galactic evolution. Subject offered last half of semester.
C. J. Allegre, S. R. Hart

12.402 Isotopic Tracers in Metallogenesis

Prereq.: 12.02
U (2)
2-0-2

Discusses principles of stable isotope fractionation; systematics of the stable isotopes of hydrogen, carbon, oxygen, and sulfur in ore deposits; principles of radiogenic isotopes as geologic tracers and the systematics of Sr, Nd, Pb, and rare-gas isotopes in ore deposits; case studies of the use of both stable and radiogenic isotopes in ore deposit genesis; regional aspects of ore deposits and their relationship to the chemical geodynamics model. Subject offered last half of semester.
C. J. Allegre, S. R. Hart

12.411 Isotope Geology (A)

Prereq.: 12.02
G (2) **Next offered 1984-85**
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.
S. R. Hart

12.42 Geochemistry of the Transition Elements (A)

Prereq.: 3.091, 12.02
G (1, 2)
3-0-6

Applications of resonance spectroscopic techniques to the study of energy levels and bonding of first series transition elements in minerals. Theory and applications of Mossbauer, EPR, ESCA, and electronic absorption spectroscopy of minerals in the earth and planetary sciences.
R. G. Burns

12.45 Trace Element Geochemistry (A)

Prereq.: 12.071
G (1)
3-0-9

Studies element distribution in rocks and minerals using data obtained from natural and experimental systems. Emphasizes models describing trace element partitioning and applications of trace element geochemistry to problems in igneous geology.
F. A. Frey

12.46 Geochemical Kinetics (A)

Prereq.: 12.02
G (2) **Not offered 1984-85**
2-0-4

Basic principles of kinetics, both theoretical and phenomenological. Solutions of diffusion equation; reviews experimental data and techniques for silicate liquids and solids. Applications to natural geochemical systems.
S. R. Hart

12.47 Advanced Metamorphic Petrology (A)

Prereq.: 12.062
G (1) **Not offered 1984-85**
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.
F. S. Spear

12.48 Advanced Igneous Petrology (A)

Prereq.: 5.60 or 3.00
G (2) **Next offered 1984-85**
3-3-6

Thermodynamics, experimental phase equilibria, and kinetics combined to infer the physical conditions of igneous rock crystallization and magma production. Uses results of experimental studies to constrain processes that control magma genesis and give rise to the diversity of igneous rocks. Discusses theoretical approaches to thermometry-barometry techniques involving solid/solid and mineral/liquid reactions, kinetic controls on crystallization, and properties of silicate melts.
T. L. Grove

12.490-12.499 Advanced Seminar in Geology and Geochemistry (A)

Prereq.: Permission of Instructor
G (1, 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

12.502 Plate Tectonics and Marine Geophysics (A)

Prereq.: 8.03, 18.075
G (2)
3-0-9

Introduces the formal theory of plate tectonics. Interpretation of magnetic anomalies and the age of the ocean floor. Thermal structure of the plates. Ocean floor depths and heat flow. Gravity anomalies. Crustal loading and lithospheric flexure. Crustal generation. Seismological constraints on plate structure. Applies these ideas to the evolution of the ocean basins.
M. McNutt, B. E. Parsons

12.512 Geoelectricity (A)

Prereq.: 8.03, 18.076
G (2) **Not offered 1984-85**
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 electrical properties of porous media and high-temperature conduction in minerals. Applications include electrical and electromagnetic measurements to investigate rock types, mineral conplacements, fluid flows, earth strains, and mantle temperatures.
T. R. Madden

12.514 Geomagnetism (A)

Prereq.: 8.03, 18.076
G (2) **Next offered 1984-85**
3-0-9

Surveys 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.
T. R. Madden

12.521 Elements of Seismology (A)

Prereq.: 18.075
G (1)
3-1-8

A basic subject in seismology and the utilization of seismic waves for the study of the earth's interior. Introduces 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
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
G (1, 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
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
G (2) **Not offered 1984-85**
3-0-9

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 tectonics.
S. C. Solomon

12.55 Properties of Rocks (A) (New)

Prereq.: 8.03, 18.03
G (1)
3-0-9

Physical properties of rocks and their relation to cracks, pores, and minerals. Topics: elastic, transport, electrical, and magnetic properties; methods of measurement; and the factors that control each property. Applications to geotechnical engineering, borehole logging, geophysical exploration.
G. Simmons

12.56 Advanced Seminar in Plate Tectonics (A)

Prereq.: 12.101, 12.102
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. Reviews key papers and latest articles.
M. N. Toksöz, P. Molnar, S. C. Solomon, J. G. Sclater, B. E. Parsons

12.58 Geodynamics (A) (New)

Prereq.: 8.03, 18.076
G (2) **Not offered 1984-85**
3-0-9

Applies fluid mechanics to geological problems. Derivation of basic equations. Viscous flows: postglacial uplift, Stokes flow, diapirism. Heat transport: the thermal structure of the plates, moving boundary problems, conductive boundary layers. Convection in fluid layers. Applications to the dynamics of plate motions, magma chamber convection, and hydrothermal circulation.
B. E. Parsons

12.581-12.589 Seminar in Geophysics (A)

Prereq.: —
G (1, 2)
Arr.

Problems of current interest in geophysics; subject matter varying from term to term. *Staff* (12.581); *K. Aki,* (12.582); *M. N. Toksöz* (12.583); *T. R. Madden,* (12.584); *G. Simmons* (12.585); *M. McNutt* (12.586); *B. E. Parsons* (12.587); *S. C. Solomon* (12.588); *P. Molnar, J. G. Sclater* (12.589).

12.591-12.599 Special Problems in Geophysics (A)

Prereq.: —
G (1, 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); *M. McNutt* (12.596); *B. E. Parsons* (12.597); *W. F. Brace* (12.598); *P. Molnar, J. G. Sclater* (12.599).

12.620J Radar Astronomy, Astrometry, and Geodesy (A) (New)

(Same subject as 6.662J)
Prereq.: 8.03, 18.075
G (1) **Not offered 1984-85**
3-0-9

Applies techniques of radio and radar to measurement of the positions, orbital and rotational motions, surface and atmospheric characteristics, and gravity fields of the planets and satellites. Observations from spacecraft and from the ground. Propagation medium effects. Radar equation. Ambiguity

resolution in active radar and in passive radio interferometry. Modulation, signal processing, detection, and analysis techniques. Radio-wave scattering. Uses of interferometry in radar mapping astrometry and geodesy.
G. H. Pettengill, C. C. Counselman, D. H. Staelin

12.691-12.699 Special Problems in Planetary Physics (A)

Prereq.: —
G (1, 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); *J. L. Elliot* (12.695); *C. C. Counselman* (12.696); *Staff* (12.698, 12.699).

Oceanography

12.70J Steady Circulation of the Atmosphere and Ocean (A)

(Same subject as 19.70J)
Prereq.: 19.69
G (2)
3-0-9

See description under subject 19.70J.
P. H. Stone, C. I. Wunsch

12.71J Wave Motions in the Atmosphere and Oceans (A)

(12.810J)
(Same subject as 19.71J)
Prereq.: 18.350 or 19.69
G (2)
3-0-9

See description under subject 19.71J.
P. Malanotte-Rizzoli, K. K. Tung

12.72 Oceanic Volcanology and Petrology (A)

Prereq.: Permission of Instructor
G (1) **Not offered 1984-85**
3-2-4

Igneous processes occurring within and around the major ocean basins. Focuses on current observational data and hypotheses proposed to explain the observations. Discusses volcanic processes at spreading centers, tectonics and vulcanism along fracture zones, island arcs, and subduction zones. Vulcanism and magmatic trends along linear island chains. Some practical training in data interpretation, petrography, and mineralogy may be arranged.
(Woods Hole Staff): W. Bryan, H. Dick, Staff

12.73 Marine Geology (A)

Prereq.: Permission of Instructor
G (2) **Not offered 1984-85**
3-0-6

Designed to acquaint those with a background in geology with the processes responsible for the composition, structure, and morphology of the ocean floor. Topics: techniques/instruments; structure, statigraphy, and processes on passive/active continental margins and in ocean basins; tectonic evolution; sedimentary processes; ocean paleoenvironment; deep-sea drilling project.
(Woods Hole Staff): W. Bryan, H. Dick, Staff

12.732 Internal Structure of Ophiolites and Oceanic Lithosphere (A) (New)

Prereq.: 12.72
G (1) **Next offered 1984-85**
3-0-6

Treats geologic structures observed on sea floor and within ophiolite complexes in relation to stress at various depths; asthenosphere flow characteristics; and response of rock materials to tectonic processes. Discusses assemblages of structures expected to evolve at accreting plate boundaries, transform faults, and subduction zones. Emphasizes geometric analysis of dikes, igneous and metamorphic layering, faults, folds, and their overprinting relationships. Permission of instructor required.
(Woods Hole Staff): J. Karson

12.74 Marine Micropaleontology (A)

Prereq.: Permission of Instructor
G (1) **Not offered 1984-85**
2-3-4

Basic principles of micropaleontology and stable isotope geochemistry with historic development and applications in biostratigraphy and biochronology, paleoecology and paleoclimatology, for nonspecialists. Major groups of marine microfossils, emphasizing those used as tools in paleoceanography (e.g., planktonic and benthonic foraminifera, calcareous nannoplankton, radiolaria and diatoms). Laboratory work includes light and SEM microscopic work, and introduces quantitative methods.
(Woods Hole Staff): W. Bryan, H. Dick, Staff

12.742 Cenozoic Foraminifera (A) (New)

Prereq.: 12.74
G (2) **Not offered 1984-85**
3-2-4

Studies ecology, paleoecology, and stratigraphy of planktonic and benthonic foraminifera, including application in paleoenvironmental reconstructions. Surveys recent and Cenozoic assemblages, emphasizing quantitative analysis in paleoceanography. Includes application of stable isotope geochemistry in marine micropaleontology. Laboratory work includes sample preparation techniques and survey of important species using light microscope and SEM. Permission of instructor required.
(Woods Hole Staff): B. Corliss, W. Berggren

12.75 Marine Sediments (A)

Prereq.: Permission of Instructor
G (2) **Next offered 1984-85**
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.
(Woods Hole Staff): W. Bryan, H. Dick, Staff

12.77 Marine Geophysics I (A)

Prereq.: Permission of Instructor
G (1) **Next offered 1984-85**
3-2-6

First term of two-term sequence on theory and practice of marine geophysics. Overall purpose is to bridge the gap between geophysical method and geological understanding. Topics: introductory geophysical time-series analysis; measurements and geological modeling of marine magnetic anomalies, gravity, topography, heatflow, and magnetotellurics. Laboratory sessions devoted to actual data. Extensive readings of geophysical literature.
(Woods Hole Staff): C. Denham, Staff

12.771-12.779 Seminar in Oceanography at Woods Hole (A)

Prereq.: —
G (1, 2)
Arr.

Topics in marine geology and geophysics, physical, dynamical, and chemical oceanography. Content varies from term to term.
(Woods Hole Staff)

12.78 Marine Geophysics II (A)

Prereq.: 12.77
G (2) **Next offered 1984-85**
3-2-6

Second term of two-term course on theory and practice of marine geophysics. Topics: terrestrial and planetary gravity; seismic wave propogation, marine reflection, and refraction seismology, including seismic data processing, modeling, and inversion. Devotes laboratory sessions to actual data. Extensive readings of geophysical literature.
(Woods Hole Staff): C. Denham, Staff

12.781 Special Problems in Chemical Oceanography at Woods Hole (A)

Prereq.: Permission of Instructor
G (1, 2)
Arr.

For graduate students desiring to perform special investigations, special laboratory work, or special fieldwork in chemical oceanography.
(Woods Hole Staff)

12.783 Topics in Geophysical Time Series Analysis (A) (New)

Prereq.: Permission of Instructor
G (2)
3-0-6

Introduces selected aspects of geophysical time series analysis, emphasizing step-by-step transformation of raw data to a usable format for statistical or dynamical modeling. Includes implementation of filtering techniques, fourier transforms, sampling strategies, auto- and cross-spectra, and empirical orthogonal function analysis. Demonstrates application of these techniques to high-frequency geophysical phenomena common to the shallow marine shelf.
(Woods Hole Staff) D. Aubrey

12.79 Marine Sediments Laboratory (A)

Prereq.: 12.75
G (2) **Next offered 1984-85**
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 microscopic and analytical analyses. Emphasizes both assigned readings and laboratory exercises for each topic. Can be taken concurrently with 12.75.
(Woods Hole Staff): J. Milliman

12.791 Special Problems in Marine Geology and Geophysics at Woods Hole (A)

Prereq.: Permission of Instructor
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
G (2) **Not offered 1984-85**
4-0-10

Chemistry of the oceanic water column. Salinity, major ion speciation, 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 system. Applications of natural and artificial radionuclides. Minor elements in seawater, oxidation-reduction processes, chemistry of the surface micro-layer.
(Woods Hole Staff): M. Bacon, P. G. Brewer

12.82 Geochemistry of Marine Sediments (A)

Prereq.: 5.41 or 3.091, 5.60
G (1)
3-0-9

Chemical and isotopic composition of sediments in space and time. Present-day surface sediments. Equilibria and kinetics. Effect of sedimentary processes on the chemical composition of seawater. Dating and accumulation rate estimation. Oxygen and carbon isotope biostratigraphy. Effect of climate fluctuations on sedimentary processes. Emphasizes mathematical techniques and modeling where appropriate.
E. A. Boyle

12.822 Paleoceanography (A)

Prereq.: Permission of Instructor
G (2)
3-0-9

History of the earth surface environment as deduced from the record in deep-sea sediments. Uses micropaleontological, isotopic, geochemical, and mineralogical changes observed in piston cores and DSDP materials to infer changes in temperature and current field of the ocean and atmosphere, changes in seawater chemistry, and to evaluate and constrain theories of environmental change.
E. A. Boyle

12.83 Marine Geochemistry (A)

Prereq.: 5.41 or 3.091, 5.60
G (2)
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. Discusses of authigenic sediments, control of seawater composition, geochemical cycles. Emphasizes development of problems and topics by students and on calculations.
J. M. Edmond

12.84 Marine Organic Geochemistry (A)

Prereq.: Permission of Instructor
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. Uses movements of synthetic organic compounds through the marine environment to illustrate some aspects of the cycling of organic carbon in the ocean. Given at Woods Hole Oceanographic Institution.
(Woods Hole Staff): J. Farrington, R. Gagosian

12.85 Oceanographic Time Series (A)

Prereq.: 18.075
G (1) **Not offered 1984-85**
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.
C. Wunsch

12.86 Internal Waves in the Ocean (A)

Prereq.: *12.71J*
G (2) **Next offered 1984-85**
3-0-6

Introduces oceanic internal gravity wave motion. Kinematic and dynamic properties of internal waves. Ray and mode description. Mechanisms of generation, dissipation, and nonlinear interaction. Observations of wavenumber-frequency structure in the deep ocean. Relationships of internal waves to both geostrophic currents and to fine-structure and turbulent mixing. Draws material from areas of current research interest.
C. C. Eriksen

12.87J Equatorial Physical Oceanography (A)

(Same subject as 19.84J)
Prereq.: 12.70
G (1) **Next offered 1984-85**
3-0-6

See description under subject 19.84J.
C. C. Eriksen, M. A. Cane

12.88 Topics in Modern Observational Physical Oceanography (A) (New)

Prereq.: 18.075
G (2) **Next offered 1984-85**
3-0-6

Topics in large-scale observational/theoretical oceanography not included in more conventional courses. The theme is the problem of observing the ocean on basin and global scales through recent developments in observational techniques and their associated mathematical methods. Introduces acoustic tomography, satellite altimetry, large-scale general circulation and chemical tracers, inverse methods, linear and quadratic programming, objective mapping, optimal estimation theory.
C. I. Wunsch

12.881-12.889 Seminar in Oceanography at MIT (A)

Prereq.: —
G (1, 2)
Arr.

Topics in marine geophysics, physical, dynamical, and chemical oceanography. Content varying from term to term.
Staff

12.891—12.899 Special Problems in Oceanography at MIT (A)

Prereq.: —
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); *M. McNutt* (12.892); *B. E. Parsons* (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.: —
U (1, 2, S)
Arr.

Research in engineering for the ocean environment including naval architecture, wave energy, seakeeping, ocean exploration, ocean transportation, ocean vehicles, utilization of resources, marine economics, systems analysis, marine policy, marine hydrodynamics, ocean acoustics, ocean structures, sailing yachts, and some aspects of marine-related management. Well-equipped and modern laboratory facilities.
J. K. Vandiver

13.001 Introduction to Fluid Mechanics for Ocean Engineers

Prereq.: 8.01, 18.02
U (1) SD
4-0-8

Introduces 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. Introduces laminar and turbulent boundary layer theory with application to marine vehicles. Briefly considers compressible flows.
J. E. Kerwin

13.002 Marine Applied Mechanics

Prereq.: *18.03*
U (2)
4-0-8

Introduces 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. Introduces energy methods, statically indeterminant structures and buckling. Marine applications: ships, offshore structures, pressure vessels.
J. K. Vandiver, T. Wierzbicki

13.003J Dynamics

(Same subject as 2.03J)
Prereq.: *2.01* or *13.002*; 2.02 or 13.001; 18.03
U (1, 2)
4-0-8

See description under subject 2.03J.
J. K. Vandiver, J. H. Williams, Jr., H. M. Paynter

13.004 Linear Systems in Ocean Engineering

Prereq.: 18.03
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. N. Newman

13.011 Hydrostatics

Prereq.: —
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 part 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.: —
G (S)
1-7-2

Elementary principles of naval ship design and statics of naval architecture. 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. Primarily for students in Course XIII-A; others admitted by permission of instructor.
D. V. Burke, Jr.

13.021 Marine Hydrodynamics I (A)

Prereq.: 1.05 or 2.20 or 13.001; *18.075* or *13.004*
G (1)
4-1-7

Develops hydrodynamic principles and their application in the fields of ocean engineering and naval architecture. Dimensional analysis, similitude and model testing. Viscous flows and boundary layers. Potential flows. Added-mass and lift forces. Surface waves.
R. J. Van Houten

13.022 Marine Hydrodynamics II (A)

Prereq.: 13.021; 18.075 or 13.004
G (2)
4-0-8

Continuation of 13.021, emphasizing analytical methods. Laminar and turbulent boundary-layer theory. Ideal flows in two and three dimensions. Lifting-surface theory for steady, unsteady, and cavitating hydrofoils. Water waves. Loads and motions of bodies in waves. Ship wave resistence. Hydrodynamics of slender bodies, maneuvering, strip theory of ship motions.
P. D. Sclavounos

13.04 Hydrofoils and Propellers (A)

Prereq.: 18.076 or 18.304
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

13.06 Numerical Methods in Marine Hydrodynamics (A) (New)

Prereq.: 13.021, 13.50, 18.075, 18.076
G (2)
3-0-9

Formulation, methodology, and techniques of numerical solutions of potential flow problems. Rudiments of finite-difference, finite-element boundary-integral-equation and spectral methods with illustrations of applications to marine hydrodynamics. Emphasizes treatment of free-

surface and open boundaries, characteristics and effects of various approaches. Projects involving hands-on development of simple computer programs.
D. K. Yue

13.07 Free Surface Hydrodynamics (A)

Prereq.: 13.022; 18.076 or 18.304
G (1) **Not offered 1984-85**
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.
J. N. Newman

13.08 Stability and Motion Control of Ocean Vehicles (A)

Prereq.: 13.021; 18.075 or 13.004
G (2)
4-0-8

Develops motion equations in six degrees of freedom and formulation of mathematical simulation models for ocean vehicle motions. Effects of excitations from control systems and ocean environment on motion response. Solutions for stability and important motions and comparisons between simulation model results and physical reality. Applications to typical ocean vehicles such as ships, submarines, hydrofoils, platforms, buoys, and towed systems.
M. A. Abkowitz

13.09 Potential Flows (A)

Prereq.: 13.022; 18.076 or 18.304
G (1) **Next offered 1984-85**
3-0-6

Develops and applies 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.
J. N. Newman

13.10J Introduction to Structural Mechanics

(Same subject as 2.071J)
Prereq.: 2.01 or 2.015 or 13.002
U (1)
3-0-9

Selected structural mechanics concepts applicable to marine and mechanical structures; thick-walled spheres, mooring lines. Beam design and optimization. Stability and determinacy of structures, methods for computing deflections, principles of virtual forces and displacements, theorem of stationary potential energy, statically indeterminate structures. Matrix analysis of structures. Introduces 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
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.
T. Wierzbicki

13.112J Analysis and Design of Offshore Structures (A)
(Revised Content and Unit)

(Same subject as 1.551J)
Prereq.: 1.51 or 13.10J
G (2)
4-0-8

See description under subject 1.551J.
J. K. Vandiver, S. Shyam Sunder

13.121 Ship Structures (A)

Prereq.: 13.111
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.
T. Wierzbicki

13.122 Ship Structural Design (A)

Prereq.: 13.10J
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.
P. C. Xirouchakis

13.123 Advanced Analysis and Design of Ocean Engineering Structures (A)

Prereq.: 13.111 or 13.112J
G (2) **Next offered 1984-85**
3-0-6

Ocean engineering structural configurations: fixed-base platforms, semi-submersibles, cable and moorings, pipelines, marine risers. Environmental loads. Introduces materials for ocean engineering. Fixed-base platforms. Marine pressure vessels: thick cylindrical and spherical shell, instability of a thin cylindrical and spherical shell, penetrations, reinforcements, closures, hatch design, stiffened cylindrical shells. Tubular joint design.
P. C. Xirouchakis

13.124 Response of Marine Structures to Impulsive Loading (A)
(New)

Prereq.: 13.111
G (2) **Not offered 1984-85**
3-0-9

Characterizes extreme loads at sea. Collisions, hydrodynamic wave loading, slamming, ice impact, internal and underwater explosions. Methods of plastic analysis for large deflections of structures. Mechanics of projectile impact. Dynamic plastic behavior and crushing of stiffened plates and shells. Design for energy absorption. Crashworthiness of land, air, sea vehicles. Local damage and tearing of hull girder under transient loading. Collapse of tubular members of offshore structures. Propagating buckle in pipelines.
T. Wierzbicki

13.131 Plastic Analysis of Structures (A)

Prereq.: 13.111
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. Theoretical and experimental behavior of beams, plates, and shells when subjected to dynamic loads. Introduction to soil mechanics and reinforced concrete structures. See 2.073 and 16.24. Consult advisor.
T. Wierzbicki

13.132 Advanced Structural Topics (A)

Prereq.: 13.111
G (1) **Not offered 1984-85**
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.
P. C. Xirouchakis

13.14J Structural Mechanics in Nuclear Power Technology (A)

(Same subject as 1.56J, 2.084J, 3.82J, 16.261J, 22.314J)
Prereq.: Permission of Instructor
G (1)
3-0-9

See description under subject 22.314J.
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.: —
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.
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
G (1)
3-0-6

See description under subject 3.90J.
K. Masubuchi, F. J. McGarry

13.17J Welding Engineering (A)

(Same subject as 3.36J)
Prereq.: 3.02 or 3.141 or 13.15
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

13.18 Case Studies in Welding Design (A) (New)

Prereq.: —
G (2) **Not offered 1984-85**
2-0-4

Problems occur in various welded structures, including ships, offshore oil drilling rigs, pressure vessels, bridges, and aerospace structures. Discusses problems: brittle fracture, fatigue, weld cracking, and distortion. Through examination of past and current cases, develops techniques for preventing these problems by proper selection of materials, joining processes, and procedures during the design stages.
K. Masubuchi

13.21 Ship Power and Propulsion (A)

Prereq.: 2.40
G (1)
3-1-8

Examines ship power and propulsion systems for commercial and naval ships. Considers 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
U (2)
3-0-9

See description under subject 2.41J.
A. D. Carmichael, J. B. Heywood, 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
G (2)
3-0-9

See description under subject 2.601J.
A. D. Carmichael, W. M. Rohsenow

13.39 Analysis of Techniques for Fabricating Structures (A)

Prereq.: 3.13 or 13.15 or 13.17J
G (2) **Next offered 1984-85**
2-0-4

Analyzes 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. Discusses 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.
K. Masubuchi

13.40 Elements of Ocean Engineering Design

Prereq.: *13.002*
U (2)
3-3-6

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. Preliminary calculations to ensure that an ocean engineering structure and vehicle have sufficient structural strength. Selection of main propellers to match vehicle and power plant. Morison's equation, loads on fixed platforms and other offshore structures.
C. Chryssostomidis

13.41 Ocean Engineering Design Principles (A)

Prereq.: 13.40, *13.021*
G (1)
3-3-6

Loads and motions of ships and offshore structures caused by waves, winds and current; 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, the one hundred year wave. Mooring statics and dynamics; dynamic positioning. Emphasizes appropriate selection of coefficients and parameters involved, and design considerations that lead to safe and economic systems.
D. V. Burke, Jr., T. L. Tinkel

13.411 Principles of Naval Ship Design (A)

Prereq.: 13.012 or 13.40; 13.10J or 13.121 or 13.122; 13.21; 13.021
G (1)
2-4-6

Design of surface ship platforms for naval applications; formal design optimization procedures; mathematical model of ship design process; engineering and economic principles governing selection of dimensions and coefficients; influence of hull form and dimensions on mobility in calm water and rough seas; internal subdivisions for efficient arrangement and maximum survivability; damage stability. Design exercises in applications of principles.
D. V. Burke, Jr., T. L. Tinkel

13.412 Principles of Ship Design (A)

Prereq.: 13.021; 13.10J or 13.111 or 13.122; 13.41
G (2) **Next offered 1984-85**
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.
C. Chryssostomidis, M. Triantafyllou

13.431 Methods of Naval Ship-System Design (A)

Prereq.: 13.012 or 13.40
G (S)
3-0-6

Overview of naval ship design and acquisition process; mechanics of designing a ship system, formulation of a systematic design plan, requirements and constraints, design philosophy and design elements; selection/optimization criteria; design trade-offs; analysis of ship design trends; marginal cost factors. Design exercises and projects in application of principles.
T. L. Tinkel

13.441 Offshore Engineering Design (A)

Prereq.: 13.10J, 13.40
G (2) **Not offered 1984-85**
2-4-6

Methodology for offshore system design. Definitions of design problem emphasizing problem objectives, design criteria, and modeling techniques. Assesses probability of failure using environmental data, short- and long-term statistics; extreme loads; fatigue. Presents a complete example for a semisubmersible or a tension leg platform and requires a term project.
M. Triantafyllou

13.451 Projects in Naval Ships Conversion Design (A)

Prereq.: 13.411 or 13.412; 13.431; 13.21
G (2)
Arr.

Project studies focused on conversion design of a naval ship. A new mission requirement is defined requiring significant ship modification. Design plan formulation. Technical aspects addressed in sufficient detail to demonstrate feasibility and desirability. Requires formal written and verbal reports. Encourages participation by several students in a single project.
D. V. Burke, Jr., T. L. Tinkel

13.461 Projects in New Construction Naval Ship Design (A)

Prereq.: 13.411 or 13.412; 13.431; 13.122; 13.21
G (1, 2, S)
Arr.

Project studies focused on preliminary design of a new naval ship fulfilling a given set of mission requirements. Design plan formulation. System level trade-off studies. Emphasizes achieving a balanced design and total system integration. Requires formal written and oral reports. Encourages participation by several students in a single project extending over two terms.
D. V. Burke, Jr., T. L. Tinkel

13.462 Projects in Ocean Engineering System Design (A)

Prereq.: 13.441, 13.411 or 13.412
G (1, 2, S)
Arr.

Determines 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
G (2)
2-4-6

Develops basic techniques employed in planning and design of complex systems through involvement in a specific project. Develops specific background 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

13.47 Control Theory Applications in Ocean Engineering (A)

Prereq.: 18.076, 13.08, 6.003, or 2.02
G (1)
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. Selects specific applications from such areas as dynamic positioning of drilling vessels, antirolling mechanisms, submarine control. Control theory background preferred but not required.
M. Triantafyllou

13.50 Computer Applications to Marine Problems (Revised Content and Unit)

Prereq.: 18.03
G (1)
3-0-9

Applies programming and numerical techniques to marine problems. Basics of computer architecture. Accuracy and efficiency of computations. Root finding. Numerical solution of linear simultaneous equations. Polynomial approximation. Interpolation, integration, differentiation. Spline curves. Numerical solution of differential equations. Discusses numerical methods applied to partial differential equations. Assigned projects based on realistic problems in naval architecture and ocean engineering. FORTRAN IV desired.
P. D. Sclavounos

13.51 Computer Models of Engineering Systems

Prereq.: 18.02, 8.01
U (1) SD
3-0-9

School-Wide Elective Subject. Description given at end of this chapter on SWE page.
B. Schumacker

13.52 Management in Engineering

Prereq.: —
U (1)
3-0-9

School-Wide Elective Subject. Description given at end of this chapter on SWE page.
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; 1.143J or 13.622J
G (1) **Next offered 1984-85**
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.
E. G. Frankel

13.62 Engineering Systems Analysis (A)

Prereq.: Permission of Instructor
G (1)
3-0-6

School-Wide Elective Subject. Description given at end of this chapter on SWE page.
R. de Neufville, J. P. Clark

13.621 Engineering Risk-Benefit Analysis (A)

Prereq.: 18.02
G (2)
3-0-6

School-Wide Elective Subject. Description given at end of this chapter on SWE page.
A. W. Drake, A. R. Odoni

13.622J Mathematical Optimization Techniques (A)

(Same subject as 1.143J)
Prereq.: Permission of Instructor
G (1)
3-0-6

See description under subject 1.143J.
H. N. Psaraftis, D. H. Marks

13.63J Advanced Reliability Analysis and Risk Assessment (A)

(Same subject as 22.40J)
Prereq.: 22.38, 22.83, 1.143J or 13.622J
G (2)
3-0-9

See description under subject 22.40J.
E. G. Frankel, C. D. Heising

13.631 Port Planning and Development (A)

Prereq.: Permission of Instructor
G (2) **Next offered 1984-85**
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; port design, investment planning, operations, analysis, regulation and environmental impact assessment.
E. G. Frankel

13.65 Production Analysis (A)

Prereq.: 1.143J or 13.622J, or 13.441 or 13.412
G (1)
3-0-6

Analyzes 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 (1.182J)
G (2)
3-0-6

Studies 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; liner shipping rate making; impact of maritime policies and regulations on the industry.
H. N. Psaraftis, Z. S. Zannetos

13.665J Logistical and Transportation Planning Methods (A)

(Same subject as 1.203J, 6.281J, 11.526J, 15.078J, 16.76J, TPP 43J)
Prereq.: 6.431, 15.075
G (1)
3-0-9

See description under subject 1.203J.
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
G (2) **Not offered 1984-85**
3-0-6

Applies Bayesian decision theory 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.
H. N. Psaraftis

13.68 Management of Marine Systems (A)

Prereq.: 15.516
G (1)
3-0-6

Analyzes 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. Permission of instructor required.
H. S. Marcus

13.682J Current Issues in Engineering

(Same subject as 1.485J, 3.562J, 6.941J, 22.87J)
Prereq.: —
G (1)
3-0-6

See description under subject 1.485J.
T. H. Lee

13.683J Cases and Projects in Engineering Management (A)

(Same subject as 1.486J, 3.563J, 6.942J, 22.88J)
Prereq.: 13.682J
G (2)
3-1-5

See description under subject 1.486J.
T. H. Lee

13.684J Technology Planning (A)

(Same subject as 1.487J, 3.564J)
Prereq.: —
G (1)
3-0-6

See description under subject 1.487J.
J. M. Utterback, R. D. Logcher

13.685J Manufacturing/Technology Interface (A)

(Same subject as 3.565J, 15.365J)
Prereq.: Permission of Instructor
G (2)
3-0-6

See description under subject 15.365J.
J. M. Utterback

13.69 International Shipping (A)

Prereq.: 13.68
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. Includes effect of world energy crisis and changing trade patterns upon demand for shipping; evaluation of shipping capacity requirements in terms of capital needs; new ship and terminal technologies; and effect of changing international relationships. Permission of instructor required.
H. S. Marcus

13.700-13.709 Special Problems in Ocean Engineering

Prereq.: —
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.: —
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.: —
U (2)
1-1-1

Series of lectures acquaints undergraduate students in ocean engineering with the many facets of the field including naval architecture and marine engineering. Explores relationships and interfaces with the various engineering and scientific disciplines. Uses current problems and research projects for illustration. Each session conducted by a different faculty member, concentrating 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
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
G (1) **Next offered 1984-85**
3-0-9

See description under subject 6.455J.
A. B. Baggeroer,
(Woods Hole Staff): R. C. Spindel

13.76 Introduction to Random Processes in Ocean Engineering (A)

Prereq.: 18.04 or 18.075 or 13.004
G (2) **Next offered 1984-85**
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.
J. H. Milgram, R. J. Van Houten

13.77J Invention

(Same subject as 2.941J, 10.802J, 16.671J)
Prereq.: —
G (1)
3-0-6

See description under subject 2.941J.
D. G. Jansson, A. D. Carmichael, W. R. Markey, J. P. Longwell

13.771 Engineering Internship

Prereq.: —
U (1, 2, S)
0-6-0

13.772 Industrial Practice in Ocean Engineering

Prereq.: 13.771
U (1, 2, S)
Arr.

13.774 Advanced Engineering Internship

Prereq.: 13.771
G (1, 2, S)
0-6-0

Enrollment restricted to students registered in Course XIII-C Program. Provides academic credit for assignments affiliated with XIII-C Program. Students register for 13,771 during their first and second company assignments, accumulating a total of 12 units. 13.772 provides academic credit for the seven month company assignment. 13.771 and 13.772 terminate with the S.B. degree. Students register for 13.774 during their third and fourth company assignments (after admission to graduate school), accumulating a total of 12 graduate units. Credit for above given upon satisfactory completion of company assignments, receipt of favorable evaluation by company supervisor, and receipt of favorable evaluation of student's report about company assignment by faculty advisor.
C. Chryssostomidis

13.78 Entrepreneurship

Prereq.: —
G (2)
4-0-5

School-Wide Elective Subject. Description given at end of this chapter on SWE page.
D. G. Jansson

13.80J Mechanical Vibration

(Same subject as 2.06J)
Prereq.: 2.03J or 13.003J
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
G (1)
3-0-9

See description under subject 2.060J.
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
G (2)
3-0-9

See description under subject 2.063J.
P. Leehey, R. H. Lyon

13.84J Flow Noise (A)

(Same subject as 2.065J, 16.082J)
Prereq.: 2.20 or 13.021 or 16.02
G (1) **Not offered 1984-85**
3-0-9

Elements of aerodynamics 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, cavitation noise. Boundary layer noise. Mach wave radiation, structural response, and radiation. Alternate years.
P. Leehey, S. E. Widnall

13.85 Fundamentals and Applications of Underwater Sound (A)

Prereq.: 13.004 or 18.075
G (2)
3-0-6

Fundamentals of underwater sound systems as controlled by physical principles and properties of the ocean and its boundaries. Analyzes sonar systems. Absorption in seawater. Transmitting and receiving arrays. Scattering and reflection. Refraction and propagation loss. Noise and reverberation. Sonar design principles. Applications in charting, navigation, station keeping, target detection, fishing, petroleum exploration, telemetry.
I. Dyer

13.861 Ocean and Seabed Acoustics I (A)

(13.86)
Prereq.: Permission of Instructor
G (1) **Not offered 1984-85**
3-0-9

Surveys 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. 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. Introductory knowledge of Fourier analysis, probability, and wave propagation necessary.
A. B. Baggeroer, (Woods Hole Staff): G. Frisk

13.862 Ocean and Seabed Acoustics II (A) (New)

Prereq.: 13.861
G (2) **Not offered 1984-85**
3-0-9

Continues 13.861, treating ray and normal mode theory in greater depth, and introducing new topics. Emphasizes "state-of-the-art" level in ocean acoustics. Topics: ray theory corrections, coupled normal mode theory, adiabatic approximation, continuum and virtual modes, rough surface scattering in mode theory, ray-mode picture connections, parabolic equation, Thomson-Haskell propagator matrix, seismic wave (body and surface) overview, WKBJ synthetic seismograms, and hydrophone-geophone intercomparisons. Permission of instructor required.
(Woods Hole Staff): J. Lynch

13.87 Wave Propagation in Random Media (A)

Prereq.: Permission of Instructor
G (2) **Not offered 1984-85**
3-0-9

Emphasizes physical principles and mathematical techniques common to most problems of wave propagation through and scattering in random media. The ocean and atmosphere as random medium. Scattering by discrete scatterers and by a continuous inhomogeneous medium. 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. Given at MIT.
(Woods Hole Staff): Y. Desaubies

13.88J Dynamics of Ocean Structures (A)

(Same subject as 1.552J)
Prereq.: 1.572, 13.80J or 2.06J
G(2)
3-0-9

Presents prediction of structural dynamic response and acquisition and analysis of experimental data for contemporary ocean structures. Evaluates fixed platforms and moored tension leg platforms. Includes dependence of predicted response on natural frequencies, damping ratios, and characteristics of the wave spectrum. Response of long cylindrical cables, pipelines, and marine risers to vortex shedding. Discusses and demonstrates experimental, data reduction, and analysis techniques. Introduces fatigue life calculation.
J. K. Vandiver, S. Shyam Sunder

13.901 Ocean Engineering Laboratory I (Revised Content)

Prereq.: 13.001
U (2) LAB
1-5-0

Experimental projects in the fields of ocean engineering and naval architecture and marine engineering, conducted at the MIT Ship Towing Tank and the MIT Variable Pressure Water Tunnel. Ocean engineering experiments arranged to solve one or more design problems selected by the instructor.
A. D. Carmichael

13.902 Ocean Engineering Laboratory II (Revised Content)

Prereq.: 13.901, 13.002, 13.003J
U (1) LAB
1-5-0

Experimental projects in the fields of ocean engineering and naval architecture and marine engineering, conducted at laboratory facilities in the Department of Ocean Engineering. Ocean engineering problems arranged to solve one or more design problems selected by the instructor.
A. D. Carmichael

13.92 Marine Policy (A)

Prereq.: Permission of Instructor
G (1)
3-0-6

Surveys major ocean uses and their associated policy issues; demonstrates relationships among uses and among the scientific, technical, economic, and political/legal aspects. Topics: law of the sea, seabed mining, offshore oil development, marine pollution, fisheries, and national security.
J. T. Kildow.

13.94 Law for Ocean Systems

(13.962)
Prereq.: Permission of Instructor
G (1)
3-0-6

Legal framework for managing ocean resources and systems, combining public law of the sea, admiralty, and the US regulatory law. OCS, tanker, shipping, and environmental regimes. Law for new ocean technologies. Questions of jurisdiction and implementation arising from new economic zones or unilateral extensions. Principles governing applicability of civil and criminal law offshore. Focus on relationship of law and technology.
J. D. Nyhart

13.961J Ocean Resources Management (A)

(Same subject as 3.581J)
Prereq.: Permission of Instructor
G (2)
3-0-6

Comparative study of nature, utilization, management of seabed mining, offshore oil development, fishing. Topics: changing perceptions of natural resources, availability, costs; results of increased demand; effects of technology on development; factors that compel new management systems; institutional and process changes in public and private sectors; role of resources in international political and economic affairs.
J. T. Kildow

13.97 Introduction to Technology and Law

Prereq.: —
U (1)
3-0-9

School-Wide Elective Subject. Description given at end of this chapter on SWE page.
J. D. Nyhart

13.98J Coastal Zone Management (A)

(Same subject as 11.365J)
Prereq.: Permission of Instructor
G (2)
3-3-6

Lecture and field work subject in methods and concepts for balanced management of land and water resources in coastal regions. Topics: physical and ecological coastal processes; implications of the range of human activities that place demands on the limited coastal resource base; institutional and regulatory framework for coastal management systems.
J. T. Kildow

13.990J Oceanographic Systems I

(Same subject as 1.697J)
Prereq.: —
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.: —
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
G (2) **Next offered 1984-85**
3-0-6

Theoretical and practical aspects of buoy systems structural design. Stability of immersed and surface floating bodies. Wave theory. Heave and roll response of buoys to ocean wave excitation. Hydrodynamic forces on constrained bodies. Equilibrium trajectories of immersed cables. Two- and three-dimensional models for computer analysis. Dynamics of mooring lines. Outline of practical aspects of buoy system design. Buoyancy materials. Mooring line components. Anchoring. Buoy system installation and retrieval. Given at MIT.
(Woods Hole Staff): H. O. Berteaux

13.998 Principles of Oceanographic Instrument Systems — Sensors and Measurements (A)

Prereq.: 2.03J/13.003J, 18.075 or 13.004
G (2) **Next offered 1984-85**
3-3-6

Introduces 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.
(Woods Hole Staff): A. J. Williams

13.999J Special Projects in Oceanographic Engineering (A)

(Same subject as 1.699J)
Prereq.: Permission of Instructor
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
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.: —
U (1, 2, S)
3-0-6

Introduces 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.
R. S. Eckaus

14.014J Engineering Aspects of Economic Analysis

(Same subject as 1.01J)
Prereq.: —
U (1)
4-0-8

See description under subject 1.01J. Credit is not given for both 14.01 and 14.014J or 1.01J.
Staff

14.02 Economic Principles II

Prereq.: —
U (1, 2, S)
3-0-6

Introduces 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.
P. Temin

14.03 Applied Microeconomics

Prereq.: 14.01
U (1, 2)
3-0-6

Designed for non-majors who desire further exposure to microeconomics and its applications. Presents basic theory of consumer and producer behavior and welfare analysis at an intermediate level. Emphasizes applications, including cost-benefit analysis, transportation, price regulation, research and development, and pollution.
Term 1: *J. v. R. Farrell*
Term 2: *W. C. Wheaton*

14.04 Intermediate Microeconomic Theory

Prereq.: 14.01
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* count toward Humanities Requirement.
E. S. Maskin

14.06 Intermediate Macroeconomic Theory

Prereq.: 14.02
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: *B. S Bernanke*
Term 2: *O. J. Blanchard*

14.07 History of Economic Thought

Prereq.: 14.01, 14.02
U (2)
3-0-6

A selective historical survey of the development of economic analysis; gives varying degrees of attention 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*
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
G (1)
4-0-8

Linear algebra emphasizing topics of interest to economists. Also topics in multivariate differential calculus and optimization theory. Provides mathematical prerequisites for econometrics.
J. E. Harris

14.110J Applied Microeconomic Analysis (A)

(Same subject as 1.147J, CTS 110J)
Prereq.: 14.01
G (1)
3-0-6

For students with primary interests outside of economics 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, emphasizing 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

14.111J Economics of Project Evaluation (A)

(Same subject as 1.148J)
Prereq.: 14.03 or 14.120
G (2) **Next offered 1984-85**
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, and energy.
C. Winston

14.120 Microeconomic Theory (A)

Prereq.: 14.03
G (1)
3-0-9

Comprehensive survey, emphasizing 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
G (1)
2-0-4

14.122 Microeconomic Theory II (A)

Prereq.: 14.04
G (1)
2-0-4

Theory of consumption, production, and distribution. Comparative static analysis, consumer surplus, duality, partial and general equilibrium, fundamental welfare theorem. Introduces monopoly, oligopoly, and uncertainty.
R. M. Solow, F. M. Fisher

14.123 Microeconomic Theory III (A)

Prereq.: 14.122
G (2)
2-0-4

14.124 Microeconomic Theory IV (A)

Prereq.: 14.121, *14.123*
G (2)
2-0-4

Introduces theory of resource allocation and price system. Emphasizes the use of efficiency prices as guide to decentralized decision making. Issues in central planning; externalities; second-best analysis. 14.124: Capital theory: one- and two-sector growth theory; welfare criteria and their limitations.
14.123: M. L. Weitzman
14.124: P. A. Samuelson, P. A. Diamond

14.132 Schools of Economic Thought (A)

Prereq.: 14.04
G (2)
3-0-9

Historical development of economics, as illustrated by selected writers: Aristotle, Aquinas, Hume, Smith, Ricardo, Malthus, Mill, Marx, Walras, Marshall.
R. L. Bishop

14.141 Disequilibrium Foundations of Equilibrium Economics (A)

Prereq.: 14.122
G (2)
2-0-4

Does a competitive economy with rational agents taking advantage of disequilibrium opportunities for arbitrage tend to approach equilibrium? Is that equilibrium competitive? Importance of the subject for the foundations of usual economic analysis and the theory of value. Historical review and modern theory of stability in relation to above question.
F. M. Fisher

14.142 Mathematical Optimization and Economic Theory (A)

Prereq.: 14.124
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.
M. L. Weitzman

14.144 Applied Price Theory (A)

Prereq.: 14.122
G (1)
Arr.

Selected topics in price theory, focus changing from year to year. Currently emphasizes the economics of exhaustible and renewable natural resources.
R. M. Solow

14.145 Economics of Uncertainty (A)

Prereq.: 14.124
G (2)
3-0-9

Individual behavior under uncertainty. Equilibrium and welfare with uncertainty. Search and information.
J. v. R. Farrell, E. S. Maskin

14.147 Economic Applications of Game Theory (A)

Prereq.: 14.122
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.
E. S. Maskin

14.148 Advanced Topics in Microeconomic Theory (A)

Prereq.: 14.124
G (1)
Arr.

14.149 Advanced Topics in Microeconomic Theory (A)

Prereq.: 14.124
G (2)
Arr.

Advanced topics in microeconomic theory of current interest.
Staff

14.151 Mathematical Approach to Economics (A)

Prereq.: 14.124
G (1)
3-0-9

The use of mathematical method in all the fields of economics.
P. A. Samuelson

14.152 General Equilibrium (A)

Prereq.: 14.04
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.
E. S. Maskin

14.153 Topics in Mathematical Economics (A)

Prereq.: 14.152
G (2) **Next offered 1984-85**
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.
T. J. Kehoe

14.191, 14.192 Economics Seminar (A)

Prereq.: 14.121
G (1, 2)
Arr.

Special economic problems.
Staff

14.193, 14.194 Seminar: Topics in Economics (A)

Prereq.: 14.121, 14.451
G (1, 2)
Arr.

Topics in economics of current interest.
Staff

14.195, 14.196 Reading Seminar in Economics (A)

Prereq.: 14.121
G (1, 2)
Arr.

Reading and discussion of special topics in economics. Open to advanced graduate students by arrangement with individual members of the staff.
Staff

14.198, 14.199 Teaching Introductory Economics

Prereq.: —
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.
R. S. Eckaus, P. Temin

Industrial Economics

14.20 Industrial Organization and Public Policy

Prereq.: 14.01
U (1)
3-0-6

Analyzes 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.
G. Saloner

14.21J Health Economics

(Same subject as HST 901J)
Prereq.: 14.01
U (2)
3-0-6

Applies theoretical and empirical tools of economics to problems of health and medical care delivery. Concentrates 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.
P. Temin

14.23 Government Regulation of Industry

Prereq.: 14.01
U (2) **Next offered 1984-85**
3-0-6

Examines economic rationale for and against government regulation of prices, entry, product quality, and production processes in various US industries. Theoretically and empirically examines economic effects of current regulatory practices through case studies.
P. L. Joskow

14.271 Problems in Industrial Economics (A)

Prereq.: 14.04
G (1)
3-0-9

Small and large enterprises in the American economy; market structures; degrees of monopoly and competition; requisites of public policy.
R. Schmalensee, G. Saloner

14.272 Government Regulation of Industry (A)

Prereq.: 14.04
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 antitrust 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
G (1)
3-0-6

Surveys 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)

(Same subject as 20.619J, HST 902J)
Prereq.: Permission of Instructor
G (1) **Not offered 1984-85**
3-0-9

See description under subject 20.619J.
J. E. Harris, S. R. Tannenbaum

14.286J Health Economics Seminar (A)

(Same subject as HST 903J)
Prereq.: 14.04
G (2)
3-0-9

Advanced subject in economics of health care sector. Considers selected topics 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
G (1)
3-0-6

14.292 Industrial Economics Seminar (A)

Prereq.: 14.271
G (2)
3-0-6

Particular problems in industrial economics.
Staff

Statistics and Econometrics

14.30 Introduction to Statistical Method in Economics

Prereq.: 18.02
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* count toward Humanities Requirement.
Term 1: *J. M. Poterba*
Term 2: *O. J. Blanchard*

14.31 Econometrics

Prereq.: 14.30
U (1, 2) LAB
3-4-5

Introduces basic econometric techniques strongly emphasizing applications. Problems in estimating such economic variables as consumption-income-price relationships, production functions, and in simulating economic models. May *not* count toward Humanities Requirement.
Term 1: *J. L. Powell*
Term 2: *E. Kuh*

14.381 Statistical Method in Economics

Prereq.: 18.02
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. L. McFadden

14.382 Econometrics I (A)

Prereq.: 14.101, 14.381
G (2)
4-0-8

14.383 Econometrics II (A)

Prereq.: 14.382
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.
F. M. Fisher, J. L. Powell, J. A. Hausman

14.384 Time-Series Analysis (A)

Prereq.: 14.382 or 14.388
G (1)
2-0-4

Theory and applications of time-series models, including stochastic processes, ARIMA processes, spectral analysis, and distributed lags.
L. Hansen

14.386 Advanced Topics in Econometrics (A)

Prereq.: 14.383
G (2)
3-0-9

Selected topics including specification error, nonlinear estimation, simulation, aggregation and the derivation of economic policy models.
J. L. Powell

14.388 Applied Econometrics (A)

Prereq.: 14.101, 14.381
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. Emphasizes applications.
D. L. McFadden

14.389 Econometrics Paper (A)

Prereq.: 14.382 or 14.31
G (1)
0-0-3

Paper in econometrics required of all Ph.D. candidates who do not take 14.383.
D. L. McFadden

14.39 Undergraduate Thesis Seminar (New)

Prereq.: 14.04, 14.06, 14.31
U (1)
2-0-4

Develops a workable thesis proposal through critical reading of current research, review and written commentary on topical literature, individual reports, and conferences. For senior economics majors.
E. C. Brown, J. L. Powell

14.391 Workshop in Economic Research (A)

Prereq.: 14.124, 14.454
G (1)
2-0-10

14.392 Workshop in Economic Research (A)

Prereq.: 14.124, 14.454
G (2)
2-0-10

Develops 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
U (1)
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.
P. A. Diamond

14.42 Economics of Pollution

Prereq.: 14.01
U (2) **Next offered 1984-85**
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
U (2)
3-0-9

Analyzes effect of taxation on microeconomic activity. Examines directions for tax reform. Income and corporation tax, Social Security programs.
M. A. King

14.451 Macroeconomic Theory I (A)

Prereq.: 14.06
G (2)
2-0-4

14.452 Macroeconomic Theory II (A)

Prereq.: 14.451
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. 14.452: Determination of aggregate output, employment, and prices. Keynes and alternate theories. The Phillips Curve. Inflation in the short and long run.
R. Dornbusch, S. Fischer

14.453 Macroeconomic Theory III (A)

Prereq.: 14.452
G (1)
2-0-4

14.454 Macroeconomic Theory IV (A)

Prereq.: 14.453
G (1)
2-0-4

Theory of involuntary unemployment; sources of wage and price stickiness; role of expectations. 14.454: Quantitative macroeconomics. Consumption, investment, and other components of aggregate demand. Structure of complete econometric models of the US economy.
14.453: B. S. Bernanke
14.454: R. M. Solow

14.458, 14.459 Advanced Topics in Macroeconomic Theory (A)

Prereq.: 14.454
G (1, 2)
Arr.

Advanced topics in macroeconomic theory of current interest.
Staff

14.462 Monetary Economics I (A)

Prereq.: 14.121, 14.451
G (1)
3-0-9

Determinants of supply of money with special attention to role of Federal Reserve System. Discusses nature of demand for money. Role of monetary policy in determination of level of economic activity. Cost of inflation and unemployment.
L. Hansen

14.463 Monetary Economics II (A)

Prereq.: 14.122, 14.452
G (2)
3-0-9

General equilibrium theory of money, interest, prices, and output; portfolio problems, and the effects of monetary phenomena on investment and accumulation of wealth with special reference to problems arising from uncertainty.
S. Fischer, O. J. Blanchard

14.471 Fiscal Theory I (A)

Prereq.: 14.04
G (1)
2-0-4

Optimum fiscal analysis (income distribution, public goods, externalities). Introduces constrained optimum analysis (deadweight burdens, Ramsey problem). Simple incidence.
M. A. King

14.472 Fiscal Theory II (A)

Prereq.: 14.471
G (1)
2-0-4

Fiscal incidence, social discount rates, fiscal changes in growth models.
M. A. King

14.473 Government Decision Theory (A)

Prereq.: 14.04
G (1) **Next offered 1984-85**
2-0-4

Positive and normative analysis of governmental decision theory and the political process.
J. Rothenberg

14.474 Fiscal Economics III (A)

Prereq.: 14.124
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.
M. A. King, J. M. Poterba

14.475 Fiscal Federalism and Local Government Economics (A)

Prereq.: 14.471
G (1) **Next offered 1984-85**
2-0-4

Role of government fiscal activity in a Federal structure.
J. Rothenberg

14.476 Social Insurance (A)

Prereq.: 14.121, 14.122
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.
P. A. Diamond

14.477 Quantitative Fiscal Analysis (A)

Prereq.: 14.04
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.
J. M. Poterba

14.478 Tax Institutions and Policy (A)

Prereq.: 14.04
G (2)
2-0-4

Analysis of tax structures, tax instruments, and problems of formulating and implementing tax policy.
E. C. Brown

14.482 Income Distribution Economics (A)

Prereq.: 14.124
G (2) **Next offered 1984-85**
3-0-9

Modern theories and empirical studies of the determinants of the distribution of income.
L. C. Thurow

International, Interregional, and Urban Economics

14.50 State and Local Government Finance

Prereq.: 14.01
U (2)
3-0-6

Issues in state and local government finance, paying particular attention 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.
H. C. Katz

14.51J Urban Economics

(Same subject as 11.008J)
Prereq.: 14.01
U (2)
3-0-6

Analyzes 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. Develops theoretical perspectives primarily through discussion of policy issues.
W. C. Wheaton

14.52 Economics of the Soviet Union and China

Prereq.: 14.02
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.
E. D. Domar

14.53 Comparative Economic Systems

Prereq.: 14.02
U (1)
3-0-6

Comparative study of the treatment of economic problems under different economic systems. Analyzes the economic ideology of capitalism, utopian writings, market socialism, workers' management, and Marxism. Functions of prices, profits, and planning in allocation of resources. Compares several capitalist and socialist countries including the US and Yugoslavia.
E. D. Domar

14.54 International Trade

Prereq.: 14.03 or 14.04
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.
E. Helpman

14.573J Urban Economic Analysis I (A)

(Same subject as 1.283J, 11.410J)
Prereq.: 14.04
G (1)
3-0-9

See description under subject 11.410J.
W. C. Wheaton

14.574J Urban Economic Analysis II (A)

(Same subject as 11.411J)
Prereq.: 11.410J or 14.573J
G (2)
3-0-9

Urban housing markets and neighborhoods. Economics of slums, ghettos, and public policy. Congestion, pollution, and urban crime. Local government in metropolitan areas. Criteria for public action.
W. C. Wheaton

14.576J Topics in Transportation Economics (A)

(Same subject as 1.284J)
Prereq.: 14.03 or 14.04
G (2)
3-0-9

See description under subject 1.284J.
C. Winston

14.581 International Economics I (A)

Prereq.: 14.04
G (1)
3-0-9

Theory of international trade and applications in commercial policy.
P. R. Krugman, E. Helpman

14.582 International Economics II (A)

Prereq.: 14.06, 14.581
G (2)
3-0-9

Adjustment in international economic relations with attention to foreign exchange markets, balances of payments, and the international monetary system.
E. Helpman, P. R. Krugman

Labor Economics and Industrial Relations

14.63 Labor in Industrial Society

Prereq.: —
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; emphasizing 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.
H. C. Katz

14.64 Labor Economics and Public Policy

Prereq.: 14.01
U (1)
3-0-6

Labor market theory, discussion of important labor market institutions, and exploration of empirical evidence pertaining to labor market functions. Particularly emphasizes understanding the effects of unions and public policy on wages and working conditions. Permission of instructor required for students without 14.01 background.
K. G. Abraham

14.671J Labor Economics (A)

(Same subject as 15.671J)
Prereq.: 14.64 or 15.663
G (1)
3-0-6

Emphasizes structure of labor markets and determinants of wage levels, unemployment, the distribution of income and employment opportunity. Gives special attention 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
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. Also explores the broad economic and social questions raised by these trends.
K. G. Abraham

14.674J Comparative Systems of Industrial Relations and Human Resource Development (A)

(Same subject as 15.674J, STS 512J)
Prereq.: 14.64 or 15.663
G (1)
3-0-6

See description under subject 15.674J.
M. J. Piore

14.691J Research Seminar in Industrial Relations (A)

(Same subject as 15.691J)
Prereq.: 14.671J or 14.672J
G (1)
3-0-6

14.692J Research Seminar in Industrial Relations (A)

(Same subject as 15.692J)
Prereq.: 14.691J
G (2)
3-0-6

See description under subject 15.691J, 15.692J.
Staff

Economic History

14.71 Topics in Economic History

Prereq.: 14.02
U (2) HUM-D
3-0-6

Applies economic analysis to historical problems. Topics vary from year to year. In the past they included "The Drive to the Indies," "The Economic Effects of the Black Death," "The Economic Causes of Slavery and Serfdom," "Agrarian Relations," "Money," and others. Limited to 20. Some knowledge of history desirable.
E. D. Domar

14.731 American Economic History (A)

Prereq.: 14.04, 14.06
G (1)
3-0-9

Surveys the beginnings of American industrialization, emphasizing a quantitative approach and the 19th century. Topics: 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
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 emphasizes land and peasant problems and industrialization methods.
E. D. Domar

14.733 European Economic History: Monetary and Financial Aspects (A)

Prereq.: 14.121
G (2) **Next offered 1984-85**
3-0-9

Surveys the development of money, banking, central banking, government and private finance, including capital markets, in Western Europe from 1600, emphasizing comparative institutional changes in national systems and the development of European-wide institutions.
C. P. Kindleberger

14.734 Problems in Economic History (A)

Prereq.: 14.731, 14.732 or 14.733
G (2) **Next offered 1984-85**
3-0-9

Analyzes problems of industrial society, focusing 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 late 19th century, contrast in international relations before and after 1914, depression of the 1930s.
P. Temin

Economic Development

14.74 Economic Growth and Development

Prereq.: 14.02
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. Considers policy measures to promote economic development and growth.
M. L. Weitzman

14.771 Problems of Economic Development (A)

Prereq.: 14.121, 14.451
G (1)
3-0-9

Analyzes 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
G (2)
3-0-9

Analyzes problems in international trade and development; studies 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
G (2)
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: 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
G (2) **Next offered 1984-85**
3-0-9

For non-economics majors on survey and analysis of problems of developing countries. 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.
R. S. Eckaus

14.780 Alternative Approaches to Macroeconomic Theory: Distribution, Growth, and Price Formation (A)

Prereq.: 14.04, 14.06
G (2)
3-0-9

Reviews neoclassical and non-neoclassical (Marxian, Cambridge-style, and other) rules describing growth and distribution models. Recent topics in Marxian debate: joint production and measurement of surplus, unequal exchange, falling rate of profit. Cambridge models: price formation, reswitching, growth. Structuralist models: underdevelopment, monetary issues.
L. J. Taylor

14.781J Political Economy I: Theories of the State and the Economy (A)

(Same subject as 17.156J)
Prereq.: Permission of Instructor
G (1)
3-0-9

See description under subject 17.156J.
M. J. Piore, S. Berger

14.782 Capitalism, Socialism, and Growth (A)

Prereq.: 14.121, 14.451
G (2) **Next offered 1984-85**
3-0-9

Comparative study of capitalism and socialism, including market socialism, workers' management (in Yugoslavia), Marxism and centrally-planned economies, emphasizing 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.
E. D. Domar

14.783 Theory of Central Planning (A)

Prereq.: 14.124
G (2) **Next offered 1984-85**
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.
M. L. Weitzman

15 Management

Managerial Economics

15.UR Undergraduate Research

Prereq.: —
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.
J. B. Orlin

15.001 Managerial Economics

Prereq.: —
U (1, 2)
4-0-8

Introduces micro and macroeconomics emphasizing 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. Introduces fiscal and monetary policy. Analyses of economic problems of relevance to management.
J. J. Rotemberg

15.012 Applied Micro and Macroeconomics

Prereq.: 14.02 or 15.001
G (1)
4-0-8

Intermediate level subject in micro and macroeconomics, emphasizing 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, T. M. Stoker

15.013 Industrial Economics

Prereq.: 15.012
G (1, 2)
3-0-6

Analyzes the structure of industry centering on concentration of sales, control of entry by economies of scale or artificial barriers. 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. Conclusions formulated on the efficiency criteria used to evaluate industries and the performance of government in controlling these industries.
R. L. Schmalensee, T. M. Stoker, E. R. Berndt

15.014 Macroeconomic Problems and Policies

Prereq.: 15.012
G (2)
3-0-6

Intermediate level subject in macroeconomics emphasizing design and analysis of policy. Studies specific aspects of macroeconomic structure in some detail including the role of expectations and of labor contracts, and the role of the government in determining aggregate consumption and investment.
J. J. Rotemberg

15.016 Public Sector Economics and Finance

Prereq.: 15.012
G (2)
3-0-6

Applies 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. Analyzes government expenditures, taxes, and transfers; problems of market failure; and role of government enterprises. Emphasizes 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.: 15.012
G (1)
3-0-6

Considers rationale, origin, and effects of the major forms of government regulation of firms and markets. Uses experience in the US 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
G (1, 2)
3-0-6

International trade and finance for students of management. Pure and applied theory of trade and commercial policy. Monetary system, foreign exchange markets and balance of payments. Macroeconomic policy in open economies. International investment and the multinational firm.
J. J. Rotemberg, P. R. Krugman

15.019 Energy Economics and Policy

Prereq.: 15.012
G (1)
3-0-6

Surveys recent work in energy economics and management, paying particular attention to US energy situation. Develops analytical methods and stresses use of research tools and results in public and private sector decision making. 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.
H. D. Jacoby, D. O. Wood

15.024 Economics and Finance: Principles and Policies

Prereq.: —
G (S)
4-0-9

Introduces 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 Case Studies in Strategic Economic Analysis (A)

Prereq.: 15.012; 15.013 or 15.014 or 15.016
G (1)
3-0-6

Analyzes public and corporate policy problems emphasizing approaching and solving complex problems. Students work through several 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.
R. S. Pindyck, S. N. Finkelstein

15.034 Applied Econometrics and Forecasting for Management (A)

Prereq.: 15.061
G (1, 2)
3-0-6

Designed for students interested in applied econometric methods and business forecasting. Emphasizes problems typically encountered in conducting empirical econometric research, in evaluating results and testing hypotheses, and in constructing forecasts. Requires term paper. Problem sets involve working with econometric models and the computer.
E. R. Berndt, E. Kuh

15.041 Research Seminar in Applied Economics

Prereq.: Permission of Instructor
G (1, 2)
2-0-4

Discusses current research problems in applied economics. Topics vary from term to term. Designed primarily for doctoral students.
T. A. Stoker, R. L. Schmalensee

Operations Research/Statistics

15.053 Introduction to Management Science

Prereq.: 18.02, *18.700*
U (1, 2) SD
4-0-8

15.058 Applied Mathematical Programming

Prereq.: 18.02, *18.700*
G (1, 2)
4-0-8

Introduces management science emphasizing basic deterministic models and their optimization. Formulates and solves linear optimization models for management applications. Simplex method, duality theory, sensitivity analysis. Introduces networks, dynamic programming, integer programming, and nonlinear programming. Solving problems by computer and interpreting the results. 15.058 is more advanced than 15.062 and substitutes for it.
J. F. Shapiro

15.061 Statistics for Management

Prereq.: 18.01
G (1, 2)
4-0-8

Introduces probability and statistical data analysis emphasizing applications in management. Topics: basic probability, sampling and data collection, exploratory data analysis, inference and diagnostics for linear regression models, statistical computing and simulation.
A. I Barnett, M. A. Wong

15.062 Decision Models for Management

Prereq.: 18.01
G (1, 2)
4-0-8

Introduces management science concepts as applied to managerial problem solving. Emphasizes identifying problems, formulating models, assessing assumptions and data requirements, and evaluating model-based recommendations. Topics: decision analysis, simulation, linear programming, and network flows.
J. B. Orlin

15.065 Decision Analysis (A)

Prereq.: Permission of Instructor
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

15.067 Competitive Decision Making (A) (New)

Prereq.: Permisison of Instructor
G (1, 2)
4-0-5

Problems of decision making in competitive and conflict situations, when behavior of competitors or adversaries affects decisions. Basic theoretical results in relevant fields. Participation in out-of-class negotiation exercises simulating real competitive business situations provides experience in making rapid but calculated decisions in situations characterized by high degree of uncertainty and sophisticated competitors.
G. M. Kaufman

15.071 Management Decision Support Models

Prereq.: —
G (S)
3-0-6

Model-based approach to modern managerial analysis. Introduces various techniques that support managerial decision making, including decision analysis, simulation, statistics, and linear programming. Emphasizes 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
G (1, 2)
4-0-8

See description under subject 18.445J.
S. Ellis, Staff

15.074 Mathematical Models and Policy Analysis (A) (New)

Prereq.: 15.061 or 15.075
G (2)
3-0-6

Case-study method exploring strengths and weaknesses of mathematical models, especially those related to data analysis, that affect decision making of legislatures, corporations, courts, and regulatory agencies. Topics: carcinogenic hazards of various substances, deterrent effect of criminal sanctions, statistical evidence in job-discrimination proceedings, effective operation of mass-transit systems.
A. I. Barnett

15.075 Applied Statistics (A)

Prereq.: 18.440 or 6.431
G (1, 2)
3-0-6

Introduces 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, M. A. Wong

15.076J Statistics for Model Building (A)

(Same subject as 18.457J)
Prereq.: 15.075 or 18.443 and 18.700
G (2)
3-0-9

Linear and nonlinear regression analysis emphasizing detection and correction of model failures and variable selection. Robust methods, bootstrap, jackknife, and cross-validation. Data transformation, graphics, and non-parametric multiple regression. Topics illustrated on actual case material. Heavy use of statistical computer packages.
R. E. Welsch

15.078J Logistical and Transportation Planning Methods (A)

(Same subject as 1.203J, 6.281J, 11.526J, 13.665J, 16.76J, TPP 43J)
Prereq.: 6.431, 15.075
G (1)
3-0-9

See description under subject 1.203J.
A. I. Barnett, R. C. Larson, A. R. Odoni, H. N. Psaraftis

15.079 Workshop in Applied Statistics

Prereq.: Permission of Instructor
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
G (1, 2)
3-0-9

See description under subject 6.251J.
J. B. Orlin, R. G. Gallager

15.082 Network Optimization (A)

Prereq.: 15.081J
G (2)
3-0-9

Network models for industrial logistics systems, transportation systems, communication systems, and other applications. Emphasizes 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
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*
G (2)
3-0-9

See description under subject 6.252J.
J. F. Shapiro, S. K. Mitter

15.085 Topics in Optimization (A)

Prereq.: Permission of Instructor
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

Prereq.: Permission of Instructor
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.
J. B. Orlin

Health Management

15.121 Seminar in Health Management (A)

Prereq.: Permission of Instructor
G (1)
3-0-6

15.122 Seminar in Health Management (A)

Prereq.: Permission of Instructor
G (2)
3-0-6

Studies 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

15.136 Health Technology (A)

Prereq.: Permission of Instructor
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. Examines factors influencing commercial development of new health technology.
S. N. Finkelstein

15.141J Comparative Health Systems (A)

(Same subject as 17.228J)
Prereq.: Permission of Instructor
G (1)
3-0-6

See description under subject 17.228J.
S. N. Finkelstein, H. M. Sapolsky

15.144 Analytical Methods for Health Policy and Management (A)

Prereq.: Permission of Instructor
G (2)
3-0-6

Applies analytical methods to health policy and management problems. Considers incidence, prevalence, cost, and other characteristics of disease and ill health having significant management or public policy implications. Reviews 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
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

International Business

15.215 International Dimensions of Management

Prereq.: —
G (2)
3-0-6

Theory and practice of international business emphasizing strategy selection in response to the changing international environment. Role of public policies in global competition and their interaction with corporate strategies. Restricted to Sloan Fellows.
D. R. Lessard

15.221 International Business Management I (A)

Prereq.: Permission of Instructor
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. Covers institutional restraints in the legal, informational, financial, and commercial areas. Term project: an analysis of a foreign market for a specified product and firm.
D. R. Lessard

15.222 International Business Management II (A)

Prereq.: 15.221
G (2)
3-0-6

A policy-oriented working seminar open only to students who have command of material covered in 15.221. Discusses environmental analysis and decision making within the international firm and its organizational evolution, plus focus on two or three major strategic corporate issues and their public policy implications. Term project: a simulated role-playing exercise in which students redesign the control system of a corporation facing increasing internationalization of its market.
R. D. Robinson

15.223 International Business Environments (A)

Prereq.: Permission of Instructor
G (1)
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. Term project: in-depth analysis of the investment environment of a given country for a firm.
D. E. Westney

15.224 Intercultural Communication I (A)

Prereq.: 15.221
G (2)
3-0-6

15.225 Intercultural Communication II (A)

Prereq.: 15.224
G (1)
3-0-6

In-depth exposure with which student has had no significant prior contact. Develops working oral proficiency in major language of target area; completion of background reading under faculty supervision; three months of investigation within target area; working paper reporting on experience abroad. Language training expenses (if MIT facilities inadequate) and those of residence and travel abroad are student's liability. Overseas exposure normally in summer between student's first and second years.
D. E. Westney

15.227 International Technology Transfer (A)

Prereq.: Permission of Instructor
G (1)
3-0-6

For students seeking careers in international industrial development, within public developmental institutions or international corporations. Focus on selection of technologies within context of diverse national policies and international agreements. Examines transfer mechanisms and the impact of financial, legal, organizational, and sociocultural factors on technology marketing and choice.
D. Leonard-Barton, K. N. Rao

History and Environment

15.268 Readings in Power and Responsibility (A)

Prereq.: Permission of Instructor
G (2)
3-0-6

Studies managerial power and responsibility in relation to today's world. Examines 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. Restricted to Sloan Fellows.
W. F. Bottiglia

Organization Studies

15.301 Managerial Psychology Laboratory

Prereq.: —
U (1, 2) LAB
2-6-4

Core subject for students majoring in management. Surveys 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. Emphasizes use of behavioral science research methods to test hypotheses concerning organizational behavior.
T. J. Allen

15.304 Complex Organizations

Prereq.: 15.301
U (2)
3-0-6

Introductory examination of various perspectives by which complex organizations may be viewed. Emphasizes 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.
Staff

15.306 Behavioral Science Research Methods

Prereq.: *15.304,* 18.05
U (1)
3-0-9

Introduces methods of behavioral science research. General strategy of behavioral research (quantitative vs qualitative analysis, hypothesis formulation); research design (purposes, variance control, control of extraneous variables, use of control groups, randomized designs, factorial designs). Specific technologies of various designs (questionnaire construction, sampling, interviews, systematic observation). Organization and development of research project.
E. H. Schein

15.307 Behavioral Science Research Practicum

Prereq.: 15.306
U (2)
2-8-8

Develops and completes research project planned in 15.306 during previous term. Interprets and applies research findings in management environment. Experiments 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.
E. H. Schein

15.311 Individuals, Groups, and Organizations

Prereq.: —
G (1)
3-0-6

Examines interpersonal and human side of both public and private enterprise. Emphasizes 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.
Staff

15.312 Managerial Leadership, Motivation, and the Nature of Work (A)

Prereq.: 15.311
G (1)
3-0-6

Examines effective managerial behaviors within organizations. Topics: conflict management, decision making, performance analysis and appraisal, time management, work design, and supervisory-subordinate relationships. Analyzes different theories of leadership and motivation; utilization and discussion of self-assessment and training programs in managerial skills.
Staff

15.313 Interpersonal Dynamics and the Management of Groups (A)

Prereq.: 15.311
G (2)
3-0-6

Examines 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
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
G (2)
3-0-6

Examination of management of organizations in various parts of the world. Determines which management styles are most appropriate in different countries and whether any general principles of management are valid internationally. 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.
D. E. Westney

15.321 Theories of Planned Change (A)

Prereq.: 15.311
G (2)
3-0-6

Examines major theories and conceptual literature on planned change of individuals, groups, and organizations. Studies current strategies employed in systematic change enabling students to increase their ability to apply these theories in organizational setting as a manager or as a consultant. Subject developed around several important, tested perspectives of theories of change. Enrollment limited; admission only by permission of instructor.
E. C. Nevis

15.322 Organizational Psychology (A)

Prereq.: Permission of Instructor
G (1)
3-0-6

Analyzes — through lectures, discussions, and class exercises — management of human resources in industry. Restricted to Sloan Fellows.
E. H. Schein

15.334 Managing Planned Change I (A)

Prereq.: Permission of Instructor
G (1)
3-0-6

Examines approaches to planning and managing change in complex organizations. Emphasizes 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
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. Emphasizes 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
G (2) **Not offered 1984-85**
3-0-6

Reviews 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.
Staff

15.339 Social Psychology of Work and Organizations (A)

Prereq.: Permission of Instructor
G (2) **Next offered 1984-85**
3-0-6

Reviews 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.
L. Bailyn

15.341 Seminar in Behavioral Sciences

Prereq.: —
G (1)
3-0-6

Develops basic concepts for understanding individual, group, and organizational behavior through critical analysis of important works in the field. Areas covered: cognitive, affective, change, control, input, throughput, output, and structural processes. Emphasizes use of behavioral science concepts for stimulating new and useful management science research and the application of behavioral science results to typical management problems. Restricted to doctoral candidates in the Sloan School of Management.
Staff

15.345 Doctoral Seminar in Organization Studies I (A)

Prereq.: Permission of Instructor
G (1)
2-0-7

15.346 Doctoral Seminar in Organization Studies II (A)

Prereq.: 15.345
G (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
G (2)
4-0-8

Introduces 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
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
G (2)
2-0-7

Seminar dealing with the interaction of work and family in the pursuit of organizational careers. Discusses 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
G (1)
2-0-7

Presents and integrates 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.
D. Leonard-Barton

15.361 Managing Professionals

Prereq.: —
G (S)
3-0-6

Examines human side of management through application of behavioral science research findings. Topics: supervising/motivating professional employees; career orientations; effective conflict management; group creativity/decision making; managing product teams; group aging; critical roles for innovation; organizational structure/communication. Emphasizes professional individuals and groups. Primarily for members of the Joint Program in the Management of Technology. Others admitted by permission of instructor.
R. Katz

15.365J Manufacturing/Technology Interface (A)

(Same subject as 3.565J, 13.685J)
Prereq.: Permission of Instructor
G (2)
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. Primarily for members of the Joint Program in the Management of Technology. Others admitted by permission of instructor.
J. M. Utterback

15.367 Marketing/Technology Interface (A)

Prereq.: 15.361 or 15.351
G (2)
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, G. L. Urban

15.369 Corporate Strategies for Managing Research, Development, and Engineering (A)

Prereq.: 15.351 or 15.361
G (2)
2-0-7

Joint seminar with the Harvard Business School technology management group. Strategic issues in managing research, development, and engineering. Considers 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 The R&D Process: Communication and Problem Solving (A)

Prereq.: 15.311 or 15.361 or 15.351
G (1)
3-0-6

Introduces sociology of science and technology, emphasizing similarities and differences between the two activities. Basic problem-solving processes in R&D. Presents research findings on intra- and inter-organizational technology flows. Role of interpersonal, organizational, and architectural factors in affecting communication of technical information.
T. J. Allen

15.373 Managing the Diffusion of Technological Innovations (A)

Prereq.: 15.311 or 15.361
G (2)
2-0-7

Seminar on the introduction of new technology into organizations and public or private sector markets. Use of specific examples from the US and overseas in examining the social, cultural, and psychological forces which aid or impede the acceptance of these new tools, processes, or techniques.
D. Leonard-Barton

15.375 New Technical Ventures (A)

Prereq.: Permission of Instructor
G (2)
2-1-6

Develops detailed plan for launching a new technical venture by each student. Lectures provide information needed to succeed at this task. Topics: organization and management of ventures; patents and other means of new product protection; obtaining venture capital; research partnerships.
E. A. von Hippel

Finance

15.411 Financial Management (A)

Prereq.: 15.511, 15.024, 15.071
G (1)
3-0-6

Surveys 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. 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 15.012
G (1, 2)
4-0-8

Surveys and analyzes financial problems facing managers, including theoretical introduction to financial institutions, financial instruments, and capital markets. Topics: functions and operations of capital markets; theory of efficient markets; portfolio and valuation theory; capital budgeting and investment decision making; firm's cost of capital; long-term financing instruments and financing decisions; dividend policy and capital structure. Primarily for students not concentrating in finance.
S. C. Myers

15.413 Topics in Corporate Financial Management (A)

Prereq.: 15.411 or 15.412
G (1, 2)
3-0-6

Extends and applies topics and concepts covered in 15.412. Covers financial planning, leasing and project financing, mergers, pensions, and new approaches to corporate investment and financing decisions.
T. A. Marsh

15.415 Finance Theory (A)

Prereq.: 15.012
G (1, 2)
6-0-9

Core theory of capital markets and corporate finance. Topics: functions and operations of capital markets; analysis of consumption-investment decisions of investors; diversification and portfolio selection; valuation theory and equilibrium pricing of risky assets; theory of efficient markets; and investment and financing decisions of firms. Theoretical foundation for further study and practical applications. Required for students concentrating in finance.
R. C. Merton, R. S. Ruback

15.418 Taxation and Business Management (A)

Prereq.: 15.412 or 15.415
G (1)
3-0-6

Analyzes effect of taxation on conduct of business. Concentrates on major decisions in which taxes impinge on the firm or its managers; concern with both theory and relevant empirical evidence. 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.: 15.018, 15.411 or 15.412
G (2)
3-0-6

Analyzes international financial decisions of corporations and financial institutions, emphasizing specific management problems including foreign exchange transactions, measurement and control of foreign exposure, working capital management, tax management, control, capital budgeting, financing, 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 Management of Financial Intermediaries (A) (Revised Content)

Prereq.: 15.415
G (2)
3-0-6

Management of banks, insurance companies, and other financial intermediaries. Asset and liability management. Cash management and the money market.
R. S. Ruback

15.432 Capital Markets and Financial Institutions (A)

Prereq.: 15.415
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 Security Prices (A)

Prereq.: 15.415
G (2)
3-0-6

Studies behavior of security prices and returns. Empirical work on efficient markets hypothesis and capital asset pricing models. Applications to portfolio management and corporate finance. Requires empirical term project.
T. A. Marsh

15.434 Capital Investment Decisions (A) (Revised Content)

Prereq.: 15.415
G (1, 2)
3-0-6

Theory and practice of capital investment decisions. Approaches to estimating risk and adjusting for it. Applications of option pricing and new approaches to valuation. Forecasting, mergers, OR and planning models, public investment decisions.
R. S. Ruback

15.435 Corporate Financing Decisions (A)

Prereq.: 15.415
G (2)
3-0-6

Theory and practice of corporate financing decisions. Empirical work on debt and dividend policy; agency cost and signaling models; issue procedures and investment banking; leasing, project financing, convertible securities.
S. C. Myers

15.436 International Managerial Finance (A)

Prereq.: 15.018, 15.415
G (1)
3-0-6

Applies financial and economic theory to international decisions of corporations and financial institutions. Identifies and analyzes factors which distinguish international from domestic setting. Modeling of specific applications including foreign exchange transactions, exposure and working capital management, tax management, capital budgeting and financial structure decisions. Primarily for students concentrating in finance. Credit not given for both 15.419 and 15.436.
D. R. Lessard

15.437 Options and Futures Markets (A) (New)

Prereq.: 15.415
G (2)
3-0-6

Develops option pricing theory. Applies theory to valuation of put and call options, loan guarantees, and corporate liabilities. Empirical tests of the models and investment strategies. Futures markets emphasizing financial futures and their uses.
R. S. Ruback

15.439 Problems in Finance (A)

Prereq.: 15.415
G (1, 2)
3-0-6

Applies the theory of finance to specific financial markets and institutions. Emphasizes investment counseling, underwriting, investment companies, options markets, banks, and international financial markets.
F. Black

15.440 Advanced Topics in Financial Economics (A)

Prereq.: 15.439
G (2)
3-0-6

Discusses in greater depth topics treated in Problems in Finance, and other active research topics. Includes: applications of the capital asset pricing model, the option pricing model, and the theory of efficient markets; puzzles in corporate finance; equilibrium in real asset and labor markets; unregulated banking; and equilibrium in international markets. Problems in Finance may be taken concurrently.
F. Black

15.441 Research Seminar in Finance (A)

Prereq.: 15.415
G (1, 2)
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

Accounting and Control

15.501 Financial and Cost Accounting

Prereq.: —
U (2)
3-0-6

Introduces basic concepts and techniques of collecting, processing and reporting financial information generated by a business. Emphasizes basic financial and cost accounting concepts, and methods of financial analysis. Examines financial goal structures and decision-making processes which give rise to information needs. Oriented toward providing information to parties external to a business.
R. T. S. Ramakrishnan

15.511 Financial and Management Accounting Systems

Prereq.: —
G (S)
3-0-6

Studies 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). Emphasizes use of accounting information in decision making, performance evaluation, and control in organizations. Restricted to Sloan Fellows.
Staff

15.515 Financial and Cost Accounting

Prereq.: —
G (1)
3-0-6

Introduces basic concepts and techniques of collecting, processing and reporting financial information generated by a business. Examines financial goal structures and decision-making processes which give rise to information needs. Introduces methods of financial analyses, with goal of enabling students to understand, and use, corporate financial statements. Oriented toward providing information to parties external to a business. Restricted to Sloan School of Management graduate students. Others admitted only by permission of instructor.
R. T. S. Ramakrishnan, H. D. Sherman

15.516 Financial and Management Accounting (A except XV)

Prereq.: Permission of Instructor
G (1)
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, R. T. S. Ramakrishnan

15.521 Management Accounting and Control (A)

Prereq.: 15.501 or 15.511 or 15.515 or 15.516
G (1, 2)
3-0-6

Examines 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. Develops framework for assessing behavioral dimensions of control system design; impact of different managerial styles on motivation and performance in an organization.
J. S. Hekimian, H. D. Sherman

15.522 Planning and Control in Nonprofit Organizations (A)

Prereq.: 15.501 or 15.511 or 15.515
G (2)
3-0-6

Principles of planning and control systems used in managing organizations not having a profit orientation. Emphasizes medical, educational, and cultural organizations and ties 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. 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
G (2)
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.).
R. T. S. Ramakrishnan

15.532 Planning and Control Systems (A)

Prereq.: 15.521
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. 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.
J. M. McInnes

15.535 Planning and Control Systems (A)

Prereq.: 15.511
G (1)
3-0-6

Designs 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. Designs responsibility accounting systems in relation to strategy; coordination of responsibility centers and issues off transfer pricing. Management of the resource allocation process under conditions of uncertainty and risk. Restricted to Sloan Fellows.
A. C. Hax

15.549 Workshop in Accounting and Control

Prereq.: Permission of Instructor
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. Selects specific topics geared to interests of participants. Primarily for doctoral students.
J. M. McInnes

Management Information Systems

15.561 Introduction to Computers, Programming, and Information Systems

Prereq.: —
G (1, 2)
0-6-0

Introductory concepts in computer hardware, software, and management information systems. Familiarization with and use of computer resources and software available at MIT which may be useful in subsequent subjects, research, or thesis work. Limited enrollment.
J. A. Meldman, M. E. Treacy

15.562 Principles of Management Information Systems (A)

Prereq.: 1.00 or 15.561
G (1, 2)
3-0-6

Introductory examination of issues related to effective use of computer-based information systems in organizations. Topics: technology (computer sysems and databases); frameworks for analyzing need for information systems; designing and implementing systems for effective use; management of the information system life cycle. Represents a condensation of 15.564, 15.565, and 15.568; credit not given for both 15.562 and 15.568. Limited enrollment.
J. A. Meldman, M. E. Treacy

15.564 Management Information Technology I (A) (Revised Unit)

Prereq.: 2.10 or 15.561
G (1, 2)
4-0-8

Introduces basic principles of computer systems and computer systems programming. Emphasizes 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. Requires students to prepare and test several programs written in System/370 Assembly Language and PL/I.
S. E. Madnick, J. J. Donovan

15.565 Management Information Technology II (A)

Prereq.: 15.564
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. Develops student's understanding of computer technology to enable its use in new and creative ways in an organization. Discusses examples of the implementation and use of actual management information systems.
J. J. Donovan, S. E. Madnick

15.568 Management Information Systems (A)

Prereq.: 15.564, *15.565*
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. Discusses major transaction processing systems of the firm as well as those systems used primarily for managerial information. Emphasizes managerial point of view and organizational issues involved in managing a firm's information resources. Credit not given for both 15.562 and 15.568.
J. F. Rockart

15.569 Decision Support Systems (A)

Prereq.: 15.562 or 15.568
G (1, 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.
M. S. Scott Morton

15.571 Advanced Computer Systems (A)

Prereq.: 15.564
G (2)
3-0-6

Operating systems and their interface to various levels of hardware and software. System architecture, new technologies, and operating systems services (storage, processors, data management, and I/O supervision). Other topics: virtual machines, multiprocessor systems, performance measurement, data security. Discusses microsystems and personal and traditional mainframe systems. Assumes knowledge of Assembler Language programming. Requires class participation and readings.
R. A. MacKinnon

15.572 Systems Simulation (A)

Prereq.: 15.061, 15.561
G (2)
3-0-6

Introduces discrete simulation and model building methodology using high-speed digital computers. Focus on event-oriented as opposed to continuous systems. Emphasizes simulation language and model building. Considers 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
G (2)
3-0-6

Examines interlocking technological and legal issues that arise in the operation of computer-based information systems in society. Emphasizes, in class discussions and in term projects, 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 data-banks, computer infringement of copyright, protection of proprietary rights in software, jurimetrics.
J. A. Meldman

15.599 Workshop in Management Information Systems

Prereq.: Permission of Instructor
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. Determines specific topics by the interest of participants and by new and important directions in information system. Background readings and active participation by students expected. Primarily for Doctoral students.
S. E. Madnick, M. E. Treacy

Law

15.612 Business and the Law

Prereq.: —
G (2)
3-0-6

Emphasizes current legal problems of concern to the business executive. Analyzes torts, contracts, product liability, antitrust aspects of marketing, and cases pending before the Supreme Court. Attention to the impact on managers of actions by administrative agencies such as NLRB, FTC, and EPA; the procedural requirements that govern their rule making; and the role of courts in resolving disputes between government and business.
G. F. Bloom

15.616 The American Legal System (A)

Prereq.: 14.01 or 15.012
G (1)
3-0-6

General introduction to law and the American legal system. Analyzes components and operation of the legal process in the context of specific legal problems. Topics: torts, contracts, criminal and constitutional law, trial procedure and evidence, and administrative law. Consideration of the scope of the judicial process and the relationships between state and Federal law. Examines judicial reasoning and the development of legal doctrine. Extensive reading of case law together with textual materials and legal essays. Research projects involving use of a law library.
J. A. Meldman

15.625 Labor Law (A)

Prereq.: 15.616
G (2)
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.
D. E. Wanger

15.631 Corporate Law for the Modern Manager (A)

Prereq.: Permission of Instructor
G (1)
3-0-6

Examines legal and ethical obligations that arise between the individual (employee, manager, officer, director), the corporation, and the world. 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.
J. F. Vittek, Jr.

15.632 Government Regulation of Business (A)

Prereq.: Permission of Instructor
G (2)
3-0-6

Government regulation of business emphasizing the legal framework. Topics: limits of due process; role of courts and agencies in solving problems of scientific uncertainty; efforts to reform administrative decision making by requiring cost-benefit analysis; costs of government regulation. Cases examine actions of agencies such as EPA, NLRB, FTC, and OSHA. Encourages students to make in-depth study of agency or regulation of their choice.
J. D. Nyhart, G. F. Bloom

15.635 International Law and Regulatory Order (A)

Prereq.: Permission of Instructor
G (2)
3-0-6

Jurisdiction, sources, and nature of international law. Issues basic to private sector managers including international economic law, extension of US domestic regulatory policies beyond US territory, and the problems of obtaining consistency among nations' regulation of transborder business. Emergence of international regulation of transportation, communications, trade, ocean use, finance, food and health standards, and multinational corporations.
J. D. Nyhart

15.640 Seminar on Government-Business Relations (A) (New)

Prereq.: Permission of Instructor
G (1)
3-0-6

Emphasizes process through which law is made at congressional, executive, and administrative agency levels and definition of key points at which business executives can shape legislation and policy. Discusses ways to resolve conflicts between government and business supplemented by guest speakers from both sectors. Requires term paper. Restricted to Sloan Fellows.
J. D. Nyhart, G. F. Bloom

Industrial Relations and Human Resource Management

15.662 Industrial Relations and Human Resource Management (A)

Prereq.: 15.511
G (1)
3-0-6

15.663 Industrial Relations and Human Resource Management

Prereq.: —
G (1, 2)
3-0-6

Introduces industrial relations and human resource management at level of the firm. Explores role of firm in its larger industrial relations systems. Examines effects of the environment on human resource management strategies. Assesses strategies against their effects on the firm, its employees, labor organizations, and public policies. Uses collective bargaining game to demonstrate dynamics of negotiations and conflict resolution. 15.662 restricted to Sloan Fellows.
15.662: *R. B. McKersie*
15.663: *T. A. Barocci, H. C. Katz, T. A. Kochan, P. A. Wallace*

15.664 Management of Human Resources (A)

Prereq.: 15.663
G (2)
2-0-7

Seminar emphasizing 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.
K. G. Abraham

15.671J Labor Economics (A)

(Same subject as 14.671J)
Prereq.: 14.64 or 15.663
G (1)
3-0-6

See description under subject 14.671J.
M. J. Piore

15.672J Public Policy on Employment and Industrial Relations (A)

(Same subject as 14.672J)
Prereq.: 14.64 or 15.663
G (2)
3-0-6

See description under subject 14.672J.
K. G. Abraham

15.674J Comparative Systems of Industrial Relations and Human Resource Development (A)

(Same subject as 14.674J, STS 512J)
Prereq.: 14.64 or 15.663
G (1)
3-0-6

International and comparative analysis of industrial relations systems and systems of human resource development. Concentrates 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

15.675 Equal Employment Opportunity and Management of Human Resources (A)

Prereq.: 14.64 or 15.663
G (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. Examines recent literature, including court decisions.
P. A. Wallace

15.676 Industrial Relations Theory and Research Seminar (A)

Prereq.: Permission of Instructor
G (2)
2-0-7

Historical evolution and assessment of research in industrial relations. Introduces doctoral students to the field and explores where their research interests fit within the broader field. First part compares the normative assumptions, theories, and methodologies used by economists, historians, sociologists, psychologists, and legal scholars from the latter 19th century to the present. Final portion explores strategies for advancing research on topics of current interest to participants.
T. A. Kochan

15.691J Research Seminar in Industrial Relations (A)

(Same subject as 14.691J)
Prereq.: 15.671J or 15.672J
G (1)
3-0-6

15.692J Research Seminar in Industrial Relations (A)

(Same subject as 14.692J)
Prereq.: 15.691J)
G (2)
3-0-6

Discusses 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

Operations Management

15.761 Operations Management (A)

Prereq.: 15.053 or 15.062, 15.061 or 6.041
G (1, 2)
3-0-6

Studies 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, capacity planning decisions, inventory control, production scheduling, and network-based management systems. Emphasizes integrated approach to management decision making. Applications from public and private sectors.
G. R. Bitran, H. C. Meal, S. C. Graves, C. H. Fine

15.763 The Practice of Operations Management (A)

Prereq.: 15.761
G (1)
3-0-6

Provides an opportunity to learn how to diagnose complex problems, structure relevant solutions to them, and deal with issues of implementing the solutions. Case analyses and projects in local manufacturing and service organizations extend understanding of and ability to deal with operating management situations. Emphasizes integrative approach using methodologies drawn from operations research, management information systems, and organization design.
S. C. Graves, H. C. Meal

15.764 The Theory of Operations Management (A)

Prereq.: 15.761
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
G (2)
3-0-6

Develops 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

15.767 Industrial Project Evaluation (A)

Prereq.: Permission of Instructor
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

15.768 Operations Management in the Service Industry (A)

Prereq.: Permission of Instructor
G (1)
3-0-6

Analyzes managerial problems in the service industry. Illustrates 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
G (1, 2)
3-0-6

Examines studies from current literature devoted to formal methods for analyzing operations management problems. Discusses case studies as time permits.
C. H. Fine

15.799 Workshop in Operations Management

Prereq.: Permission of Instructor
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

Marketing

15.811 Marketing (A)

Prereq.: 15.071, 15.511
G (1)
3-0-6

Analyzes elements of marketing strategy which can be utilized by business, governmental, and social organizations to meet needs of their clientele. Topics: product development, advertising, selling, and pricing. Reviews contributions of management science in providing new techniques for solution of marketing problems. Restricted to Sloan Fellows.
G. L. Urban

15.812 Marketing Management (A)

Prereq.: 15.061 or 6.041 or 14.30 or 18.05
G (1, 2)
3-0-6

Introduces concepts, challenges, and sampling of techniques necessary to manage the marketing function. Topics: marketing research, consumer behavior, new product development, advertising strategy, promotion, personal selling, distribution, and pricing. Lectures, guest speakers. Problem assignments or cases.
G. L. Urban, J. R. Hauser

15.824 Marketing Communications (A)

Prereq.: 15.812
G (1)
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. Lectures, case discussions, projects.
Staff

15.825 Marketing Models (A)

Prereq.: Permission of Instructor
G (1)
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, L. McAlister

15.826 Industrial Marketing (A)

Prereq.: 15.812
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. Emphasizes using models and research results to solve industrial marketing problems. Lectures, case discussions, research project.
Staff

15.828 New Product Development (A)

Prereq.: 15.812
G (2)
3-0-6

Identifies new market opportunities. Designs "core benefits" of a new product having high potential. Designs physical product and marketing mix to fulfill the "core benefits." Testing, launching, and managing the new product. Develops theory, measurement, and models to manage this process. Requires term project.
J. R. Hauser

15.832 Measurement for Management (A)

Prereq.: 15.061
G (2)
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. Develops questionnaires, scaling and psychometric methods for measuring perceptions, attitudes, and preferences. Statistical techniques for analyzing these types of data.
Staff

15.834 Marketing Strategy (A)

Prereq.: 15.812
G (1, 2)
3-0-6

Examines marketing aspects of strategy formulation. Studies market phenomena that are foundations of strategy. Analyzes management science models for brand, product line, strategic business unit, and corporate marketing strategy. Lectures, cases, guest speakers. Requires term project.
L. McAlister, G. L. Urban

15.838 Research Seminar in Marketing (A)

Prereq.: 15.812
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

Prereq.: Permission of Instructor
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.
Staff

System Dynamics

15.852 Principles of Dynamic Systems I

Prereq.: —
U (1, 2) SD
3-0-9

15.872 Principles of Dynamic Systems I (A)

Prereq.: Permission of Instructor
G (1, 2)
3-0-9

Introduces principles for modeling dynamic social and industrial systems. Emphasizes 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. Tutorial session arranged for 15.852.
J. D. Sterman

15.873 Principles of Dynamic Systems II (A)

Prereq.: 15.872
G (2)
3-0-9

Continues 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.
J. D. Sterman

15.874 System Dynamics for Business Policy (A)

Prereq.: Permission of Instructor
G (1)
3-0-9

Introduces modeling of corporate and industrial systems. Examines 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. Develops skills in portraying complex managerial systems, and deriving understanding through quantitative modeling and computer simulation.
J. D. W. Morecroft

15.875 Applications of System Dynamics (A)

Prereq.: 15.872 or 15.874
G (2)
3-0-6

Project-based subject applying methods of system 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

15.878 Economic Dynamics (A)

Prereq.: 15.872
G (1)
3-0-6

Introduces system dynamics modeling of economic systems focusing on simple generic structures identified in the System Dynamics National Project. Combines lectures, exercises, and a term project on subject of student's choice. Topics: economic cycles; inflation and unemployment; capital investment and monetary policy; energy-economy interaction; and the economic long wave.
J. D. Sterman, P. M. Senge

15.879 Seminar in System Dynamics Policy Analysis (A)

Prereq.: 15.872
G (1, 2)
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: problems in designing policies based on forecasts, problems with use of leading and lagging indicators on policy inputs, economic policy, energy policy.
P. M. Senge, J. D. Sterman

15.880 System Dynamics (A)

Prereq.: 15.071
G (1)
3-0-3

Introduces dynamic modeling of managerial policy issues in public and private organizations. Emphasizes building intuitive understanding of feedback structures underlying growth, stagnation, and cyclical fluctuation. Develops skills in causal-loop diagramming of complex situations, and in the techniques of quantitative modeling and computer simulation. Studies previous system dynamics applications in business and human delivery organizations. Restricted to Sloan Fellows.
E. B. Roberts

General Policy and Special

15.921 Business and Social Pressures (A)

Prereq.: Permission of Instructor
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
G (1)
2-0-4

Studies 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
G (1, 2)
3-0-6

Deals 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.
M. Horwitch, G. B. M. Walker, Jr., Z. S. Zannetos

15.933 Financial Strategy (A)

Prereq.: 15.412, 15.931
G (1)
3-0-6

Applies 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
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.
Z. S. Zannetos

15.935 Seminar on Corporate Strategy and Structure (A)

Prereq.: 15.931
G (2)
3-0-6

Uses 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. Combines 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

15.937J Economics of Ocean Transportation (A)

(Same subject as 13.661J)
Prereq.: 14.120 or 15.012 or CTS 110J
G (2)
3-0-6

See description under subject 13.661J.
Z. S. Zannetos, H. N. Psaraftis

15.939 Advanced Topics in Policy and Strategy (A)

Prereq.: 15.931
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.
M. Horwitch, G. B. M. Walker, Jr., Z. S. Zannetos

15.951 Special Studies in Management

Prereq.: —
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.: —
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.: —
G (1, 2)
Arr.

Opportunity for group study by graduate students on current topics related to management not otherwise included in curriculum.
Staff

15.977 Seminar in Management

Prereq.: —
G (1)
2-0-1

Investigates effective management through informal meetings with executives representing a range of industries and functions in both public and private sectors. Examines managerial philosophies, practical problems of management, personal career paths, enabling students to develop skill in asking questions.
P. B. Cronin

15.978 Seminar in Management (A)

Prereq.: 15.511
G (1)
3-0-6

Studies fundamental economic, financial, organizational, and administrative relationships analyzed and discussed by experienced leaders in business, labor, and public administration. Examines 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.: —
U (1, 2)
Arr.

Undergraduate research opportunities in Aeronautics and Astronautics. For further information contact Departmental Coordinator:
E. A. Witmer
Staff

16.001 Unified Engineering I

Prereq.: 8.01, *18.03*
U (1) SD
5-2-5

16.002 Unified Engineering II

Prereq.: 8.01, *18.03*
U (1)
5-2-5

16.001: Requires simultaneous registration with 16.002. 16.002: Presents principles and methods of engineering 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.
W. M. Hollister, J. W. Mar, M. Martinez-Sanchez, S. E. Widnall, H. Y. Wachman

16.003 Unified Engineering III

Prereq.: 16.001, 16.002
U (2)
5-2-5

16.004 Unified Engineering IV

Prereq.: 16.001, 16.002
U (2)
5-2-5

16.003: Requires simultaneous registration with 16.004. 16.004: Presents concepts, principles, and methods of engineering, emphasizing unified presentation of disciplines, 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.
A. L. Elias, W. M. Hollister, A. R. Odoni, M. Martinez-Sanchez, H. Y. Wachman, S. E. Widnall, E. A. Witmer

16.005 Introduction to Aerospace Engineering

Prereq.: —
U (2)
2-2-5

Presents broad view of steps involved in developing aerospace systems from preliminary design to production. Drafting techniques, weight estimation, aerodynamic analysis, control, structural design, cost estimating, manufacturing processes, certification, and service engineering discussed in the context of an aerospace vehicle which each student designs. Recommended for freshmen.
R. H. Miller, J. W. Mar

16.008 Computer Models of Engineering Systems

Prereq.: 18.02, 8.01
U (1) SD
3-0-9

School-Wide Elective Subject. Description given at end of this chapter on SWE page.
B. Schumacker

16.02 Aerodynamics

Prereq.: 16.004 or 2.20 or 1.05
U (1, 2)
4-0-8

Kinematics and dynamics of fluids in aerodynamic applications. Vorticity, circulation. Biot-Savart Law. Lift, thrust, momentum theorem. Thermodynamics in fluid flows. Boundary layers. Flows: channel and supersonic. Shock-expansion theory, characteristics. Ackeret wing theory. Distribution of singularities, method of images. Incompressible flow; classical hydrodynamics. Complex potentials, conformal mapping. Wings and bodies in subsonic flow. Kutta condition. Prandtl-Glauert theory. Transonic flows.
J. E. McCune

16.023 Introduction to Computational Fluid Dynamics (Revised Unit)

Prereq.: 16.02 or 16.06 or 2.21 or 18.354
U (2)
3-0-9

Introductory subject in modern finite difference techniques for inviscid and viscous flow field calculations. Fundamentals of consistency, stability, convergence, iteration methods, and truncation error effects introduced for elliptic, hyperbolic, and parabolic partial differential equations. Stresses applications of the methods to fluid flow problems through computational problem sets. Requires knowledge of FORTRAN.
E. M. Murman, W. T. Thompkins, Jr.

16.025 Numerical Fluid Dynamics (A)

Prereq.: 16.02 or 16.06, *18.075*
G (1)
3-0-9

Solution of flow field partial differential equations by discrete approximation methods (finite difference, finite volume, panel). Physical concepts and equations for subsonic, transonic, supersonic viscous and inviscid flows. Numerical modeling topics include errors and accuracy, stability, convergence, linear algebra, discontinuities (shocks), iterative solutions. Applications to airfoils, channels. Computer assignments.
J. R. Baron, E. M. Murman

16.026 Advanced Computational Fluid Dynamics (A)

Prereq.: 16.025
G (2)
3-0-9

Computational methods for compressible inviscid and viscous flow. Treats Potential, Euler, and Navier-Stokes equations in general nonorthogonal, curvilinear coordinates using finite-difference methods. Covers coordinate system generation and time-splitting techniques in detail, introduces turbulence modeling and computer architecture considerations. Draws applications 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) (Revised Unit)

Prereq.: 16.026
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.
E. M. Murman, W. T. Thompkins, Jr.

16.03 Aerospace Heat and Mass Transfer (Revised Unit)

Prereq.: 16.004
U (2)
3-0-9

Introduces modes of heat transfer. Coupling and similarities between momentum, heat, and mass transfer. Identifies essential physical properties and dimensionless parameters. Explores practical aerospace applications 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.
M. Finston

16.035 Fluid Mechanics (A)

Prereq.: 16.02 or 16.06, 18.075
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 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

16.04 Fluid Dynamics of Flight and Reentry Vehicles (New)

Prereq.: 16.02 or 16.06
U (2)
4-0-8

Flow over vehicles. Boundary layers, separation, stall. Heat transfer in boundary layers and at stagnation points. Turbulence and transition. Reynolds analogy. Kinetic theory concepts. Free molecule flow over bodies. Surface scattering; particles radiation. Generalized boundary conditions. Hypersonic flight. Supersonic lift wave drag. Low AR wings. Transonic and subsonic flow. Low-speed, high-lift flight. Unsteady flow. Oscillating airfoils, flutter. Interference; wind tunnels; experiments.
J. E. McCune, L. Trilling, H. Y. Wachman

16.041 Aerodynamics of Viscous Fluids — Boundary Layer Approximation (A)

Prereq.: 16.035
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 emphasizing incompressible flows. Surveys experimental and theoretical methods for estimating quantities of interest in aeronautical applications. Introduces turbulent flows.
E. E. Covert

16.042 Viscous Boundary Layers — II (A)

Prereq.: 16.041
G (1)
3-0-9

Generalization of viscous phenomena to problems arising primarily in compressible flow for aerospace vehicles and propulsion systems. Includes laminar and turbulent boundary layers, heat transfer, transpiration cooling, stability and transition, viscous-inviscid interaction, mixing layers and base flows, real gas effects, ablation. Classical development of basic concepts, emphasizes modern numerical methods. Application in subsonic, transonic, supersonic, hypersonic regimes.
E. M. Murman, J. R. Baron

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
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. Discusses problems of current interest.
M. T. Landahl, E. L. Mollo-Christensen

16.051 Gas Dynamics (A)

Prereq.: 16.035
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. Draws examples from wing and body configurations and test facility requirements.
J. R. Baron

16.052 Real Gas Dynamics (A)

Prereq.: 16.035
G (1) **Next offered 1984-85**
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 very high speed and entry space vehicles, test facilities, and gas dynamic lasers. Alternate years.
J. R. Baron

16.055 Unsteady Fluid Mechanics (A)

Prereq.: 16.035
G (1) **Not offered 1984-85**
3-0-9

Fluid mechanics of fixed airfoils, wings, bodies, and cascades in unsteady potential flows, or moving airfoils, wings, bodies, and cascades in a uniform stream. Topics: pressure distribution and other characteristics in both frequency domain and time domain (indicial response) for incompressible and compressible flows. A limited discussion of viscous effects, boundary layers, and separations introduced where appropriate. Alternate years.
E. E. Covert

16.06 Space Gas Dynamics

Prereq.: 16.004 or 2.20 or 1.05
U (1)
4-0-8

Elements of gas dynamics relevant to propulsion of spacecraft and to forces and thermal loads on them, in particular one-dimensional dynamics and nozzle flows; waves; hypersonic flows; and elements of convective, conductive, and radiative heat transfer. Introduces molecular flows; kinetic theory of gases; the kinetics of gas-surface interaction; accommodation phenomena. Applications to performance of space vehicles.
L. Trilling, H. Y. Wachman

16.07 Aerodynamics of Wings and Bodies (A)

Prereq.: 16.035, 18.075
G (2) **Next offered 1984-85**
3-0-9

Presents theoretical methods for predicting aerodynamic loading on thin lifting surfaces and slender flight vehicles in subsonic and supersonic flow. Topics: potential aerodynamics, constant density flow, inner and outer solutions, and real gas effects.
W. L. Harris

16.081J Principles of Acoustics (A)

(Same subject as 2.060J, 13.81J)
Prereq.: 2.03J or 16.004, 18.075
G (1)
3-0-9

See description under subject 2.060J.
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
G (1) **Not offered 1984-85**
3-0-9

See description under subject 13.84J.
S. E. Widnall, P. Leehey

16.09 Nonlinear Wave Propagation (A)

Prereq.: 18.075, 16.035
G (2) **Not offered 1984-85**
3-0-9

Physical description and mathematical treatment of nonlinear effects occurring in wave propagation in fluid continua. Topics: water waves, nonlinear underwater acoustics, and gas dynamic shock waves.
W. L. Harris

16.10 Aircraft Performance, Stability, and Control (New)

Prereq.: 6.004, *16.30*
G (1)
3-0-6

Studies applied aerodynamics for estimating lift and drag forces and moments. Propulsion system characteristics. Performance estimation: takeoff, climb, turn, range, and speed. Basic control requirements in roll, yaw and pitch, and control surface aerodynamics. Aircraft static stability for longitudinal and lateral cases. Introduces dynamic stability. Uses interactive computer-aided engineering for preliminary design of aircraft.
R. H. Miller, R. S. Simpson, A. L. Elias

16.16 Introduction to Flight Vehicle Dynamics

Prereq.: 16.004 or 1.05; or 2.20, 18.03
U (1) **Next offered 1984-85**
3-0-9

Theory of flight; airfoils, lift, drag, and applied aerodynamics. Root locus, and similar control techniques. Airplane performance, engine characteristics. Introduces stability and control of airplanes. Equations of motion. Static stability, neutral points, and maneuver points. Effect of CG movement. Linearized equations of motion and stability derivatives. Characteristic longitudinal and lateral motions. Elements of handling qualities. Effects of variation of aerodynamic parameters on airplane stability and control.
R. V. Ramnath

16.17 Advanced Flight Dynamics and Control (A)

Prereq.: 16.16
G (2) **Next offered 1984-85**
3-0-9

Brief review of applied aerodynamics. Wing, fuselage, and tail contributions. Power, compressibility, and aeroelastic effects. Modern approach to aircraft stability and control. Motion along steep trajectories, reentry dynamics, and stability of a shuttle vehicle. Human pilot models and autopilots. Variable flight conditions. VTOL transition. Sensitivity to parameter variations in variable systems. Motion at high angle-of-attack, roll coupling, and other nonlinear flight regimes.
R. V. Ramnath

16.20 Structural Mechanics

Prereq.: 16.004 or 2.01 or 13.001
U (1, 2)
5-0-7

Applies solid mechanics to analyzing high technology structures. Plane stress, plane strain problems. Bending, shear, torsion of rods and thin wall beams. Introduces 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.
T. H. H. Pian, J. Dugundji

16.21 Plates, Stability, and Thermoelasticity (A)

Prereq.: 16.20
G (2) **Not offered 1984-85**
3-0-9

Analyzes 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. Alternate years.
E. A. Witmer, T. H. H. Pian

16.22 Shell Structures (A)

Prereq.: 16.20
G (1) **Not offered 1984-85**
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. Alternate years.
J. Dugundji

16.23 Structural Design of Gas Turbine Engines (A)

Prereq.: 16.20, 16.54
G (2) **Next offered 1984-85**
3-0-9

Overall structural design and layout of modern gas turbine engines. Emphasizes the unique aspects induced by the high temperatures and rotation speeds. Reviews thermodynamic cycle analysis and aerodynamics to determine operating loads. Both stationary and rotating structural components, blades, disks and shafts analyzed. Thermal stresses, creep, low cycle fatigue, rotor dynamics, aeroelasticity and crack growth. Discusses materials, structural testing and retirement of components. Considers design tradeoffs between performance, and lifecycle cost and durability. Alternate years.
E. F. Crawley, D. J. Jordan

16.24 Plasticity, Viscoelasticity, and Creep (A)

Prereq.: 16.20
G (2) **Next offered 1984-85**
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, correspondence 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
G (1) **Next offered 1984-85**
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. Emphasizes application of theory to practice. A portion devoted to study of case histories drawing examples from past, present, and future vehicles. Guest lecturers bring their experiences for discussion.
J. W. Mar

16.261J Structural Mechanics in Nuclear Power Technology (A)

(Same subject as 1.56J, 2.084J, 3.82J, 13.14J, 22.314J)
Prereq.: Permission of Instructor
G (1)
3-0-9

See description under subject 22.314J.
J. E. Meyer, O. Buyukozturk

16.27 Finite Element Method (A)

Prereq.: 16.20
G (1)
3-0-9

Formulation of finite element method through use of variational principles 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. Emphasizes practical ways of constructing and assembling the element matrices and methods of solving large systems of algebraic equations by modern computers. Students required to carry out actual solutions using the digital computer.
E. A. Witmer

16.28 Advanced Finite Element Method (A)

Prereq.: 16.27
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

16.291 Manufacturing with Advanced Composite Materials

Prereq.: —
U (1)
1-3-2

Introduces the various methods used to manufacture parts made of advanced composite materials. Revolves around laboratory sessions in the Technology Laboratory for Advanced Composites. Students gain hands-on experience by using various laboratory techniques to fabricate and test graphite/epoxy specimens. Lectures supplement laboratory sessions with background information on the nature of composites, curing, composite machining, secondary bonding, and the testing of composites.
P. A. Lagace

16.292 Design with Filamentary Composite Materials (A)

Prereq.: 16.20
G (2)
3-1-8

Studies the behavior of the filamentary composite materials composed of boron, graphite, glass, and Kevlar fibers embedded in a matrix. Material properties of fibers and matrices. Anisotropic elasticity, classical laminated plate theory, micromechanics, and interlaminar stresses. Several laboratory experiments demonstrate concepts from the classroom. Design concepts and cost-effective applications.
P. A. Lagace

16.293 Advanced Topics in Filamentary Composite Materials (A)

Prereq.: 16.292 or Permission of Instructor
G (1)
3-0-9

Generalized study of the anisotropic properties of composite laminates. Failure modes, fracture theories/correlations, damage tolerance, fatigue, interlaminar stresses, environmental effects. Reviews current problems in the applications of composite materials in the aerospace and automotive industry. Guest lecturers share their experiences.
J. W. Mar, P. A. Lagace

16.30 Principles of Automatic Control

Prereq.: 18.03
U (1, 2)
3-0-9

Fundamental physical and analytical principles used in the design of automatic control systems. Emphasizes 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. Recommended for the second term of the junior year or later.
H. P. Whitaker, A. L. Elias

16.311 Principles of Instrumentation and Control (A)

Prereq.: 16.30
G (1)
3-0-9

Introduces 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.
B. K. Walker

16.312 Principles of Optimal Control (A)

Prereq.: 16.31, 16.37
G (2)
3-0-9

Studies 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.
B. K. Walker

16.321 Fault Tolerant Control Systems I (A)

Prereq.: 16.37
G (2)
3-0-9

The first of a two-term sequence of subjects in designing and analyzing control systems which can sustain component failures and continue to function. Presents an overview of the area and is a reasonable terminal subject for those who cannot take the two-term sequence. Statistical failure models. Methods for masking component failures. Methods for detecting and isolating component failures. Evaluates performance of redundant control systems.
W. E. Vander Velde, B. K. Walker

16.322 Fault Tolerant Control Systems II (A)

Prereq.: 16.321
G (1)
3-0-9

Continuation of the material introduced in 16.321 emphasizing more advanced topics. Data editing and other techniques for masking sensor failures. System model-based methods for isolating actuator and sensor failures. Batch and sequential decision algorithms. Use of Markov and semi-Markov chain analysis in evaluating the performance of redundant control systems. Case studies of redundant system design.
W. E. Vander Velde, B. K. Walker

16.33 Computer Control of Dynamic Systems (A)

Prereq.: 16.30
G (1)
3-0-9

Elements of linear discrete-time system theory: state description, stability, z-transform analysis, controllability, observability, canonical forms. Analyzes linear discrete-time control systems: stability, root locus, frequency response. 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.
W. S. Widnall

16.34 Automatic Control of Flight Vehicles (A)

Prereq.: 16.30
G (2) **Next offered 1984-85**
3-0-9

Applies design techniques and principles to advanced automatic control systems for air and space vehicles. Synthesis of control systems from standpoint of meeting mission specifications. Typical engineering problems associated with design of control equipment, considering limitations and uncertainties of components, random input effects, mass cross-coupling effects. 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
U (2)
3-2-7

See description under subject 6.023J.
L. R. Young, L. S. Frishkopf, R. W. Mann

16.352J Sensory-Neural Systems (A)

(Same subject as 6.532J)
Prereq.: Permission of Instructor
G (1) **Not offered 1984-85**
3-0-9

See description under subject 6.532J.
C. M. Oman, L. S. Frishkopf

16.355J Models of Man-Machine Systems (A)

(Same subject as 2.181J)
Prereq.: 18.03
G (1)
3-1-8

See description under subject 2.181J.
L. R. Young, T. B. Sheridan

16.356J Biomedical Signal Processing (A)

(Same subject as HST 582J)
Prereq.: 6.003
G (1)
3-6-3

See description under subject HST 582J.
R. V. Kenyon, D. Adam

16.36 Flight Simulation (A)

Prereq.: 18.03, 16.30 or 6.003 or 2.14
G (1)
3-6-3

Simulation of aircraft for research and pilot training. Conversion of aircraft equations of motion and data package into a digital computer model. Simplified transfer functions. Principles of vision relevant to out-the-window displays. 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 in the lab. Assumes familiarity with FORTRAN programming.
R. V. Kenyon, L. R. Young, A. L. Elias

16.37 Statistical Problems in Automatic Control (A)

Prereq.: 16.30
G (1)
3-0-9

Statistical problems of importance to control system engineers. Reviews 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
G (2)
3-0-9

Stochastic processes: mean square calculus, Wiener process, white noise, Gaussian processes, Markov processes, Ito stochastic calculus, Kolmogorov's equations. Linear filtering and smoothing theory: Kalman filter, 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. Gaussian second-order filter. Optimal control of stochastic linear systems: separation theorem.
W. S. Widnall

16.381 Lasers and Optics for Applications (A)

Prereq.: 8.03
G (1)
3-0-9

16.382 Lasers and Optics for Applications (A)

Prereq.: 16.381
G (2)
3-0-9

Fundamentals of modern optics and lasers emphasizing applications. Propagation of light in a vacuum. Polarization properties. Interference and diffraction. Interaction of radiation with simple atoms and molecules. Stimulated absorption, spontaneous and stimulated emission. Homogeneous and inhomogeneous broadening mechanisms. Propagation of light in gases, plasmas, isotropic and anisotropic solids, and fibers. Lasers. Steady state and transient behavior. Optical resonators. Survey of gas, liquid, solid, and semiconductor lasers. Single-frequency selection, Q-switching and mode locking. Optics of laser beams. Modulation, deflection, and detection of light. Measurement of displacement, linear and angular velocity, temperature and gas density. Principles of fiber optic sensors. Holography. Laser spectroscopic techniques with emphasis on resolution. Optical frequency and wavelength standards.
S. Ezekiel

16.39 Algorithms for Function Minimization and Optimal Control (A)

Prereq.: 18.076 or 18.085
G (2) **Not offered 1984-85**
3-0-9

Develops 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, introduces variational calculus, the maximum principle, dynamic programming. Considers unconstrained and constrained problems. Compares the complexity and performance of different optimum-seeking algorithms.
W. E. Vander Velde

16.40 Principles of Flight Guidance

Prereq.: 16.30
U (2)
3-1-8

Introduces 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
G (1)
3-0-9

First half treats 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. Analyzes and evaluates single and two degree of freedom instruments and their errors. Includes laser, electrostatic and dry-tuned gyros, and models of state-of-the-art hardware. Students obtain a thorough understanding of inertial space concepts and hardware.
W. R. Markey, P. K. Chapman, J. S. Sinkiewicz

16.42 Inertial Engineering II (A)

Prereq.: 16.41
G (2) **Next offered 1984-85**
3-0-9

Continues 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. Seminars held by staff members of the Charles Stark Draper Laboratory on topics chosen primarily by the class.
W. R. Markey

16.46 Astrodynamics I (A)

Prereq.: 18.03
G (1)
3-1-8

Fundamentals of astrodynamics; two-body and n-body approximate and precision orbit determination. Fundamentals of space vehicle navigation emphasizing 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. Selected applications from the Apollo and Space Shuttle programs.
R. H. Battin

16.47 Astrodynamics II (A)

Prereq.: 16.46
G (2)
3-1-8

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
G (1)
3-0-6

Reviews 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
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

Prereq.: 16.004 or 2.20, 2.40; or 10.301, 10.13
U (1)
3-0-9

Fundamental thermodynamics and fluid mechanics aspects of various types of dynamic and direct energy converters. Discusses advantages of Carnot, Rankine, Brayton, Otto, and Diesel cycles. Chemical reactions: combustion, gasification, and liquefaction processes. Considers environmental pollution factors. Discusses principal fossil fuel energy systems in use and under development (fluidized bed, gas turbine, MHD, and fuel cell systems). Emphasizes system integration.
J. F. Louis

16.53 Rocket Propulsion

Prereq.: 16.004
U (2)
3-1-8

Velocity requirements for orbital and interplanetary flight. Available velocity increments and staging. Treats rocket systems involving liquid, solid, and hybrid propellants, 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)

Prereq.: 16.53, 8.03
G (2)
3-0-9

Reviews rocket propulsion fundamentals. Discusses advanced thruster concepts from air-breathing boosters to electric propulsion. Liquid rocket pressurization schemes. Physics and engineering of small thrusters for station-keeping and attitude control. Methods and concepts for electric power generation in space, photovoltaic, solar, thermal, and nuclear systems, and various conversion schemes. Power transmission and reception.
M. Martinez-Sanchez

16.54 Aircraft Engines and Gas Turbines

Prereq.: 16.004
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. Discusses various engine types including turbojet, turbofan, and turboprop. Limitations imposed by material properties and stresses. Emphasizes future design trends including reduction noise, pollutant formation, fuel consumption, and weight.
E. E. Covert, D. J. Jordan

16.541 Aircraft Turbine Engines (A)

Prereq.: 16.54
G (1)
3-0-9

Fluid mechanics, thermodynamics, and solid mechanics of aircraft turbine engines. 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. Stress and associated temperature limits and influence of blade cooling techniques on turbines.
W. T. Thompkins, Jr.

16.543 Internal Flows in Turbomachines (A)

Prereq.: 16.035 or 2.25
G (2)
3-0-9

General features of internal flows with application to compressors and turbines. Fundamental concepts of rotational flows, inherent unsteadiness of turbomachines, boundary layers, wakes, and losses in turbomachines. Axisymmetric swirling flows, blade element theory, streamline curvature computations. Effects of viscosity and compressibility in internal flows. Secondary flows. Flow instabilities in turbomachines. Recent developments and experimental information.
E. M. Greitzer, J. E. McCune

16.544 Advanced Gas Turbines Utilizing Ceramics

Prereq.: Permission of Instructor
G (1)
3-0-9

Utilization of low-cost gas turbines in automobiles and other ground vehicles promises improved efficiencies but requires improved designs and higher temperature materials for satisfactory performance over a range of output power. Addresses design and fabrication of advanced engines using ceramic materials: issues include cycle efficiencies, component design considerations, design for brittle materials, effects of materials properties and fabrication limitations. Interdisciplinary subject involves lecturers from industry or government.
A. H. Epstein, Staff

16.55 Ionized Gases (A)

Prereq.: 8.211
G (1)
3-0-9

Properties and behavior of low-temperature plasmas for magnetohydrodynamics, thermionic energy conversion, plasma propulsion, gas lasers. Equilibrium of ionized gases: energy states, statistical mechanics, and equilibrium. Kinetic theory: motion of charged particles, distribution function, collisions, characteristic lengths and times, cross-sections, transport properties. Gas surface interactions: thermionic emission, sheaths, probe theory. Radiation in plasmas, diagnostics.
M. Martinez-Sanchez

16.551 Plasmadynamics and Magnetohydrodynamics

Prereq.: Permission of Instructor
G (2)
3-0-9

Motion of conducting fluids in electric and magnetic fields. Electrodynamics: discharges and arcs, current transfer to immersed electrodes, effect of the Lorentz Force on flow. Magnetohydrodynamics: power generation and propulsion, simple inviscid and compressible flows, electric conductivity, Hall effect, ion slip, non-equilibrium electronic heating, viscous effects, nonuniformities, time-dependent MHD performance. Plasma generators, thrusters, circuit breakers, and MHD generators.
J. F. Louis

16.56 Noise Control Engineering (A)

Prereq.: Permission of Instructor
G (2)
3-0-9

Reviews physical principles of noise generation, transmission, and absorption, and the effect of noise on humans. Noise rules and criteria. Specific topics: aerodynamic noise, compressor, fans, and propellors, acoustically induced instabilities in valves, heat exchangers. Mufflers and duct liner technology.
K. U. Ingard

16.60 Advanced Special Project (A)

Prereq.: —
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.: —
G (1, 2)
Arr.

16.602 Advanced Special Subject

Prereq.: —
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.: —
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.: —
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

Prereq.: 6.071 or 6.002; 2.10
U (1, 2)
2-8-2

Laboratory explores the operation of microcomputers and methods of interfacing digital and analog devices to microcomputers. Machine and assembly language programming. Use of software development system. Parallel and serial digital interfaces. Digital to analog and analog to digital conversion. Timing and interrupts. Arithmetic limitations. Software versus hardware trade-offs. Control of real-time events and physical systems. Final project: automatic control of electromechanical system. Limited enrollment.
W. S. Widnall

16.62 Experimental Projects

Prereq.: 16.004
U (1, 2) LAB
2-6-4

Helps student gain practical insight and acquire an understanding of the scientific principles as applied to "project" experiments. Student prepares project goals, plans project, constructs apparatus, conducts experiments, and relates experimental results to initial goals. Affords opportunity to apply knowledge gained. Provides a valuable link between theory and practice. Limited to Avionics Option, Co-op, and transfer students.
J. H. Haritonidis

16.621 Experimental Projects I

Prereq.: 16.004
U (1, 2)
1-1-1

Introduces laboratory experimental techniques. Principles of reliable measurements. 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 carried through to completion under 16.622.
J. H. Haritonidis

16.622 Experimental Projects II

Prereq.: 16.621
U (1, 2) LAB
1-7-4

Helps student gain practical insight and improved understanding of engineering experimentation through design and execution of "project" experiments. Building upon work in 16.621, student constructs and tests equipment, makes systematic experimental measurements of phenomena, analyzes data, compares theoretical predictions with results. Written final report on entire project and formal oral presentation. Provides valuable link between theory and practice.
J. H. Haritonidis

16.64 Flight Measurement Laboratory

Prereq.: 16.002
U (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. Typical investigations include determination of stability derivatives, verification of performance specifications, and measurement of navigation system characteristics. Limited to students in Aeronautics and Astronautics.
W. M. Hollister

16.65 Measurement, Instrumentation, and Computers (A) (Revised Content)

Prereq.: 16.02, 16.20, 6.071
G (2)
3-0-9

Foundation for experimentation in aerodynamics and structural mechanics: including sensor selection, analogue signal processing, and computer data acquisition. Emphasizes physical system constraints and the practical aspects of experimentation.
A. H. Epstein

16.671J Invention

(Same subject as 2.941J, 10.802J, 13.77J)
Prereq.: —
G (1)
3-0-6

See description under subject 2.941J.
W. R. Markey, D. G. Jansson, A. D. Carmichael, J. P. Longwell

16.672 Entrepreneurship

Prereq.: —
G (2)
4-0-5

School-Wide Elective Subject. Description given at end of this chapter on SWE page.
D. G. Jansson

16.673 Inventions and Patents

Prereq.: 14.02
U (1)
3-0-6

School-Wide Elective Subject. Description given at end of this chapter on SWE page.
R. H. Rines

16.701 Principles of Systematic Policy Analysis

Prereq.: Permission of Instructor
G (1)
3-0-6

Introduces the systematic analysis of policy choices, emphasizing approaches, concepts, and techniques employed. Main focus on techniques for comparing major project or program alternatives. Studies time-streams of benefits and costs. Pertinent operations research techniques including linear and integer programming, project scheduling, and game theory. Introduces decision analysis and utility theory.
A. R. Odoni

16.704 Seminar in Air Transportation Analysis and Planning

Prereq.: —
G (1) **Next offered 1984-85**
1-0-5

Reviews 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

16.71J Computer Algorithms in Transportation (A) (New)

(Same subject as 1.204J)
Prereq.: 1.00 or 16.008; 1.03
G (2)
3-0-6

See description under subject 1.204J.
D. F. X. Mathaisel, G. Kocur

16.72 Air Traffic Control (A)

Prereq.: 6.071 or 16.40
G (2)
3-0-6

Introduces 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. Requires term paper.
A. L. Elias, R. W. Simpson

16.73 Airline Management (A)

Prereq.: 16.74
G (2)
3-6-3

Marketing, managerial economics, and regulatory aspects of both domestic and international airline industry. 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. 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.
R. W. Simpson, D. F. X. Mathaisel, A. L. Elias

16.74 Air Transportation Economics (A)

Prereq.: 14.001
G (1)
3-0-6

Introduces fundamental concepts for the economic analysis of airline systems. Contrasts basic models of the operation of air transport markets with neoclassical microeconomic models. Defines market systems for air transport service, and develops a theory for pricing, demand, costs, and supply for regulated and unregulated, domestic and international markets. Presents market models for equilibria in isolated markets and over a network of markets.
R. W. Simpson

16.751 Flight Transportation (A)

Prereq.: 16.30
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, A. L. Elias, R. W. Simpson

16.752J International Air Transportation

(Same subject as 17.334J)
Prereq.: —
G (1)
3-0-6

Emphasizes political aspects of international air transport. Topics: international civil aircraft industry; types of airline ownership; characteristics of air transport in North and South America, Europe, Middle East, Africa, Asia, USSR; world route patterns; bilateral negotiations; international air transport organizations; air transport in developing nations; unlawful interference with aircraft; international air cargo industry. Term paper.
B. R. Gidwitz

16.76J Logistical and Transportation Planning Methods (A)

(Same subject as 1.203J, 6.281J, 11.526J, 13.665J, 15.078J, TPP 43J)
Prereq.: 6.431, 15.075
G (1)
3-0-9

See description under subject 1.203J.
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
G (2)
3-0-6

Studies application of linear programming and network flow theory to operational problems in flight transportation systems. Reviews graph theory. Network flow theory. Integer programming and branch and bound methods. Dynamic programming. Reviews implementation of computerized mathematical programming systems. Applies the theory to scheduling, aircraft and crew routing, timetable optimization, passenger traffic flow, flight planning, etc. Students use 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
G (2)
3-0-6

See description under subject 1.231J.
A. R. Odoni, R. de Neufville

16.783J Engineering Policy Thesis Seminar (A)

(Same subject as 1.980J, TPP 13J)
Prereq.: Thesis Registration
G (1, 2)
2-0-1

See description under subject TPP 13J.
A. R. Odoni, R. de Neufville

16.784 Engineering Systems Analysis (A)

Prereq.: Permission of Instructor
G (1)
3-0-6

School-Wide Elective Subject. Description given at end of this chapter on SWE page.
R. de Neufville, J. P. Clark

16.792 Introduction to Technology and Law

Prereq.: —
U (1)
3-0-9

School-Wide Elective Subject. Description given at end of this chapter on SWE page.
J. D. Nyhart

16.794 Engineering Risk-Benefit Analysis (A)

Prereq.: 18.02
G (2)
3-0-6

School-Wide Elective Subject. Description given at end of this chapter on SWE page.
A. W. Drake, A. R. Odoni

16.80 Industrial Practice

Prereq.: —
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.: —
U (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. Limited to students registered in Course XVI-C.
W. E. Vander Velde

16.802 Advanced Engineering Internship

Prereq.: 16.801
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. Limited to students registered in Course XVI-C who have been admitted to the Graduate School.
W. E. Vander Velde

16.81 Space Flight Dynamics

Prereq.: 16.004, 18.03
U (2)
3-0-9

Topics: launch trajectory analysis, orbit insertion navigation requirements, orbital mechanics and spacecraft dynamics, the space environment (gravity gradients, atmospheric drag, radiation environment), rendezvous and docking approaches, thermal equilibrium, reentry trajectory analysis, convective and radiative heating, thermal protection system analysis, hypersonic maneuvering, and landing dynamics of low L/D vehicles.
D. L. Akin

16.821 A Management View of Engineering Seminar

Prereq.: —
G (1)
2-0-4

For students whose objective is a career in engineering. Provides opportunities to examine management topics related to the conduct of engineering activities in industrial environment. A case approach employed to look at management interfaces between engineering and other corporate functions such as marketing, finance, manufacturing, quality, etc. Attention given to role of engineer in acquisition of new business, as well as the treatment of management of large projects. Consideration given to technical and business aspects of starting new ventures within corporate environment.
J. Yamron

16.84 Flight Vehicle Engineering

Prereq.: 16.02
U (2)
2-3-7

Design of an atmospheric flight vehicle to satisfy stated performance, stability, and control requirements. Emphasizes 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
U (1)
4-0-8

Reviews fundamental principles used in engineering development of space systems. Design of a complete system including trajectory analysis, entry dynamics, propulsion systems, structural design, thermal control, environmental control, support systems, weight and cost estimates. Students participate in teams, each responsible for one of several subsystems, providing experience in project organization and interaction between disciplines.
R. H. Miller, M. Martinez-Sanchez, E. F. Crawley, D. L. Akin

16.851 Satellite Engineering (A)

Prereq.: Permission of Instructor
G (1)
3-0-9

Fundamentals of satellite engineering design. Studies orbital environment. Analyzes problems of station keeping, attitude control, communications, power generation, structural design, thermal balance, and subsystem integration. Considers trade-offs among weight, efficiency, cost, and reliability. Discusses choice of design parameters such as size, weight, power levels, temperature limits, frequency, bandwidth. Examples taken from current satellite systems.
W. M. Hollister

16.87 VTOL Aircraft (A)

Prereq.: 16.02
G (1) **Next offered 1984-85**
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.
N. D. Ham

16.88 Aerodynamics, Structural Dynamics, and Aeroelasticity of Wind Turbines and Rotorcraft (A)

Prereq.: 16.02
G (1) **Not offered 1984-85**
3-0-6

An analytical discussion of fundamental aerodynamic, structural dynamic, and aeroelastic characteristics common to wind turbines and rotorcraft. Includes the horizontal-axis and vertical-axis types of wind turbine, and the helicopter and tilting rotor-propeller types of rotorcraft. Alternate years.
N. D. Ham

16.91 Structural Dynamics (A)

Prereq.: 16.20
G (1)
3-0-9

Vibrations of simple and complex structures: bars, strings, rods, beams, plates; emphasizes physical concepts. Analyzes 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, with examples and interpretation. Introduction to self-excited vibrations: divergence and flutter of aircraft. See 2.032. Consult advisor.
E. F. Crawley

16.92 Advanced Aeroelasticity (A)

Prereq.: 16.004, 16.91
G (2) **Not offered 1984-85**
3-0-9

Presents 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 laws and wind tunnel modeling. Responses to gusts and random excitation. Derivation of unsteady airloads. Simple nonlinear aeroelastic behavior. Alternate years.
E. F. Crawley

16.94 Advanced Structural Dynamics (A)

Prereq.: 16.91
G (2) **Next offered 1984-85**
3-0-9

Reviews transient response of linear systems. Emphasizes nonlinear vibrations and transient response of structures; elastic and inelastic material behavior and large deflections. Finite element, finite difference, and assumed mode methods. Modal and direct numerical timewise

integration techniques. Transient strain and displacement responses; permanent deformation. Impact and propagation of both elastic and inelastic stress waves in solids. Nonlinear geometric vibratory responses of elastic structures; forced and parametric excitation. Alternate years.
E. A. Witmer

16.991 Aeronautics and Astronautics Seminars

Prereq.: —
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.: —
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.: —
U (1)
3-0-9

School-Wide Elective Subject. Description given at end of this chapter on SWE page.
R. T. Lund, D. P. Hoult, H. S. Marcus

16.ThG Graduate Thesis (A)

Prereq.: —
G (1, 2, S)
Arr.

Program of graduate research leading to an S.M., E.A.A., Ph.D., or Sc.D. thesis; to be arranged by the student with an appropriate MIT faculty member, who is then thesis supervisor.
H. Y. Wachman

17 Political Science

Political Philosophy/Social Theory

17.101 Revolution and the Theory of Politics

Prereq.: —
U (2) 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.
S. Berger

17.103 Socialism

Prereq.: —
U (2) HUM-D **Next offered 1984-85**
3-0-6

Studies the Socialist movement, ideas, and politics from the Industrial Revolution to the present. Explores history and theories of Socialism in Europe, Russia, USA. Topics: Utopian Socialists, Marx, Lenin, Stalinism, Social Democracy, Euro-Communism, and Socialism in the US.
S. Berger

17.104 Philosophies of Social Science (A) (New)

Prereq.: Permission of Instructor
G (2)
3-0-9

With the goal of enhancing philosophical literacy, this subject addresses philosophical issues arising in contemporary social scientific research practice. Issues of explanation and understanding, the justification of theories and arguments, objectivity and commitment in political research. Literatures on democratization and international conflict provide the points of reference for discussion.
H. R. Alker, Jr., J. Cohen

17.105J Political Philosophy

(Same subject as 24.233J)
Prereq.: One Philosophy Distribution subject
U (1)
3-0-9

17.106J Political Philosophy (A)

(17.152)
(Same subject as 24.611J)
Prereq.: Previous subject in Modern Political Philosophy
G (1)
3-0-9

Considers the implications for an understanding of democracy of several traditions of modern social and political thought: individualist rational choice approaches, theories of the general will, and historical materialism. Readings: Locke, James Mill, Arrow, Downs, Rousseau, Rawls, Marx. Graduate students are expected to pursue the subject at greater depth through reading and individual research. Meets with 17.105J.
J. Cohen

17.107 Introduction to Political Theory: Individual and Community

Prereq.: —
U (1) HUM-D **Next offered 1984-85**
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. Extent to which political society is justified in shaping the lives and consciousness of its members. Foundations of political authority. Readings include: Plato, Aristotle, St. Augustine, St. Thomas, Machiavelli, and Luther.
B. H. Smith

17.111 Political Sociology

Prereq.: —
U (1)
3-0-6

Introduces 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

17.113J Classics in Political Philosophy (New)

(Same subject as 24.09J)
Prereq.: —
U (1) HUM-D
3-0-6

See description under subject 24.09J.
J. Cohen

17.150 Basic Concepts of the Social Sciences (A)

Prereq.: Permission of Instructor
G (1) **Next offered 1984-85**
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

17.154J The Rise of the Modern State (A)

(Same subject as STS 510J)
Prereq.: Permission of Instructor
G (1)
3-0-9

See description under subject STS 510J.
C. F. Sabel

17.156J Political Economy I: Theories of the State and the Economy (A)

(Same subject as 14.781J)
Prereq.: Permission of Instructor
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

17.160 Topics in the Sociology of Bureaucracy (A)

Prereq.: Permission of Instructor
G (2)
3-0-9

Central theme is relation between rule making, administrative efficiency, and the exercise of power. Discusses readings of contemporary studies of bureaucratic organization. Framework applies consideration of relations between state apparatus and society. Topics: Absolutism and rise of state authority, Legalism and Corporatism as techniques of Social Compromise, and Bonapartism. Readings are historical and comparative; but where possible, readings chosen to facilitate discussion of contemporary role of the bureaucracy in US. Requires seminar-length paper.
C. F. Sabel

American Politics/Public Policy

Public Policy

17.201J Politics and Public Policy

(Same subject as 11.007J)
Prereq.: —
U (1, 2) HUM-D
3-0-9

Introduces political aspects of public policy. Considers philosophical rationales for government action and the evolution of public policy in American history; the policy-making process; basic strategies of government control: including market regulation; mass persuasion and 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

17.202 Theories of Public Policy (A)

Prereq.: Permission of Instructor
G (1)
3-0-9

Analyzes political issues involved in the conduct of policy analysis. Topics: criteria for government intervention (e.g., efficiency, equity, security, liberty, community); alternative methods of government intervention (market and incentive policies, standard-setting, creation of legal rights and duties, information-based strategies); philosophical assumptions (e.g., statistical indicators, cost-benefit analysis, risk analysis, microeconomic models). Students apply the theoretical issues to a policy topic of their choice.
D. A. Stone

17.203 Evaluation Research Laboratory

Prereq.: —
U (2) LAB
3-5-4

Introduces 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. Carries out individual evaluation projects as part of subject. May *not* count toward Humanities Requirement.
J. Freeman

17.205 Bureaucracy and Public Policy

Prereq.: —
U (2)
3-0-6

Studies structure of public organizations and the politics of bureaucracy in the US, examining 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.
D. Metlay

17.213 Regulation

Prereq.: —
U (1) **Next offered 1984-85**
3-0-6

17.214 Regulation (A)

(17.230)
Prereq.: Permission of Instructor
G (1) **Next offered 1984-85**
3-0-9

Analyzes theoretical issues that cut across many substantive areas of regulation, including health and safety, environment, public utilities, and transportation. Topics: deciding when to regulate, explaining the behavior of regulatory agencies, evaluating alternative regulatory instruments, evaluating proposals for regulatory reform and deregulation. Literature drawn from law, economics, and political science. Graduate students are expected to pursue the subject at greater depth through reading and individual research. Meets with 17.213.
D. A. Stone

17.217 Media and Public Policy

Prereq.: 17.255
U (2) **Next offered 1984-85**
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 material from current relations. Each class presents a "case" of current media concern analyzing news coverage using video and guests.
E. Diamond

17.220J The Policy-Making Process (A)

(Same subject as TPP 22J)
Prereq.: Permission of Instructor
G (2)
3-0-9

How the social process of decision making affects the content of decisions. Considers basic processes: markets, voting, small group consensus, bargaining, expert decisions, adversary processes, bureaucratic discretion, and lotteries. Readings and discussions examine conditions for selection of each process, their characteristics, how each maximizes certain values and influences likely outcomes, and indications for reform. Open to qualified undergraduates.
D. A. Stone

17.227 Comparative Health Systems

(17.207)
Prereq.: —
U (1)
3-0-6

17.228J Comparative Health Systems (A)

(Same subject as 15.141J)
Prereq.: Permission of Instructor
G (1)
3-0-6

Considers the organization and major issues facing health systems in the US and selected other countries from a variety of perspectives, including those of the physician, the manager, and the policy analyst. Considers cost, quality, access, and technology considered in depth in nonprofit, proprietary, and government elements of the systems. Graduate students are expected to pursue the subject at greater depth through reading and individual research. Meets with 17.227.
H. M. Sapolsky, S. N. Finkelstein

17.232J International Food and Nutrition Policy (A)

(Same subject as 20.411J)
Prereq.: 17.562J
G (2)
2-0-7

See description under subject 20.411J.
M. B. Wallerstein

17.234 Business and Government (A)

Prereq.: Permission of Instructor
G (2) **Next offered 1984-85**
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

17.235 Organization Theory

(17.219)
Prereq.: —
U (1)
3-0-9

17.236 Theory of Organization (A)

Prereq.: Permission of Instructor
G (1)
3-0-9

Considers the historical roots of modern administrative theory: the effect of technology on organizational structure and functions, how decisions are made within organizations, emphasizing cognitive bases for decision making, how actors in an organization's environment influence organizational behavior, the problem of executive control, the challenges of uncertainty and complexity for organizational performance. Graduate students are expected to pursue the subject at greater depth through reading and individual research. Meets with 17.235.
D. Metlay

American Politics

17.241 Introduction to the American Political Process

Prereq.: —
U (1, 2) HUM-D
3-0-9

Studies 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, W. D. Burnham

17.243 American Politics and Social Change

Prereq.: —
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. 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. —
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

17.249 Electoral Politics in the US

Prereq.: 17.241
U (1) **Next offered 1984-85**
3-0-6

Analyzes 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 to extremist political movements and the behavior of electorates under acute stress.
W. D. Burnham

17.251 Congress and the American Political System

Prereq.: —
U (2) **Next offered 1984-85**
3-0-6

17.252 Congress and the American Political System (A)

(17.262)
Prereq.: Permission of Instructor
G (2) **Next offered 1984-85**
3-0-9

Focuses both on the internal processes of the House and Senate and on the place of Congress in the American political system. Attention to committee behavior, leadership patterns, and informal organization. Considers relations between Congress and other branches of government, as well as relations between the two houses of Congress itself. Graduate students are expected to pursue the subject at greater depth through reading and individual research. Meets with 17.251.
T. Ferguson

17.253 Executive Leadership: Presidents, Governors, and Mayors

Prereq.: 17.241
U (2)
3-0-9

17.254 Executive Leadership: Presidents, Governors, and Mayors (A)

(17.268)
Prereq.: Permission of Instructor
G (2)
3-0-9

Examines 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 research one or more political executives who interest them. Graduate students are expected to pursue the subject at greater depth through reading and individual research. Meets with 17.253.
W. D. Burnham, T. Ferguson

17.255 Politics, TV, and the News

Prereq.: —
U (1)
3-0-6

The role of television, considered by some the most powerful mass medium in shaping American public attitudes. Focus on TV but newspapers and magazines also discussed. Topics: political coverage of elections and policies; news "management" by both government and media; Presidential access to media; coverage of foreign news; science and technology; economics. Lectures and recitations combine "live" and taped appearances of guests and presentation of issues.
E. Diamond

17.260 Graduate Seminar in American Politics (A)

Prereq.: 17.241
G (2)
3-0-9

Analyzes the American political system with primary emphasis on the national level. Examines American political culture, federalism, American party system, representation and public policy, and major institutional components of the national policy process. 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

17.264 Dynamics of Electoral Politics (A)

Prereq.: 17.241
G (2) **Next offered 1984-85**
3-0-9

Analyzes mass voting behavior in the US, past and present. Evaluates leading theories of American electoral politics in light of inferences from data analysis. Emphasizes 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
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 receive some attention.
T. Ferguson

17.270 Evolution of American Politics (A)

Prereq.: 17.241 or 17.249 or 17.245 or 17.251
G (1)
3-0-9

17.271 Evolution of American Politics

(17.247)
Prereq.: —
U (1)
3-0-6

Provides students with historical background for understanding growth and change in American national political structures and processes to their present state. Orients the approach, however, 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. Emphasizes developments in the 20th century. Graduate students are expected to pursue the subject at greater depth through reading and individual research. Meets with 17.270.
W. D. Burnham

17.272 American Political Economy (A)

Prereq.: 17.241
G (2)
3-0-9

Offers a view of the field as a whole for students without a special background. Considers classical and modern texts representing several influential but sharply contrasting approaches. Divergent methodological presuppositions and attitudes toward key terms as "economics," "politics," and "history" in later works of these traditions highlighted. Evaluates major American political institutions and processes in the context of American political economy.
W. D. Burnham, T. Ferguson

Urban Politics and Public Policy

17.281 Urban Politics

Prereq.: —
U (2)
3-0-6

Analyzes 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

17.285 Racial and Ethnic Politics

Prereq.: —
U (1) **Next offered 1984-85**
3-0-6

Analyzes 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
G (1)
3-0-9

Examines current issues in urban politics, and alternative perspectives for analyzing them. Includes: 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. Considers the utility of pluralist and neo-Marxist frameworks in understanding American urban political development and public policy.
M. Lipsky

17.290 Urban Political Economy

Prereq.: Permission of Instructor
G (2)
3-0-9

17.293 Urban Political Economy

Prereq.: —
U (2)
3-0-6

Analyzes the changing roles and functions of cities in the evolving framework of American political economy. 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. Graduate students are expected to pursue the subject at greater depth through reading and individual research. Meets with 17.290.
E. L. Jackson

17.294 Urban Scarcity Politics and City Fiscal Policy (A)

Prereq.: Permission of Instructor
G (1)
3-0-9

17.295 Urban Scarcity Politics and City Fiscal Policy

(17.297)
Prereq.: —
U (1)
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. Attention to internal city politics, external political actors, agencies, and markets, and to exogenous structural forces (regional economic shifts, social demographics, and national urban policies). Graduate students are expected to pursue the subject at greater depth through reading and individual research. Meets with 17.294.
E. L. Jackson

17.296 Bureaucracy and Public Organizations (A)

Prereq.: Permission of Instructor
G (2)
3-0-9

Analyzes organizations that provide public services, and their role in the American political economy. Emphasizes comparisons across policy areas, such as health, education, policing, and social welfare, and across public, quasi-public, and private organizational types that bear on quality, availability, and accountability in such public services. Includes balance between professional and bureaucratic control and client roles in service delivery. Open to qualified undergraduates.
M. Lipsky

Science, Technology and Policy

17.301 Science, Technology and Politics

Prereq.: —
U (1)
3-0-6

17.302 Science, Technology, and the State (A)

(17.320)
Prereq.: 17.241
G (1)
3-0-9

Examines the impacts of science and technology on governmental institutions and processes. Includes extent to which science and technology have transformed fundamental political institutions and relationships, role of scientists and engineers in political decision making, societal mechanisms for reaching decisions on controversial technological issues, and impact of science and technology on foreign policy and international political relationships. Graduate students are expected to pursue the subject at greater depth through reading and individual research. Meets with 17.301.
D. Metlay

17.303 Theories of Technological Society and Politics

Prereq.: —
U (2) **Next offered 1984-85**
3-0-6

17.304 Theories of Technical Society and Politics (A)

(17.324)
Prereq.: Permission of Instructor
G (2) **Next offered 1984-85**
3-0-9

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, and the control of technology. Considers the writings of Marx, Ellul, Mumford, and others. Graduate students are expected to pursue the subject at greater depth through reading and individual research. Meets with 17.303.
D. Metlay

17.305J Rationality, Risk, and Choice in Industrial Society

(Same subject as STS 401J)
Prereq.: —
U (2) HUM-D
3-0-9

See description under subject STS 401J.
J. Yellin

17.307J Legal and Scientific Issues in Environmental Controversies

(Same subject as STS 411J)
Prereq.: Permission of Instructor
U (1)
3-0-9

See description under subject STS 411J.
J. Yellin

17.322 Seminar in Systematic Policy Analysis and Technology Assessment (A)

Prereq.: 14.001, 14.002
G (2)
3-0-6

Analyzes 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.
G. W. Rathjens

17.326 International Organization, Legal and Political Response to Science and Technology (A)

Prereq.: 17.320
G (1) **Next offered 1984-85**
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. Conducted jointly with Harvard Law School. Limited enrollment. Permission of instructor required.
E. B. Skolnikoff

17.328 Science and Technology in International Affairs (A)

Prereq.: 17.302
G (1)
3-0-9

Explores the roles of science and technology in the international system, and process by which foreign policy involving science and technology is made in the US and internationally. Provides an overview of major international political effects 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.
E. B. Skolnikoff

17.330J Seminar on Technology and Development

(Same subject as 21.506J, 22.94J)
Prereq.: Permission of Instructor
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

17.334J International Air Transport

(Same subject as 16.752J)
Prereq.: —
G (1)
3-0-6

See description under subject 16.752J.
B. R. Gidwitz

17.336J Scientific Knowledge, Social Values, and Politics (A)

(Same subject as STS 207J)
Prereq.: Permission of Instructor
G (2)
2-0-10

See description under subject STS 207J.
L. R. Graham, P. Buck

Internships

17.351J State and Local Government Internships

(Same subject as 11.197J)
Prereq.: —
U (1, 2)
3-0-9

Year-long internships in public and not-for-profit organizations supplemented by a seminar. Instructor assists in arranging internships which normally run from October to April. 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 second term. No new students accepted in second term. Upon successful completion of two semesters, student petitions for one Humanities Elective credit are honored.
Staff

17.353 Media and Public Policy Internships

Prereq.: 17.255
U (2) **Next offered 1984-85**
3-0-9

Deals with relationships among politics, policy, and mass media and combines weekly seminars with an eight-hour per week internship in a media-related position. Specific case studies of political uses of television, magazines, and newspapers drawing upon materials from current relations. Each class presents a "case" of current media concern, and analyzes coverage using video and guests. Limited enrollment. Permission of instructor required.
E. Diamond

International Relations/Arms Control and Defense Studies

International Relations and Foreign Policy

17.401 Just Wars, Total Wars and Nuclear Wars (Revised Content)

Prereq.: —
U (2) HUM-D
4-0-8

The contemporary debate about nuclear war put in the context of historical, political, and moral arguments about just and unjust wars (including wars of religion and crusades), total wars (those without limits on objectives, arenas, and weaponry) and totalitarian states (those unlimited in the jurisdiction and political means of their power exercisers). Documentary film, video, and audio media supplement class discussions.
H. R. Alker, Jr., E. Diamond

17.403 American Foreign Policy in a Changing World

Prereq.: 17.401 or 17.407
U (1) 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.: —
U (1)
3-0-6

17.406 Seminar in Middle Eastern Politics (A)

(17.426)
Prereq.: Permission of Instructor
G (1)
3-0-9

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. Graduate students are expected to pursue the subject at greater depth through reading and individual research. Meets with 17.405.
W. E. Griffith, L. P. Bloomfield, N. Choucri

17.407 International Relations: War and Peace

Prereq.: —
U (1) **Next offered 1984-85**
3-0-6

Introduces 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.: Permission of Instructor
G (1)
3-0-9

Selective review and critical discussion of the literature of international relations. Compares 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. Open to undergraduates by permission of instructor only.
N. Choucri, H. R. Alker, Jr.

17.422 International Political Economy (A)

Prereq.: Permission of Instructor
G (2) **Next offered 1984-85**
3-0-6

Interdisciplinary analysis of ways in which nations undertake dual international objectives: pursuit of power and wealth. Surveys major competing paradigms of international political economy, including neo-classical economics, Marxist and neo-Marxist theories, dependency theses, and structural European views of power relations, among others. Analyzes political and economic dimensions of international trade, capital flows, foreign investment, and military and strategic policies. Reviews the evolution of international economic organizations and political implications.
N. Choucri

17.428 US Foreign Policy — Past, Present, Future (A)

Prereq.: Permission of Instructor
G (2)
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 by permission of instructor only.
L. P. Bloomfield

17.430 The Foreign Policy Process (A)

Prereq.: Permission of Instructor
G (1) **Next offered 1984-85**
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, NSC and State Dept., and System weaknesses. Organizing for interdependence. 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.
L. P. Bloomfield

17.432 Field Seminar in International Relations and Foreign Policy

Prereq.: Permission of Instructor
G (2)
Arr.

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
G (2)
3-0-6

Problem approach to areas and issues based on student interest. Reviews major themes that cut across the field, such as national security, international organizations, and interdependence. Preparation for generals and professional work.
L. P. Bloomfield

17.438 African Foreign Relations (A)

Prereq.: Permission of Instructor
G (1) **Next offered 1984-85**
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.
W. R. Johnson

17.441 International Regimes and Organizations

(17.409)
Prereq.: 17.403 or 17.405
U (1)
3-0-9

17.442 International Regimes and Organizations (A)

Prereq.: Permission of Instructor
G (1)
3-0-9

Studies origins and activities of international institutions as well as the network of rules and norms that regularize international behavior. Surveys and assesses empirical evaluations of the effectiveness of international regimes with emphasis on collective security and functional cooperation. Evaluates public goods and other approaches to the study of international regimes. Graduate students are expected to pursue the subject at greater depth through reading and individual research. Meets with 17.441.
J. Freeman, A. Hollick

17.444 Political Economy of the Middle East (A)

Prereq.: Permission of Instructor
G (1)
3-0-9

Focuses on economic and political transformations in the Middle East since World War II. The effects of the decolonization process in conjunction with efforts at institutional development provide the context for evaluating development strategies, changes in resource availability, and alternative paths to growth and change. A principal emphasis on competing strategies for change and modernization, and attendant political and economic consequences. Advanced undergraduates with permission of instructor.
N. Choucri

Defense and Arms Control Studies

17.461 Strategic Nuclear Forces

Prereq.: —
U (1)
3-0-6

17.462 Strategic Nuclear Forces (A)

(17.480)
Prereq.: Permission of Instructor
G (1)
3-0-6

Introduces planning of strategic nuclear forces. Emphasizes strategic nuclear competition and methods used to analyze the cost and effectiveness of alternative missile and bomber capabilities in achieving deterrence and stability. Graduate students are expected to pursue the subject at greater depth through reading and individual research.
W. W. Kaufmann

17.463 General Purpose Forces

Prereq.: —
U (2)
3-0-6

Introduces planning of the general purpose forces. Emphasizes methods used to analyze the cost and effectiveness of alternative land, air, and naval capabilities in achieving deterrence and stability. Attention to NATO and the Warsaw Pact.
T. R. I. Greenwood

17.465J In Pursuit of Arms Control: Analysis of the Past and Choices for the Future

(Same subject as 22.003J)
Prereq.: —
U (1)
3-0-6

Reviews and analyzes 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, European nuclear and conventional forces, Mutual and Balanced Force Reductions, and new military technology. Students learn to evaluate and to design arms control and national security policies. 22.003J also may count toward Humanities Requirement.
T. R. I. Greenwood

17.467 Arms Trade and Foreign Policy

Prereq.: —
U (2)
3-0-6

Considers international trade in arms from perspective of producing and non-producing states. Topics considered: foreign policy rationales for the trade, nature and pattern of recent arms trade, the diffusion of military technology and production, factors that will affect the future, and proposals for control.
A. C. Leiss

17.469 Military Forces and Foreign Policy

Prereq.: —
U (1)
3-0-6

17.470 Military Forces and Foreign Policy (A)

(17.492)
Prereq.: Permission of Instructor
G (1)
3-0-9

A comparative examination of US and Soviet defense policies, foreign policies, and the use of their military forces in the post-war period. Analyzes 20 historical cases involving deterrence of central war, coercive diplomacy, crisis management, and limited intervention. Discusses implications for military force posture planning and military strategy. Graduate students are expected to pursue the subject at greater depth through reading and individual research. Meets with 17.469.
S. M. Meyer

17.482 General Purpose Forces (A)

Prereq.: 17.480
G (2)
3-0-6

Introduces the planning of the nuclear and non-nuclear general purpose forces. Emphasizes methods used to analyze the cost and effectiveness of alternative land, air, and naval capabilities in achieving deterrence and stability. Attention to the ability of NATO to deter the Warsaw Pact. Open to undergraduates by permission of instructor only.
W. W. Kaufmann

17.486J The Technology and Politics of Nuclear Weapons and Arms Control (A)

(Same subject as 6.932J)
Prereq.: Permission of Instructor
G (2)
4-0-8

Reviews 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
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
G (2)
3-0-9

Examines a selection of the historical, recurrent, and contemporary issues that have arisen in the planning and implementation of Soviet 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.
S. M. Meyer

17.494 Modeling Laboratory for Defense/ Arms Control Analysis (A)

Prereq.: 17.480 or 17.482 or 17.488
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

14.496 Seminar on European Security (A)

Prereq.: Permission of Instructor
G (2)
3-0-9

Considers issues in the military and political security of Europe in the post-1945 period, decline of the cold war, consolidation of status quo; the German question and Ostpolitik; MBFR negotiations; role of new weapons systems (SS-20, Pershing 2, Cruise Missile); differing W. European and US estimates of the USSR and their policy results; the energy crisis and US-W. European differences on Middle Eastern policy.
W. E. Griffith

17.498 Defense Issues and Budgets (A) (New)

Prereq.: 17.480
G (2)
3-0-6

Introduces US defense budget and five-year defense plan. Uses force planning methods to assess the adequacy of current US nuclear and non-nuclear capabilities and to evaluate alternatives to the current budget plan. Open to undergraduates by permission of instructor only.
W. W. Kaufmann

See also 17.301, 17.302, 17.328, 17.401, 17.403, 17.405, 17.406, 17.407, 17.420, 17.428, 17.430, 17.583, 17.587, 17.604.

Comparative Politics/Political Development/Communist Studies

Theories and Research Methods

17.501 The Quest for Equality and Development in Third World Countries

Prereq.: —
U (1) HUM-D **Next offered 1984-85**
3-0-9

Examines value aspects of, and policy choices in, attempts to balance economic growth with social and economic equality in underdeveloped countries. Tensions between growth and equality explored in such policy areas as education, population control, investment, land reform, food and nutrition: primary attention given to 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 international context. Looks at specific countries in Subsahara Africa, Latin America, and Asia.
M. Weiner

17.505 Colonial Analogy

Prereq.: —
U (1) **Next offered 1984-85**
3-0-9

Analyzes 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. Examines 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)

Prereq.: 17.150
G (2)
3-0-6

Examines 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

17.507 Comparative Political Economy

(17.157)
Prereq.: —
U (1) **Next offered 1984-85**
3-0-6

17.508 Comparative Political Economy (A)

Prereq.: Permission of Instructor
G (1) **Next offered 1984-85**
3-0-9

The interrelationship of polity and economy emphasizing selected topics of special interest to political scientists, e.g., assessing the impact of elections on fiscal and monetary policy, the political-business cycle, and role of the public and private sectors in promoting economic growth. Graduate students are expected to pursue the subject at greater depth through reading and individual research. Meets with 17.507.
J. R. Freeman

17.512 Theories of Political Development (A)

Prereq.: Permission of Instructor
G (1)
3-0-9

Studies 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
G (2)
3-0-9

Explores 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. Draws case materials from contemporary Asia, Africa, and Latin America.
M. Weiner

17.516 Democratic Elections in Developing Countries (A)

Prereq.: Permission of Instructor
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. Attention to socioeconomic and class theories which may explain development and institutionalization of democratic institutions. Considers impact of the electoral process on popular participation, demand-making, patron-client relations, interethnic conflicts, political organization and legitimacy. Countries studied: Colombia, Greece, India, Malaysia, Nigeria, Portugal, Sri Lanka, Turkey and Venezuela and a number of countries in Africa and the Caribbean.
M. Weiner

17.521 Political Economy of Asia

Prereq.: —
U (1)
3-0-9

Comparative analyses of economic and political developments of India, China, Japan, and Korea-Taiwan-Singapore. Focuses on the politics of economic planning; relationships between policy and performance; political and social consequences of different developmental approaches; and Asian economies in global perspective.
L. W. Pye, R. J. Samuels, M. Weiner

17.522 Research Seminar on African Development (A)

Prereq.: 17.576
G (1) **Next offered 1984-85**
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.
W. R. Johnson

See also 17.154J, 17.156J.

Advanced Industrial Societies

17.532J Problems of Advanced Industrial Societies (A)

(Same subject as STS 575J)
Prereq.: 17.156J
G (2)
3-0-9

Analyzes selected current political economy issues. Topics include Inflation, industrial relations systems, the "crisis of ungovernability," public assistance and family policy, and "reindustrialization." Open to qualified undergraduates by permission of instructor.
S. Berger, M. J. Piore

17.534 Domestic Politics of Western Europe (A)

Prereq.: Permission of Instructor
G (1)
3-0-6

Compares politics and society in France, Great Britain, Germany, and Italy. Analyzes "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
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.
S. Berger

17.538 The Crisis of the Welfare State (A)

Prereq.: Permission of Instructor
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 problems considered.
D. A. Stone

17.539 Politics and Policy in Contemporary Japan

(17.533)
Prereq.: —
U (1) **Next offered 1984-85**
3-0-6

17.540 Politics and Policy in Contemporary Japan (A)

Prereq.: Permission of Instructor
G (1) **Next offered 1984-85**
3-0-9

Analyzes 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. Attention to the development of less idiosyncratic approaches to the study of Japan. Graduate students are expected to pursue the subject at greater depth through reading and individual research. Meets with 17.539.
R. J. Samuels

See also 17.156J.

Developing Countries

17.543 Comparative Politics of Latin America

Prereq.: —
U (1)
3-0-6

17.544 Comparative Politics of Latin America (A)

(17.580)
Prereq.: Permission of Instructor
G (1)
3-0-9

Introductory survey of Latin American politics in a comparative perspective. Theoretical focus on three contrasting models of development: modernization, dependency, and bureaucratic-authoritarianism. Four case studies with different political systems and economic models since 1960: Chile, Peru, Brazil, Cuba. Graduate students are expected to pursue the subject at greater depth through reading and individual research. Meets with 17.543.
P. Smith

17.545 Political Change in South Asia: India, Pakistan, Bangladesh, and Afghanistan

Prereq.: —
U (2)
3-0-6

17.546 Political Change in South Asia: India, Pakistan, Bangladesh, and Afghanistan (A)

(17.570)
Prereq.: Permission of Instructor
G (2)
3-0-9

Examines the major political changes occurring in the region: the changing role of political parties and the military; the impact of caste, linguistic, religious, tribal, and class forces; the electoral process; the political determinants and consequences of development policies; and the changing involvement of external powers. Attention to issues of national integration, political legitimacy, and political participation. Graduate students are expected to pursue the subject at greater depth through reading and individual research. Meets with 17.545.
M. Weiner

17.547 Chinese Politics

Prereq.: —
U (2)
3-0-6

17.548 Chinese Politics (A)

(17.568)
Prereq.: Permission of Instructor
G (2)
3-0-6

Analyzes contemporary Chinese politics, both pre-Communist and Communist. Focus on the process of modernization and political development of Chinese civilization. Graduate students are expected to pursue the subject at greater depth through reading and individual research. Meets with 17.547.
L. W. Pye

17.549 Political and Economic Development of Tropical Africa

Prereq.: —
U (2) HUM-D **Next offered 1984-85**
3-0-9

Studies major facets and problems of economic and political development in tropical Africa. Introduces the history and cultures of African peoples and the politics and government of new African states. Considers the impact of African culture and philosophy on modern politics. A general introduction to African Politics.
W. R. Johnson

17.551J Nationalism and Nation Building in 20th-Century Africa

(Same subject as 21.451J)
Prereq.: —
U (2) HUM-D **Next offered 1984-85**
3-0-9

17.552 Nationalism and Nation Building in 20th-Century Africa

(17.572)
Prereq.: Permission of Instructor
G (2) **Next offered 1984-85**
3-0-9

See description under subject 21.451J. Graduate students are expected to pursue the subject at greater depth through reading and individual research. Meets with 17.551J.
R. I. Rotberg

17.553J History and Politics of the Third World through the Novel

(Same subject as 21.455J)
Prereq.: —
U (1) **Next offered 1984-85**
3-0-6

See description under subject 21.455J.
R. I. Rotberg

17.562J Nutrition and National Development

(Same subject as 20.410J)
Prereq.: Permission of Instructor
G (1)
3-0-9

See description under subject 20.410J.
M. B. Wallerstein

17.564J Research Seminar in Imperialism and Colonialism

(Same subject as 21.457J)
Prereq.: Permission of Instructor
G (1)
3-0-6

See description under subject 21.457J.
R. I. Rotberg

17.566 Comparative Asian Politics (A)

Prereq.: Permission of Instructor
G (2) **Next offered 1984-85**
3-0-6

Comparative analysis of political systems of Asia. 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.
L. W. Pye

17.574 Comparative African Politics: Crises in Southern Africa (A)

Prereq.: Permission of Instructor
G (2)
3-0-6

Comparative analysis of political systems and problems of southern Africa. 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.: —
G (2) **Next offered 1984-85**
3-0-9

Analyzes 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. Emphasizes policies being pursued by the government to promote economic and social development.
W. R. Johnson

17.578 Race Relations, Politics and Development in the Caribbean (A)

Prereq.: Permission of Instructor
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.
R. I. Rotberg

See also 17.232J, 17.426, 17.438.

17.584 Religion, Politics, and Social Change (A)

Prereq.: Permission of Instructor
G (2) **Next offered 1984-85**
3-0-9

17.585 Religion, Politics, and Social Change

(17.581)
Prereq.: —
U (2) HUM-D **Next offered 1984-85**
3-0-6

Major issues of religion and politics in various developing countries. Focus on: theories of religion's impact on social change, 2) differing church-state concepts in the major world religions, 3) religion as a progressive and reactionary political force, 4) religion under authoritarian governments. Case studies from Latin America, Africa, Middle East, and Asia. Graduate students are expected to pursue the subject at greater depth through reading and individual research. Meets with 17.584.
B. H. Smith

17.586 The Military and Politics in Comparative Perspective (A)

Prereq.: —
G (2) **Next offered 1984-85**
3-0-9

17.587 The Military and Politics in Comparative Perspective

(17.583)
Prereq.: —
U (2) **Next offered 1984-85**
3-0-6

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. Graduate students are expected to pursue the subject at greater depth through reading and individual research. Meets with 17.586.
B. H. Smith

17.588 Field Seminar in Comparative Politics (A)

Prereq.: Permission of Instructor
G (2) **Next offered 1984-85**
Arr.

For advanced graduate students planning to offer General Examinations in the field of comparative politics. Assumes the student has a familiarity with a sampling of the major works in this field, but wishes opportunity to deepen and broaden that familiarity. No research papers required. Topics: political participation, interest groups, the intellectual history of the field, political culture, methodologies, political development, and public policy.
R. J. Samuels, Staff

See also 17.330J

Communist Studies

17.602 Continuity and Change in Soviet Politics (A)

Prereq.: Permission of Instructor
G (1)
3-0-9

17.603 Continuity and Change in Soviet Politics

Prereq.: —
U (1)
3-0-9

Analyzes the nature and evolution of Soviet politics centered on four topics: 1) Lenin's theory and practice in creating the Bolshevik party and seizing power; 2) competing responses to the economic and political dilemmas of building a socialist regime in a peasant society, 1917–1928; 3) origins and impact of Stalin's totalitarian system; 4) broad outline of changes in Soviet politics since Stalin. Graduate students are expected to pursue the subject at greater depth through reading and individual research. Meets with 17.602
D. L. M. Blackmer

17.604 Soviet and Chinese Foreign Policy and the Communist World (A)

Prereq.: 17.602
G (1)
3-0-9

Reviews Soviet state and party relations with China and East Europe during the Stalin period and analyzes 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
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
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

17.609J Seminar in the Historical and Political Evolution of the Soviet Union

(17.601J)
(Same subject as 21.378J)
Prereq.: Permission of Instructor
U (2)
3-0-6

17.610 Seminar in the Historical and Political Evolution of the Soviet Union

Prereq.: Permission of Instructor
G (2)
3-0-9

Graduate students are expected to pursue the subject at greater depth through reading and individual research. Meets with 17.609J. See description under subject 21.378J.
L. R. Graham

17.612 The Soviet Political System (A)

Prereq.: 17.602
G (2)
3-0-9

Research seminar on the Soviet political system with special emphasis on the period since Stalin's death. Three main objectives:
1) evaluation of competing interpretations of Soviet politics, including efforts to apply to the Soviet Union concepts derived from the study of other political systems; 2) discussion of major issues in contemporary Soviet politics;
3) student research.
D. L. M. Blackmer

See also 17.490

Political Communication/ Political Behavior

17.705 The Social Effects of Communications Technologies

Prereq.: —
U (2)
3-0-6

Current 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

Prereq.: —
U (2) HUM-D
3-0-6

Studies 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 Communication and Public Opinion (A)

Prereq.: Permission of Instructor
G (2)
3-0-9

The role of public opinion in the political process. Deals with: historical emergence of organized opinion, how public opinion relates to private attitudes; practices of parties and pressure groups; conditions under which communication is effective or ineffective. Open to qualified undergraduates.
I. D. Pool

17.722 Social Impact of Communication Systems (A)

Prereq.: Permission of Instructor
G (1)
3-0-9

Compares communications systems of societies dominated by mass media (as our own) with both less developed and emerging new systems. Examines communications in developing countries, American mass media, and such new technologies as CATV, satellites, and data networks. Analyzes social impacts of each. Open to qualified undergraduates.
I. D. Pool

17.726 Political Culture (A)

Prereq.: Permission of Instructor
G (2) **Next offered 1984-85**
3-0-9

Analyzes the psychological and attitudinal bases of politics. Special emphasis on socialization patterns, styles of politics, and elite operational codes. Open to qualified undergraduates.
L. W. Pye

17.734 Personality and Politics (A) (New)

Prereq.: Permission of Instructor
G (2)
3-0-9

Examines the bearing of modern personality theory, especially the psychoanalytic, on politics. A major concern will be the nature of leadership. Topics: psychology of leaders, relations of leader and led, and mass psychology of political movements. Draws particularly on materials on American Presidents and the Presidency for illustrative purposes: favors an historical perspective. Open to qualified undergraduates.
B. Mazlish

17.736 Reading Seminar in Communications Research (A)

Prereq.: Permission of Instructor
G (1, 2)
3-0-9

Reading and discussion of special topics in communications research and policy analysis by arrangement with individual staff members.
Staff

17.740J Telecommunications Technology and Policy (A) (New)

(Same subject as 6.933J)
Prereq.: Permission of Instructor
G (1)
3-0-9

Basis in technology, law, and economics for the regulation of telecommunications common carriers such as AT&T, the Postal Service, specialized international record carriers. Role of new technologies such as microwaves, satellites, integrated digital networks, computer communications, value-added services, and cable TV. Issues of competition, monopoly, and technical standards. Open to qualified undergraduates.
I. D. Pool, M. A. Sirbu

17.742J Mass Communication Technology and Policy (A) (New)

(Same subject as 4.254J)
Prereq.: Permission of Instructor
G (2)
3-0-9

Assesses the relationship between changing mass communications technologies and the policy issues of press freedom, content diversity, cross-media ownership, public access, copyright, and the deregulation movement. Examines the social impact of the emergence of printing and broadcasting and the effect of satellite technology, cable televison, videodiscs, videotex, and other new media on the communications industry.
W. R. Neuman, A. B. Lippman

17.744 International Communications (A) (New)

Prereq.: Permission of Instructor
G (1)
3-0-9

Includes the structure of the international telecommunications systems, the way in which agreements are reached through organizations such as the ITU and Intelsat, controversial issues about international broadcasting, orbit and spectrum allocations, and trans-border data networks. Examines telcommunications industry structure in Europe, Japan, Canada, USSR, and developing countries.
M. Tyler, C. Jonscher

17.748 Information and Communications Industries (A) (New)

Prereq.: Permission of Instructor
G (2)
Arr.

Analyzes past developments and future strategies of industries providing information and communications systems and services including computing, telecommunications, office automation, database services, and new media. Reviews factors causing growth in information needs of the economy. Examines options for business strategy and policy in the information and communications industries.
C. Jonscher

See also 17.255

Polimetrics/Models and Methods

17.810 Research Methods in Explanatory and Evaluative Analysis (A) (New)

Prereq.: Permission of Instructor
G (2)
2-2-8

Studies experimental and non-experimental methodologies with attention both to evaluation and explanation. Includes human-simulation, machine-simulation, Markov chains, interrupted time series analysis, and correlational methods. Substantive applications emphasize studies of macropolitical relationships with illustrations drawn primarily from international and comparative politics.
J. Freeman

17.812 Analytic Approaches to the Study of Micropolitics (A) (New)

Prereq.: Permission of Instructor
G (2)
2-2-8

Introduces a variety of research strategies and methods appropriate for studying micropolitics, e.g., public organizations, professions, policy implementation, and social movements. Considers research methods including the case study approach, documentary analysis, interviewing techniques, participant observation, and evaluation methodologies. Presents materials which illustrate sound use of such methods as well as their limitations.
D. Metlay, M. Lipsky

17.814 Research Methods in Political Behavior (A) (New)

Prereq.: Permission of Instructor
G (1)
2-2-8

Basic principles of research methodology for the testing and refinement of social science theory in the areas of political behavior, political sociology, social psychology, and communications. Includes survey design and analysis, experimental research, content analysis, and field research.
W. R. Neuman

17.816 Field Research Methods in Comparative Politics and Political Development (A) (New)

Prereq.: Permission of Instructor
G (1)
2-2-8

Introduces a variety of approaches and methods for conducting research in Western Europe and developing countries, including elite interviewing, participant observation, case studies, cross cultural survey research, and documentary research. Attention to conceptual, practical, and ethical issues of conducting research abroad, e.g., the role of language in social research, the limits and uses of official sources, and ethical responsibilities of social scientists.
M. Weiner

17.818J Applied Social Research, Public Policy, and the Social Sciences (New)

(Same subject as STS 440J)
Prereq.: —
G (1)
3-0-9

Problems and possibilities in policy-oriented social research. Historical and contemporary case studies treat three questions: what does applied social research contribute to policy making; how scientific is it; and do the natural sciences offer useful models for the combining of theory, fact, and application in the social sciences?
P. Buck

17.838 Mathematical Political Science (A)

Prereq.: Permission of Instructor
G (1) **Next offered 1984-85**
2-2-8

First part focuses on rational models of collective choice including two-person game theory. Second part covers systems theoretic explanations with applications primarily drawn from the literature on electoral mobilization, class conflict, and political economy. Open to qualified undergraduates.
J. Freeman

17.842 Reading and Interpreting Quantitative Research in Political Science and Public Policy (A)

Prereq.: Permission of Instructor
G (2)
3-0-9

For students who do not expect to use quantitative methods in their work, but who would like to be able to understand the quantitative work reported in journals and research reports. A basic literacy subject teaching the student how to read and interpret the quantitative literature in various subfields of political science and public policy. Takes readings from key journals in the fields of American Government, comparative politics, international relations, area studies, and public policy.
S. M. Meyer

17.846 Multivariate Political Analysis (A)

Prereq.: Permission of Instructor
G (2)
2-2-8

Focus on multivariate data analysis procedures emphasizing regression. Includes: dichotomous dependent variables, distributed logs, and instrumental variables. 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

17.848 Complex Models of Social Systems (A)

Prereq.: Permission of Instructor
G (1)
Arr.

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. Discusses models from biological, linguistic, logical, semiotical, and artificial intelligence traditions. Examples drawn from small group, urban, national, and international contexts.
H. R. Alker, Jr.

17.850 Advanced Topics in Statistical Modeling (A)

Prereq.: 17.846
G (1)
3-0-6

Focus on selected topics in statistical modeling and data-based simulation, including: lag theory, intervention analysis, analytical vs numerical techniques of dynamic analysis, nonlinear estimation methods. Emphasizes political science applications. Open to undergraduates by permission of instructor.
J. Freeman

See also 17.150, 17.488, 17.494, 17.901.

General

17.UR Undergraduate Research

Prereq.: —
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.: —
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.
D. L. M. Blackmer

17.905-17.911 Reading Seminar in Social Science

Prereq.: —
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.: —
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.: —
U (1, 2)
Arr.

Program of undergraduate research leading to the writing of an S.B. Thesis. To be arranged by the student under approved supervision.
D. L. M. Blackmer

17.950-17.960 Reading Seminar in Social Science (A)

Prereq.: Permission of Instructor
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.
D. L. M. Blackmer

17.ThG Graduate Political Science Thesis (A)

Prereq.: Permission of Instructor
G (1, 2)
Arr.

Program of graduate research and writing of thesis to be arranged by the student with supervising committee.
D. L. M. Blackmer

18 Mathematics

General Mathematics

18.UR Undergraduate Research

Prereq.: —
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.
A. P. Mattuck, Staff

18.001 Calculus (Revised Content)

Prereq.: Assumes some prior knowledge of calculus
U (1)
5-0-7

Emphasizes the concepts and techniques of calculus relevant to science and technology. Mathematical formulation of problems and approximate methods of solution. Short review of limits and differentiation with discussion of some advanced methods. Intensive study of integration; perturbation and iteration procedures; stability; series; summation techniques; asymptotics; numerical analysis; vector algebra; special topics.
D. J. Benney

18.002 Calculus

Prereq.: 18.001 or 18.01 or 18.011 or 18.012
U (1, 2)
5-0-7

Continues 18.001. Presents 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: *H. P. Greenspan*
Term 2: *S. J. Gates*

18.01 Calculus

Prereq.: —
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, l'Hôpital's rule, and Taylor series. Information: A. P. Mattuck.

18.011 Calculus

Prereq.: Assumes some prior knowledge of calculus
U (1)
5-0-7

Reviews 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.: —
U (1)
5-0-7

Covers much the same material as 18.01, but at a deeper and more rigorous level. Emphasizes careful reasoning and understanding of proofs. Assumes knowledge of elementary calculus. 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.
J. R. Munkres

18.02 Calculus

Prereq.: 18.001 or 18.01 or 18.011 or 18.012
U (1, 2, S)
5-0-7

Calculus of several variables. Vector algebra in 3-space, determinants, matrices. Vector-valued functions of one variable, space motion. Scalar functions of several variables: partial differentiation, gradient, approximation techniques. Multiple integrals with applications. Vector fields, line and surface integrals, exact differentials, Green's theorem, Divergence Theorem, Stokes' Theorem. Additional topics: linear algebra (term 1); infinite series (term 2).
Term 1: *H. Rogers, Jr.*
Term 2: *A. P. Mattuck*

18.021 Calculus

Prereq.: 18.011
U (2)
5-0-7

Continues 18.011: calculus of several variables, with elementary linear algebra and applications. Scalar functions of several variables: partial differentiation, gradient, approximation techniques. Multiple integrals with applications. Vector fields, line integrals, exact differentials. Elementary linear algebra, Jacobians. Green's Theorem, surface integrals, Divergence Theorem, Stokes' Theorem. Applications and special topics such as extrema theory in economics. Permission of instructor required for those not having 18.011.
F. P. Peterson

18.022 Calculus with Theory

Prereq.: 18.012
U (2)
5-0-7

Continues 18.012. Parallel to 18.02, but at a deeper level, emphasizing careful reasoning and understanding of proofs. Considerable emphasis on linear algebra and vector integral calculus.
J. R. Munkres

18.03 Differential Equations

Prereq.: 18.002 or 18.02 or 18.021 or 18.022
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. Emphasizes formulation of natural phenomena in terms of differential equations and interpretation of the solutions.
Term 1: *D. G. Quillen, J. Kahn*
Term 2: *A. Toomre, Staff*

18.04 Complex Variables with Applications

Prereq.: 18.03
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: *K. K. Tung*

18.041 Principles of Applied Mathematics

Prereq.: 18.002 or 18.02 or 18.021 or 18.022
U (1)
3-0-9

Introductory survey of fundamental concepts in applied mathematics: optimization, random process, coding, computer algorithms. This independent half of the complete sequence emphasizes the ideas and topics that relate to a "discrete" mathematical approach: computation, combinatorics, probability, linear programming.
G. L. Miller

18.042 Principles of Applied Mathematics

Prereq.: 18.03
U (2)
3-0-9

Introductory survey of fundamental concepts in applied mathematics: propagation, stability, equilibrium, optimization. This independent half of the complete sequence emphasizes 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
U (2) SD
3-0-9

Elementary introduction, with applications to the social, physical, and life sciences. More oriented toward theory and concepts than 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.: —
U (1) G (1) SD
3-0-9

Introduces 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

18.057 Introduction to Applied Statistics (A except XVIII)

Prereq.: —
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; normal distribution; estimation of proportions and means; one-way analysis of variance; correlation and multiple regression; analysis of 2- and 3-way frequency tables. 18.057 emphasizes the intuitive bases of common statistical procedures and using interactive computer packages to analyse a wide variety of data sets. Does not preclude taking 18.441, 18.443, or 18.444 for credit.
W. H. DuMouchel

18.063 Introduction to Algebraic Systems

Prereq.: 18.02 or 18.002 or 18.021 or 18.022
U (1) SD
4-0-8

Introduction to algebraic systems primarily for students interested in computer and information sciences, with emphasis on finite systems. Reviews elementary set theory, natural numbers, modular arithmetic, induction, counting arguments. 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
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
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. Information: F. B. Hildebrand.
Term 2: *F. B. Hildebrand*

18.076 Advanced Calculus for Engineers (A except II, VI, XVI, XVIII, XXII)

Prereq.: 18.075
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. Information: F. B. Hildebrand.
Term 1: *F. B. Hildebrand*

18.085 Methods of Applied Mathematics for Engineers (A except VI and XVIII)

Prereq.: 18.075
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. Information: F. B. Hildebrand.

18.089 Review of Mathematics

Prereq.: —
G (S)
Arr.

Reviews calculus and differential equations. Primarily for students in Course XIII-A. Degree credit allowed only in special circumstances.
A. P. Mattuck

18.093 Tutoring in Mathematics

Prereq.: 18.002 or 18.02 or 18.021 or 18.022
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.
A. P. Mattuck

18.099 Independent Activities

Prereq.: —
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

Analysis

18.100 Analysis I (A except XVIII)

Prereq.: 18.03 or 18.031
U (1, 2) G (1, 2)
3-0-9

Two options offered, both covering fundamentals of mathematical analysis: convergence of sequences and series, continuity, differentiability, Riemann integral, sequences and series of functions, uniformity, interchange of limit operations. Both options show the utility of abstract concepts and teach understanding and construction of proofs. *Option A* chooses less abstract definitions and proofs, and gives applications where possible. *Option B* is more abstract and is for students with more mathematical maturity; places greater emphasis on point-set topology.
Option A: Term 1: *H. Bercovici*
Term 2: *A. P. Mattuck*
Option B: Term 1: *I.E. Segal, Staff*
Term 2: *W. Ambrose, Staff*

18.101 Analysis II (A except XVIII)

Prereq.: 18.100, 18.701 or 18.710
U (1) G (1)
3-0-9

Continues 18.100, stressing the topics most useful in the study of manifolds and global analysis: differentiable maps, Jacobians, differentials, inverse and implicit function theorems, n-dimensional Riemann integral, change of variables in multiple integration, differential forms, general version of Stokes' theorem.
J. R. Munkres

18.102 Analysis II (A except XVIII)

Prereq.: 18.100
G (2) **Next offered 1984-85**
3-0-9

Continues 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.
S. M. Paneitz, Staff

18.103 Fourier Analysis—Theory and Applications (A except XVIII)

Prereq.: 18.100
G (2)
3-0-9

Continues 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
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. Students report on and discuss topics taken from current journals or from texts not regularly used in other mathematics subjects. Certain topics may require an additional prerequisite. Topic 1983-84: Distributions.
W. Ambrose

18.115 Functions of a Complex Variable (A)

Prereq.: 18.100
G (1)
3-0-9

Exponential and trigonometric functions, Cauchy integral formula, holomorphic and meromorphic functions. Infinite series and products, the gamma function. Harmonic functions, conformal mapping, Dirichlet's problem.
D. S. Jerison

18.116 Topics in Complex Variables (A)

Prereq.: 18.115
G (2)
3-0-9

Topics vary from year to year: may be repeated for credit. Topics in the past: classical theory of automorphic functions; modular forms; and Riemann surfaces. Emphasizes as elementary an exposition as possible.
N. C. Ankeny

18.117 Topics in Several Complex Variables (A)

Prereq.: 18.115, 18.125
G (1) **Next offered 1984-85**
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. $\bar{\partial}$-Neumann problem.
D. S. Jerison, Staff

18.125 Measure and Integration (A)

Prereq.: 18.100
G (1)
3-0-9

General theory of Lebesgue integration. Foundations of real analysis. The basic theorems of Fubini, Radon-Nikodym, Riesz-Fischer, et al.; Banach, L^p and Hilbert spaces.
W. Ambrose

18.126 Functional Analysis (A)

Prereq.: 18.125
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.
H. Bercovici

18.128 Geometric Measure Theory (A)

Prereq.: 18.125
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.
F. Morgan

18.129 Operator Theory (A)

(18.247)
Prereq.: 18.125
G (1)
3-0-9

General theory of bounded and unbounded linear operators. Spectral theory in Hilbert space. Stone and Hille-Yosida theorems. Perturbation and scattering theory. C*- and W*-algebras of operators. Applications to harmonic analysis; the Plancherel theorem for general groups. Direct integrals of Hilbert spaces and spectral multiplicity theory.
I. E. Segal

18.135 Fourier Analysis (A) (Revised Content)

Prereq.: 18.125
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)

Prereq.: 18.102
G (1)
3-0-9

Treats 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.
G. Uhlmann

18.156 Introduction to Microlocal Analysis (A)

Prereq.: 18.155, 18.965
G (2)
3-0-9

Examines 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)

Prereq.: 18.155, 18.156
G (1) **Next offered 1984-85**
3-0-9

Examines 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.
R. B. Melrose, Staff

18.158 Topics in Differential Equations (A)

Prereq.: 18.125
G (1)
3-0-9

Content varies from year to year; may be repeated for credit. Topics for 1983-84: Nonlinear functional analysis and differential equations in Banach spaces; applications to nonlinear partial differential equations. Degrees of mappings and fixed-point theorems. Calculus in Banach spaces. Implicit function theorem. Nonlinear semigroups. Global treatment of nonlinear wave equations.
S. M. Paneitz

18.168 Analysis on Lie Groups and Homogeneous Spaces (A)

Prereq.: 18.755
G (2) **Next offered 1984-85**
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.
S. Helgason, Staff

18.175 Theory of Probability (A)

Prereq.: 18.125
G (2) **Next offered 1984-85**
3-0-9

Ergodic theorems, laws of large numbers, convergence of probability measures, central limit theorems, stochastic processes, Brownian motion, martingales, strong Markov properties.
R. M. Dudley, Staff

18.177 Stochastic Processes (A)

Prereq.: 18.175
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 Graduate Analysis Seminar (A) (New)

Prereq.: Permission of Instructor
G (1)
3-0-21

Studies original papers in differential analysis and differential equations. Intended for first- and second-year graduate students. Permission must be secured in advance.
R. B. Melrose

18.255 Mathematical Theory of Quantum Fields (A) (Revised Content)

Prereq.: Permission of Instructor
G (2)
3-0-9

Free boson and fermion fields and their particle and wave representations. Functional integration; real Hilbert space case and relations with Wiener integral; holomorphic functionals on complex Hilbert space. Clifford algebra; spinors in Hilbert space. Quantization of relativistic wave equations and generalizations in curved space-times. Nonlinear local functions of quantum fields; constructive quantum field theory. Requires basic operator theory or intuitive quantum field theory and appropriate mathematical arrangements.
I. E. Segal

18.256 Theoretical and Statistical Cosmology (A)

(18.259)
Prereq.: Permission of Instructor
G (2) **Next offered 1984-85**
3-0-9

The empirical background of cosmology; major observations and selection effects; survey of theories. Optimal statistical methods for model building and cosmological hypothesis testing. Mathematical theory of space-times with given structures; isotropy and homogeneity considerations. Chronometric and Doppler redshift theories; Einstein, deSitter, and Friedman-Lemaitre universes; the cosmic background radiation. Requires equivalent of graduate standing in mathematics or physics.
I. E. Segal

18.257 The Architecture of Fundamental Mathematical Physics (A)

Prereq.: Permission of Instructor
G (1) **Next offered 1984-85**
3-0-9

The basic principles of cosmology, elementary particle and quantum field theory, and general relativity, from a modern mathematical standpoint. For mathematicians who want an overview of fundamental theoretical physics, or for physicists who want to see how higher mathematics (C*-algebra, symmetries in space-time bundles, nonlinear partial differential equations, functional integration) is applicable. For integration and orientation; not a substitute for detailed technical courses.
I. E. Segal

18.284 Introduction to Functions of a Complex Variable (A except XVIII)

Prereq.: 18.03
G (1)
3-0-9

18.285 Introduction to Functions of a Complex Variable (A)

Prereq.: 18.115 or 18.284
G (2) **Next offered 1984-85**
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.
R. P. Stanley

18.295 Tensor Calculus (A)

Prereq.: 18.700
G (1)
3-0-9

Tensors, differential forms and Riemannian geometry with applications in general relativity. Some modern differential geometry.
S. J. Gates

Applied Mathematics

18.301 Introduction to Physical Mathematics I

Prereq.: 18.03
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.
D. Z. Freedman

18.302 Introduction to Physical Mathematics II

Prereq.: 18.301, 18.04 or 18.284
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.
P. Marcus

18.305 Methods of Applied Mathematics I (A)

Prereq.: 18.04 or 18.075 or 18.284 or 18.302
G (1)
3-0-9

18.306 Methods of Applied Mathematics II (A)

Prereq.: 18.04 or 18.075 or 18.284 or 18.302
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; WKB method; multiple scales. Term 2: partial differential equations; transform methods; characteristics, initial and boundary-value problems; Green's functions; singular perturbation problems; nonlinear wave propagation.
18.305: *A. Fowler*
18.306: *S. A. Orszag*

18.307 Methods of Applied Mathematics III (A)

Prereq.: 18.04 or 18.075 or 18.284 or 18.302
G (1)
3-0-9

Selection of material from the following topics: calculus of variations (the first variation and the second variation). 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
G (2)
3-0-9

Reviews 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. Emphasizes topics of current research interest.
R. R. Rosales

18.313 Probability

Prereq.: 18.002 or 18.02 or 18.021 or 18.022
U (2) SD
4-0-8

Development of theory and applications of probabilistic concepts for scientists and engineers. Emphasizes 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. Introduces the Central Limit Theorem and the foundations of probability.
G.-C. Rota

18.314 Applied Combinatorial Analysis

Prereq.: 18.001 or 18.01 or 18.011 or 18.012
U (2)
3-0-9

Applications of combinatorial methods to practical problem solving. Emphasizes problems involving discrete optimization. Techniques from graph theory, matching theory, network flows. Other topics include enumeration, sorting and coding.
D. R. Richman

18.315 Combinatorial Theory (A)

Prereq.: Permission of Instructor
G (1)
3-0-9

Content varies from year to year. May be repeated for credit. Topics for 1983-84: lattice theory, enumeration, umbral calculus, Möbius functions, generating functions, incidence geometries, matroids, matching theory, Ramsey theory, graphs.
G.-C. Rota

18.316 Seminar in Combinatorics (A)

Prereq.: Permission of Instructor
G (2)
3-0-9

Content varies from year to year; may be repeated for credit. Readings from current research papers in combinatorics. Topic to be chosen and presented by the class.
D. J. Kleitman

18.318 Topics in Combinatorics (A)

Prereq.: Permission of Instructor
G (2)
3-0-9

Content varies from year to year; may be repeated for credit. Topic for 1983-84: symmetric functions and their applications to combinatorics and representation theory.
R. P. Stanley

18.325 Topics in Applied Mathematics (A)

Prereq.: Permission of Instructor
G (1, 2)
3-0-9

Term 1: **Large-Scale Dynamics in the Atmosphere and Oceans.** Geostrophic equations on a sphere. Internal Rossby waves. Planetary mountain waves and radiation of energy. Instabilities of currents. Energy cycles; enstrophy and geostrophic turbulence. Term 2: **Techniques of Mathematical Modeling.** Dimensional and scaling analysis, bifurcation theory, nonlinear stability, singular perturbation theory, with specific applications to problems in geophysics, biology, engineering, and industry. Topics in terms 1 and 2 are independent.
Term 1: *K.K. Tung*
Term 2: *A. Fowler*

18.335 Numerical Methods of Applied Mathematics I (A)

Prereq.: 18.302, 18.700
G (1)
3-0-9

18.336 Numerical Methods of Applied Mathematics II (A)

Prereq.: 18.335
G (2)
3-0-9

Introduces 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.
P. Marcus, Staff

18.354 Fluid Mechanics

Prereq.: 18.04 or 18.075 or 18.302
U (1)
3-0-9

18.355 Fluid Mechanics (A)

Prereq.: 18.354
G (2)
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. 18.355 is a selection of topics from other fluids courses not offered this year.
18.354: *D. J. Benney*
18.355: *W. V. R. Malkus*

18.356 Rotating Fluids (A)

Prereq.: 18.305, 18.354
G (1)
3-0-9

General theory of rotating fluid motions; transient flows; effects of viscosity, stratification, and compressibility; wave motion; nonlinear interactions; applications to planetary flow.
W. V. R. Malkus

18.357 Seminar in Fluid Dynamics (A)

Prereq.: 18.354
G (1)
3-0-9

Nonlinear stability theory; theories of transition, onset of chaos. Statistical theories of turbulence. Properties of homogeneous and shear turbulence.
S. A. Orszag

18.358 Hydrodynamic Stability and Turbulence (A)

Prereq.: 18.355
G (2) **Next offered 1984-85**
3-0-9

Linear stability theory of incompressible and compressible flows. Nonlinear stability theory; theories of transition, onset of chaos. Statistical theories of turbulence. Turbulence transport approximations. Properties of homogenous and shear turbulence.
W. V. R. Malkus

18.375 Stellar Dynamics and Galaxies (A)

Prereq.: 8.06, 18.076, or 18.302
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. Global modes, dynamical mechanisms for their excitation and maintenance. Simulation of real galaxies.
C. C. Lin

18.395 Group Theory with Applications to Physics (A)

Prereq.: 18.302 or 18.305 or 8.321
G (2) **Next offered 1984-85**
3-0-9

Selection of topics from the theory of finite groups, Lie groups, and group representations presented with some applications to quantum mechanics and particle physics.
D. Z. Freedman

18.396 Topics in Theoretical Physics (A)

Prereq.: 8.321
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, 18.063 or 18.703
U (2)
3-0-9

Topics in algebra with application to computer science. Introduces algorithms and relevant algebra. Possible topics in algebra: modular arithmetic, permutation groups, finite fields, polynomial rings, linear algebra, and lattices. Applications to primality testing, factoring polynomials and integers, GCD, coding theory, cryptography, discrete Fourier transforms, Rubic cubes, isomorphism testing. Some knowledge of linear or abstract algebra useful. Complements 18.424 but may be taken independently. No computer programming.
G. L. Miller

18.420J Computability, Automata, and Formal Languages

(Same subject as 6.045J)
Prereq.: 18.041 or 18.063
U (1, 2)
3-0-9

See description under subject 6.045J.
Term 1: *C. Leiserson*
Term 2: *M. Sipser*

18.424 Linear and Combinatorial Optimization (Revised Content)

Prereq.: 18.700
U (1)
3-0-9

Linear programming, simplex algorithm, duality theorems, implications; matching algorithms, network flows and related linear programs; graph problems; NP-completeness. Complements 18.411, but may be taken independently.
R. Kannan

18.425 Symbolic and Algebraic Computation (A)

Prereq.: 18.700, 18.411 or 18.703
G (2)
3-0-9

Studies the computational complexity of algebraic questions. Topics: tests for primality, factoring integers and polynomials, finite fields, algebraic fields and solvability by radicals, permutation groups and graph isomorphism, polynomial root finding.
G. L. Miller

18.427J Theory of Computation (A)

(Same subject as 6.840J)
Prereq.: 6.045J or 18.420J, 18.511
G (1)
3-0-9

A graduate introduction to computability, undecidability, computational complexity, mathematical logic, and expressiveness of programs. Elementary recursion theory: Gödel numberings, reducibility, degrees of undecidability, Kolmogorov complexity. Elementary complexity theory: time and space measures on computation, inherently complex decidable predicates, efficient reducibility, complete problems. Undecidable theorem-proving problems: predicate calculus and arithmetric. Inherently complex decidable problems: examples from logic and automata theory.
M. Sipser, A. R. Meyer

18.428 Computation by Automata (A)

Prereq.: 18.420J or 18.427J
G (2) **Next offered 1984-85**
3-0-9

An advanced course in complexity theory exploring current research topics. Nondeterministic, alternating, probabilistic, and parallel computation models. Boolean circuits. Complexity classes and complete sets. The Polynomial-time hierarchy. Relativization. Definitions of randomness. Approaches to the P = ?NP and related questions. Alternate years.
M. Sipser

18.436 Topics in Algorithms and Complexity

Prereq.: Permission of Instructor
G (2)
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.
F. T. Leighton

18.437J Algorithms (A)

(Same subject as 6.851J)
Prereq.: 18.063, 18.700; 6.046 or 18.411 or 18.424
G (2)
3-0-9

See description under subject 6.851J.
R. Kannan, R. L. Rivest

18.438 Advanced Algorithms (A)

Prereq.: 18.437J
G (1)
3-0-9

Explores in greater depth topics from 18.437J/6.851J and current research in algorithms. Topics differ from year to year. Students read and present research papers in class. May be repeated for credit.
R. Kannan

18.439 Theory of Parallel Computation and VLSI (A) (New)

Prereq.: 18.437J
G (1)
3-0-9

Draws material from current research topics involving parallel computation on fixed-connection networks and Very Large Scale Integration (VLSI). Includes algorithms for sorting, matrix multiplication, FFT and min spanning tree on systolic arrays, shuffle-exchange graphs and meshos of trees. VLSI topics: mathematical modeling of chips, area-time trade-offs, algorithms for placement and routing, designs of configurable and fault-tolerant systems, schemes for minimizing propagation delays and wafer-scale integration.
F. T. Leighton

Applied Mathematics: Statistics

18.440 Probability and Random Variables

Prereq.: 18.002 or 18.02 or 18.021 or 18.022
U (1, 2) SD
4-0-8

Topics 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. Applications to statistics and decision theory. Information: R. M. Dudley.
Term 2: *R. M. Dudley*

18.441 Statistical Inference (A except XVIII)

Prereq.: 6.041 or 18.440 or 18.313
U (2), G (2)
4-0-8

Introduces 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. Information: S. Ellis.

18.443 Statistics for Applications (A except XVIII)

Prereq.: 18.440 or 18.313 or 6.041
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. Information: S. Ellis.

18.444 Probability and Statistics for Scientists and Engineers (A)

Prereq.: 18.002 or 18.02 or 18.021 or 18.022, 18.700
G (1)
Arr.

Accelerated introduction covering material in 18.440, 18.441 and part of 18.445J; for engineers and scientists talented mathematically and who need to apply statistical ideas but lack time for two or three semesters of course work. Case study point of view. 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. Information: S. Ellis.

18.445J Introduction to Stochastic Processes (A)

(Same subject as 15.073J)
Prereq.: 18.313 or 18.440 or 6.041
G (1, 2)
4-0-8

Introduces the theory and application of stochastic processes. Empirical phenomena for which stochastic processes provide models. Random walk, gambler's ruin, recurrent events, discrete-time Markov chains, Branching processes, Poisson processes, renewal theory. Continuous-time Markov chains, birth and death processes, queueing theory, and Brownian motion. Information: S. Ellis.

18.446 Applied Time Series Analysis (A)

Prereq.: 18.443
G (1)
4-0-8

Statistical techniques commonly used to analyze time series data. Topics: estimation of trends and seasonal adjustment, stationary series — autocorrelation and spectrum. Estimation and interpretation of spectra. ARIMA models and fitting them to data. Analysis of bivariate series — cross correlation and cross spectrum. Emphasizes learning techniques by using them on actual data.
S. Ellis

18.448 The Analysis of Categorical Data (A)

Prereq.: 18.441 or 18.443 or 15.075
G (2)
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. 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
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 analysis of covariance (ANOCOVA). Properties of the

multivariate normal and related distributions, linear models, general linear hypothesis. Geometric interpretation. Finally: effect of departure from assumptions and nonparametric analogs of ANOVA. Information: W. H. DuMouchel.

18.456 Multivariate Methods in Statistics (A)

Prereq.: 18.700, 18.441
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. Selects topics from the following: multivariate regression, discriminant analysis, and pattern classification. Cluster analysis, factor analysis, and principal components. Multidimensional scale analysis. Contingency tables. Information: S. Ellis.

18.457J Statistics for Model Building (A)

(Same subject as 15.076J)
Prereq.: 18.443 or 15.075, 18.700
G (2)
3-0-9

See description under subject 15.076J.
R. E. Welsch

18.458 Non-parametric Statistics and Statistical Robustness (A)

Prereq.: 18.440, 18.441
G (1)
3-0-9

Statistical methods commonly used when the functional form of the underlying distribution is unknown. Nonparametric methods 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. Also discusses goodness of fit tests, including chi-square, contingency tables, and Kolmogorov-Smirnov methods. Information: W. H. DuMouchel.

18.459 Statistical Laboratory (A)

Prereq.: Permission of Instructor
G (2)
2-0-4

Lectures consist of presentations of applied problems with or without solutions. Students 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.
W. H. DuMouchel

18.465 Topics in Statistics (A)

Prereq.: Permission of Instructor
G (1, 2)
3-0-9

Introduces some special theoretical topics in mathematical statistics at an intermediate level. Assumes familiarity 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. Information: S. Ellis.

18.466 Mathematical Statistics (A)

Prereq.: 18.441 or 18.443
G (1)
3-0-9

Decision theory, estimation, confidence intervals, hypothesis testing. Introduces large sample theory. Asymptotic efficiency of alternative statistical procedures. Linear statistical inference. Permission of instructor required.
R. M. Dudley

18.467 Mathematical Statistics (A)

Prereq.: 18.466, 18.102 or 18.125
G (2)
3-0-9

Continues 18.466, using elementary measure theory. Sequential analyses. Permission of instructor required.
R. M. Dudley, Staff

18.468 Advanced Time Series Analysis (A)

Prereq.: 18.441 or 18.443
G (2)
4-0-8

Stationary vector processes. Correlation. Spectra. Vector autoregressive-moving average models — parameterisation and estimation. The Kalman filter. Depending on participants' interests, topics chosen from: robust filtering and parameter estimation; incomplete data problems; model order determination; nonlinear models. Permission of instructor required.
S. Ellis

18.475 Current Topics in Statistics (A) (New)

Prereq.: Permission of Instructor
G (2)
3-0-6

Introduces current topics in applied mathematical statistics at an intermediate level. Assumes students are familiar with the elements of probability theory and the fundamental concepts and basic techniques of statistical inference. Typically covers several topics connected by a common theme. Information: S. Ellis.

18.485 Risk Theory (A)

Prereq.: 18.441 or 18.443
G (1)
3-0-9

Surveys 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. Information: W. H. DuMouchel.

Logic

18.504 Seminar in Logic

Prereq.: —
U (2) **Next offered 1984-85**
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. Students report on and discuss topics taken from current journals or from texts not regularly used in other mathematics subjects.
S. D. Friedman, Staff

18.511 Introduction to Mathematical Logic

Prereq.: —
U (1)
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.
H. Rogers, Jr.

18.515 Mathematical Logic (A)

Prereq.: 18.511
G (1)
3-0-9

18.516 Mathematical Logic (A)

Prereq.: 18.515
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.
18.515: *M. Stanley*
18.516: *S. D. Friedman*

18.565 Recursion Theory (A)

Prereq.: 18.516
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.
S. D. Friedman

18.575 Theory of Models (A)

Prereq.: 18.516
G (1) **Next offered 1984-85**
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, Staff

18.585 Set Theory (A)

Prereq.: 18.516
G (2)
3-0-9

Forcing. Chooses other topics in set theory 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.
M. Stanley

18.595 Seminar on Current Topics in Logic (A)

Prereq.: 18.565, 18.575, 18.585
G (1, 2)
3-0-9

Analyzes results of current interest in logic. Students present recent developments in the field for general discussion. Uses formal and informal sources. 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
G (2)
3-0-9

Universal algebra. General properties shared by algebraic systems. Categories of algebras, free algebras, independence, elementary equivalence, equational completeness, elements of model theory, properties preserved under algebraic operations. 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
U (1, 2, S) SD
3-0-9

Basic subject on matrix theory and linear algebra, emphasizing topics useful in other disciplines: systems of equations, vector spaces, determinants, eigenvalues, similarity, positive definite matrices. Applications to Gauss elimination with pivoting, least squares approximations, stability of differential equations, linear programming, and game theory. Compared with 18.710 this subject is oriented towards linear algebra as used in applications. 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
U (1)
3-0-9

18.702 Algebra II

Prereq.: 18.701
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. First term: group theory, geometry, and linear algebra. Second term: rings and fields: ideals, polynomial rings, factorization, modules, Jordan form for matrices, extension fields, Galois theory.
R. D. Schafer

18.703 Modern Algebra

Prereq.: 18.002 or 18.02 or 18.021 or 18.022
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, emphasizing 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.
Term 1: *G. W. Whitehead*
Term 2: *J. H. Silverman*

18.704 Seminar in Algebra and Number Theory

Prereq.: 18.702 or 18.703
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. Students report on and discuss topics taken from current journals or from texts not regularly used in other mathematics subjects.
R. D. Schafer

18.705 Commutative Algebra (A)

Prereq.: 18.701-02 or 18.700, 18.703
G (1)
3-0-9

18.706 Noncommutative Algebra (A)

Prereq.: 18.705
G (2) **Next offered 1984-85**
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.
L. Ein

18.710 Abstract Linear Algebra

Prereq.: 18.002, 18.02 or 18.021 or 18.022
U (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. Information: A. P. Mattuck.

18.711 Game Theory (Revised Content)

Prereq.: —
U (1)
3-0-9

Two-person combinatorial games. Finding winning moves in such games as Nim, Hackenbush, and Dots-and-Boxes. Analysis of positions. Algorithmic and algebraic strategies for reduction of positions. Study of impartial games. Matrix games not treated. No formal prerequisite, but students should be familiar with mathematical reasoning.
D. R. Richman

18.715 Homological Algebra (A) (Revised Content)

Prereq.: 18.705
G (1)
3-0-9

18.716 Homological Algebra (A) (Revised Content)

Prereq.: 18.715
G (2)
3-0-9

The cyclic cohomology of Connes for algebras, applications to the index theorem and algebraic K-theory.
D. G. Quillen

18.720 Applications of Linear Algebra

Prereq.: 18.700 or 18.710
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. Develops from the foundation provided by 18.700.
W. G. Strang

18.725 Algebraic Geometry (A)

Prereq.: 18.705
G (1)
3-0-9

Introduces contemporary algebraic geometry. 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
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. Topic 1983-84: Continuation of 18.725.
S. Kleiman

18.735 Topics in Algebra (A)

Prereq.: 18.702 or 18.703
G (1) **Next offered 1984-85**
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. Information: N. C. Ankeny.

18.737 Linear Algebraic Groups (A)

Prereq.: 18.705
G (2)
3-0-9

Introduces 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
G (1) **Next offered 1984-85**
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.
V. Kač, Staff

18.745 Introduction to Lie Algebras (A)

Prereq.: 18.755
G (2)
3-0-9

Emphasizes 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 modules.
S. Helgason

18.749 Infinite-dimensional Lie Algebras (A)

Prereq.: 18.745
G (2) **Next offered 1984-85**
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, Staff

18.755 Introduction to Lie Groups (A)

Prereq.: 18.100, 18.710
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 on Lie Groups (A)

Prereq.: 18.755
G (2) **Next offered 1984-85**
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. Emphasizes connections with classical analysis and representation theory.
S. Helgason, Staff

18.757 Representations of Lie Groups (A)

Prereq.: 18.755
G (1)
3-0-9

Lie groups, Lie algebras, and their representations. Induced representations. Representations of compact groups, nilpotent groups, and semi-simple groups. Analysis on semisimple Lie groups and symmetric spaces. Invariant differential operators and their role in representation theory.
B. Kostant

18.758 Representations of Lie Groups (A)

Prereq.: 18.757
G (2) **Next offered 1984-85**
3-0-9

Representations of semisimple Lie groups: theory of Harish-Chandra modules, Langlands' classification, Kazhdan-Lusztig conjectures. Decomposition of principal series representations, unitarity problem.
D. A. Vogan, Staff

18.765 Harmonic Analysis on Symmetric Spaces and Applications (A) (New)

Prereq.: Permission of Instructor
G (1)
3-0-9

Harmonic analysis on 1) symmetric spaces such as the Poincaré, quaternionic, and Siegel upper-half planes, 2) fundamental domains for the action of discrete groups of isometrics. Part 1 involves work of Harish-Chandra and Helgason. Part 2 involves analogues of Poisson's summation formula such as Selberg's trace formula. Applications to number theory, statistics, and mathematical physics.
A. A. Terras

18.769 Topics in Lie Theory (A)

Prereq.: Permission of Instructor
G (1, 2) **Next offered 1984-85**
3-0-9

Topics in Lie theory, varying from year to year. May be repeated for credit. Term 1: representations of reductive groups over a finite field; representations of Hecke algebras. Term 2: representation theory of infinite dimensional Lie algebras and groups and its applications. Possible topics: Bruhat decomposition of infinite flag varieties, singularity theory, and completely integrable systems. Requires familiarity with Lie groups and Lie algebras.
Term 1: *G. Lusztig*
Term 2: *V. Kač*

18.775 Algebraic Number Theory (A)

Prereq.: 18.705
G (2)
3-0-9

18.776 Algebraic Number Theory (A)

Prereq.: 18.775
G (2) **Next offered 1984-85**
3-0-9

Reviews basic algebraic number theory. Classical formulation of class field theory, including existence and uniqueness of class fields, the conductor-discriminant formula, Artin's reciprocity law. Artin L-series. Adelic formulation. The "simple algebra" approach. Applications to the study of arithmetic of cubic fields and (if time permits) to the theory of complex multiplication.
D. J. Wright

18.781 Theory of Numbers

Prereq.: 18.701 or 18.703
U (1)
3-0-9

Studies 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.
N. C. Ankeny

18.785 Analytic Number Theory (A)

Prereq.: 18.115
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.
N. C. Ankeny

18.786 Topics in Number Theory (A)

Prereq.: Permission of Instructor
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; diophantine geometry. Topic for 1983-84: Modular forms.
H. M. Stark

Topology and Geometry

18.901 Introduction to Topology I (A except XVIII)

Prereq.: 18.100
G (1, 2)
3-0-9

18.902 Introduction to Topology II (A except XVIII)

Prereq.: 18.901, 18.701 or 18.703
G (2)
3-0-9

Introduces 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.
18.901: Term 1: *G. W. Whitehead*
Term 2: *T. D. Cochran*
18.902: *G. W. Whitehead*

18.904 Seminar in Topology

Prereq.: 18.901
U (2) **Next offered 1984-85**
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. Students report on and discuss topics taken from current journals or from texts not regularly used in other mathematics subjects. Certain topics may require an additional prerequisite.
D. M. Kan, Staff

18.905 Algebraic Topology (A)

Prereq.: 18.702 or 18.705; 18.901
G (1)
3-0-9

18.906 Algebraic Topology (A)

Prereq.: 18.905
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.
F. P. Peterson

18.915 Graduate Topology Seminar (A)

Prereq.: 18.906
G (1)
3-0-21

Study and discussion of important original papers in the various parts of algebraic and differential topology. Open to all students who have had 18.906 or the equivalent, not only prospective topologists.
D. M. Kan

18.917 Advanced Topology (A)

Prereq.: 18.906
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.
T. D. Cochran

18.950 Elementary Differential Geometry

Prereq.: 18.100
U (2) **Next offered 1984-85**
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.
W. Ambrose, Staff

18.961 Elementary Differential Topology

Prereq.: 18.101, 18.901
U (2)
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.
W. M. Goldman

18.965 Geometry of Manifolds (A)

Prereq.: 18.101
G (1)
3-0-9

18.966 Geometry of Manifolds (A)

Prereq.: 18.965
G (2)
3-0-9

Differentiable manifolds, vector fields and forms, introduction to Lie groups, the DeRham theorem, Riemannian manifolds. 18.966 continues 18.965. Focuses on symplectic geometry and classical dynamical systems.
V. W. Guillemin

18.969 Topics in Geometry (A)

Prereq.: 18.965
G (1) **Next offered 1984-85**
3-0-9

Content varies from year to year; may be repeated for credit. Topics have included geometry of hyperbolic space; discontinuous groups of isometries of hyperbolic space; limit sets of Kleinian groups; uniformization; convexity; structure of discrete subgroups; rigidity; deformation theory (Teichmüller space, geometric convergence, hyperbolic Dehn surgery); ergodic properties of geodesic flow; existence of hyperbolic structures on 3-manifolds. Permission of instructor required for students not having 18.965.
W. M. Goldman, Staff

18.975 Elliptic Operators (A)

Prereq.: 18.965
G (1) **Next offered 1984-85**
3-0-9

18.976 Elliptic Operators (A)

Prereq.: 18.975
G (2) **Next offered 1984-85**
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. 18.976 continues 18.975. Spectral properties of differential and pseudodifferential operators on open manifolds, scattering theory, non-self-adjoint operators.
V. W. Guillemin, Staff

18.994 Seminar in Geometry

Prereq.: —
U (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. Students report on and discuss topics from current journals or texts not regularly used in other math subjects. May be repeated for credit.
R. B. Melrose, Staff

18.999 Mathematical Reading

Prereq.: —
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.
N. C. Ankeny

19 Meteorology and Physical Oceanography

19.UR Undergraduate Research

Prereq.: —
U (1, 2)
Arr.

Undergraduate research opportunities in Meteorology. For further information consult the Departmental Coordinator.
F. Sanders, Staff

19.05J Environmental Chemistry of the Ocean-Atmosphere System

(Same subject as 12.20J)
Prereq.: —
U (1)
3-0-9

See description under subject 12.20J.
R. E. Newell, J. M. Edmond

19.10 Past and Present Climate

Prereq.: —
G (2)
3-0-9

Properties of climate system. Climatic fluctuations on time scales up to 100,000 years. Phenomena of drought, biennial oscillation and Southern Oscillation. Role of volcanoes, carbon dioxide changes and anthropogenic effects in altering climate. Reconstruction of ice-age climate from ocean bed cores, pollen records, isotope rations in ice cores. Theories of ice ages. Recent climate forecasting. Relationships between climate, agriculture, and energy. Prerequisite: Institute Science Requirement.
R. E. Newell

19.43 Synoptic Meteorology I (A)

Prereq.: 19.69 or 18.350
G (1)
3-3-6

Develops 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. Analyzes current weather situations as global database and interest dictates. Forecasting for Boston.
F. Sanders

19.44 Synoptic Meteorology II (A)

Prereq.: 19.43
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. Analyzes meteorological data, both routinely available and from special field experiments.
F. Sanders

19.46 Numerical Modeling in Meteorology and Oceanography (A)

Prereq.: 19.71J
G (1)
3-0-9

Derives simplified sets of model equations, primarily by scale analysis. Discusses characteristics of atmospheric and oceanographic motions relevant to numerical analysis. Studies principal numerical methods used in geophysical fluid models. Consistency, convergence, linear and nonlinear stability. Data assimilation and the problem of meteorological noise. Draws examples from meteorology and oceanography, with emphasis on numerical weather prediction.
M. A. Cane

19.50 Physical Meteorology (A) (New)

Prereq.: 5.60, 18.075
G (1)
3-0-9

Introduces atmospheric thermodynamics, physics, and chemistry. Thermodynamics of moist and dry air. Physics and chemistry of clouds and precipitation. Transfer of solar and thermal radiation through the atmosphere and radiative heating. Atmospheric electricity. Remote sensing of atmospheric temperature, winds, precipitation, and composition by passive (e.g., infrared radiance) or active (e.g., radar) techniques.
R. E. Passarelli, R. G. Prinn

19.63 Diagnostic Studies of the General Circulation (A)

Prereq.: 19.70J or 19.71J
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. Discusses the validation and use of numerical general circulation models as atmospheric analogs.
P. H. Stone, R. D. Rosen

19.64 Atmospheric Modeling (A)

Prereq.: 19.70J or 19.71J, 19.72
G (2)
3-0-9

Develops 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. Applies 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
G (1)
3-0-9

See description under subject 16.044J.
E. L. Mollo-Christensen, M. T. Landahl

19.66 Atmospheric Convection (A)

Prereq.: 19.69
G (2)
3-0-9

Introduction and theory of dry convection over isolated heat sources. Basic theory of Rayleigh convection. Extensive treatment of the thermodynamics of moist and cloudy air. Observations and dynamics of isolated convective clouds; turbulence in saturated and partly saturated mixtures. Moist and dry convective boundary layers. Organization of moist convection on larger scales and interaction of convective ensembles with the large-scale environment.
K. A. Emanuel

19.681 Synoptic Scale Dynamics in the Atmosphere and Oceans (A)

Prereq.: 19.69, 19.70J, 19.71J
G (1)
3-0-9

Quasi-geostrophic equations for a stratified fluid on a sphere. 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. 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.
E. N. Lorenz

19.682 Instability and Turbulence in Geophysical Systems (A)

Prereq.: 19.681
G (2)
3-0-9

Comprehensive introduction to the methodology of stability theory as applied to problems of interest in geophysical fluid dynamics. Emphasizes problems governed by quasi-geostrophic dynamics. 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.
G. Flierl

19.69 Fluid Dynamics of the Atmosphere and Ocean (A)

Prereq.: 8.03, 18.04
G (1)
3-0-9

Introductory subject for first-year graduate students in meteorology and oceanography. Eulerian and Lagrangian kinematics. Equations of mass, momentum, and energy in Eulerian form in rotating frames of reference. Vorticity, vorticity theorems, and Bernoulli theorems. Potential vorticity. Role of fluid rotation on the planetary scale. Rossby waves. Ekman layers. Wave motion and instability. Scaling and geostrophic approximation. Rudiments of potential theory.
(Woods Hole Staff): J. Pedlosky

19.70J Steady Circulation of the Atmosphere and Ocean (A)

(Same subject as 12.70J)
Prereq.: 19.69
G (2)
3-0-9

Uses fundamental principles in modeling steady flows in the atmosphere and ocean illustrating general methods which apply to either fluid and also important contrasts between the two. Including quasi-geostrophy on the beta plane and sphere, Ekman pumping, Hadley and Ferrel circulations, wind and thermally driven ocean circulation models, steady waves in the atmosphere.
P. H. Stone, C. I. Wunsch

19.71J Wave Motions in The Atmosphere and Oceans (A)

(Same subject as 12.71J)
Prereq.: 18.350 or 19.69
G (2)
3-0-9

Introduces 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.
P. Malanotte-Rizzoli, K. K. Tung

19.73 Chemistry and Dynamics of Upper Atmospheres (A)

Prereq.: 19.69, 19.50
G (2)
3-0-9

Describes composition, structure, circulation, and energetics of upper atmosphere and ionosphere. Transport of trace substances and atmospheric escape. Chemical kinetics in atmosphere. Photochemical-dynamical steady states. Dynamics of upper atmosphere. Excitation and propagation of internal gravity and quasi-geostrophic waves. Describes stratospheric ozone layer, emphasizing interactions between chemistry, dynamics, and radiation. Physics and dynamics of ionosphere and magnetosphere and coupling to the neutral atmosphere.
R. G. Prinn, J. V. Evans

19.74 Cloud and Precipitation Physics (A)

Prereq.: 19.02, 18.03, 5.60
G (1)
3-0-9

Introduces 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
G (2)
3-0-9

Introduces radar sensing of the atmosphere emphasizing the meteorological information content of coherent (Doppler) and non-coherent (non-Doppler) radar signals.
R. E. Passarelli

19.76 Dynamical Oceanography (A)

Prereq.: 19.69
G (1)
3-0-9

Detailed overview of the phenomenology of the world's oceans (distribution of water masses, major ocean currents, warm water sphere, cold water sphere, the upper layer of the ocean and the wind-driven circulation, the deep layers of the ocean and the thermohaline circulation). Emphasizes the dynamical concepts underlying water mass analysis, geostrophy and the dynamic method, simple inverse models, linear models and basic vorticity balances for the wind-driven circulation, and thermohaline circulation.
P. Malanotte-Rizzoli

19.78 Dynamics of Shelf Circulation (A)

Prereq.: 19.851
G (2) **Not offered 1984-85**
3-0-6

Advanced discussion of tides over the shelf, coastally-trapped waves, and wind driven upwelling and circulation over the shelf. Emphasizes 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.
(Woods Hole Staff): K. Brink, R. C. Beardsley

19.83 Modeling Oceanic Systems

Prereq.: 8.02, 18.03
U (2) SD **Next offered 1984-85**
3-0-9

Introduces methods of constructing and testing conceptual and mathematical models of oceanic processes. Observational methods and results. Basic theories and mathematical techniques for simplifying and solving models. Most examples drawn from oceanographic physics and a basic groundwork of descriptive oceanography, including the large-scale circulation, strong currents, wave motions, diffusion, and instabilities presented. Equivalent course is 12.21.
G. Flierl

19.84J Equatorial Physical Oceanography (A)

(Same subject as 12.87J)
Prereq.: 12.86
G (1) **Next offered 1984-85**
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. Discusses equatorial undercurrents, El Nino, monsoonal ocean variability, and other topics. Permission of instructor required.
C. C. Eriksen, M. A. Cane

19.842 Dynamics of Eddies and Circulation (A)

Prereq.: Permission of Instructor
G (2) **Not offered 1984-85**
3-0-9

Theory of ocean eddies and waves of scales $\geq$ 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.
(Woods Hole Staff): P. B. Rhines

19.86 The General Circulation of the Oceans (A)

Prereq.: Physical Oceanography Major
G (1)
3-0-6

Extensive reading list on observation basis of modern interpretations of global and regional ocean circulation with lectures providing an overview synthesis. Material is predominantly concerned with low frequency and large-scale circulations. Discusses higher frequency and smaller scale processes only in connection with their impact on larger scale distributions. Requires written report on a general circulation topic and final exam (essay) given. Permission of instructor required.
(Woods Hole Staff): M. McCartney

19.89 Special Problems in Oceanography (A)

Prereq.: Permission of Instructor
G (1, 2)
Arr.

Reading, consultation, and original investigation on oceanographic problems.
Staff

19.891-19.899 Special Problems in Oceanography (A)

Prereq.: —
G (1, 2)
Arr.

Reading, consultation, and original investigation on oceanographic problems.
Woods Hole Staff

19.901 Undergraduate Research Problem

Prereq.: —
U (1, 2)
Arr.

19.902 Undergraduate Research Program

Prereq.: —
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*
G (1, 2)
Arr.

Reading, consultation, and original investigation on oceanographic problems.
Staff

19.94 Special Problems in Meteorology

Prereq.: —
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
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.: —
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)

Prereq.: Permission of Instructor
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.
(Woods Hole Staff): J. A. Whitehead

19.971-19.979 Special Subject in Oceanography (A)

Prereq.: —
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)

Prereq.: Permission of Instructor
G (2) **Next offered 1984-85**
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.
(Woods Hole Staff): M. G. Briscoe, R. Weller

19.99 Experimental Physical Oceanography

Prereq.: Permission of Instructor
G (1) **Next offered 1984-85**
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.
(Woods Hole Staff): H. L. Bryden

20 Nutrition and Food Science

Undergraduate Subjects

General Graduate Subjects

Undergraduate Laboratory Subject

20.002 Laboratory in Applied Biology

Prereq.: 5.41, 7.01 or 20.021
U (1) LAB
2-8-4

Techniques in basic analytical biochemistry and separation science. Enzyme assays, disc gel electrophoresis, affinity chromatography, use of radioisotopes, experimental surgery, and other techniques. Recommended for students anticipating careers in applied areas of biology such as biochemical engineering, toxicology, pharmacology, nutrition, cancer research, genetic engineering, medicine.
R. S. Langer, Jr., A. M. Klibanov, M. A. Marletta, M. R. Rosner, W. G. Thilly

Undergraduate Research

20.ThU Undergraduate Thesis

Prereq.: —
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.
M. A. Marletta

20.UR Undergraduate Research Opportunities

Prereq.: —
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.
M. A. Marletta

20.011 Special Projects in Undergraduate Research

Prereq.: —
U (1)
Arr.

20.012 Special Projects in Undergraduate Research

Prereq.: —
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.
M. A. Marletta

General Undergraduate Subjects

20.021 Nutrition and Metabolism

Prereq.: 5.41
U (1) SD
4-0-8

Surveys the scope of nutrition and metabolism, the chemistry of the nutrients and nutritional deficiency. Physiology of nutrient uptake and transport. Fuel metabolism in cells. Special function (mammalian milk; placental metabolism; visual process; musculoskeletal system). Also discusses human requirements for energy, proteins, vitamins and minerals. Permission of instructor required.
N. W. Solomons

20.022J Human Physiology (New)

(Same subject as 7.54J)
Prereq.: 7.05
U (1)
3-0-9

Comprehensive course in human physiology emphasizing the molecular basis and applied aspects of organ function and regulation in health and disease. Material includes a review of cell structure and function as well as the mechanisms by which the endocrine and nervous systems integrate cellular metabolism. Emphasizes examination of the cardiovascular, pulmonary, gastrointestinal, and renal systems.
M. F. Holick, M. Krieger, R. D. Rosenberg

20.111 Analytical Practices in Biochemistry (A)

Prereq.: 5.42
G (1)
3-8-5

A series of techniques basic to analytical biochemistry. Basic spectro-photometric analyses and separations, including high-pressure liquid chromatography and affinity chromatography, taught in first portion of subject. Modular laboratories present specialized techniques, mass spectrometry analysis, tissue culture microbiology, and others. Emphasizes quantitative interpretation.
R. S. Langer, Jr., Staff

20.113J Biostatistics I (A)

(Same subject as 18.055J)
Prereq.: Permission of Instructor
U (1) G (1) SD
3-0-9

See description under subject 18.055J.
W. M. Rand

20.114 Biostatistics II (A)

Prereq.: 20.113J
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

Graduate Subjects by Area

Metabolism and Human Nutrition

20.211 Regulation of Intermediary Metabolism (A)

Prereq.: 7.05, 20.022, 20.111
G (2)
5-2-8

Regulation of intermediary metabolism emphasizing 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)

Prereq.: 20.022, 7.05
G (2)
4-0-8

Function and metabolism of essential nutrients and factors that affect nutrient metabolism in the mammalian organism. Integrates knowledge of their biochemistry and physiology, based on studies in experimental animals, with a detailed discussion of human nutrition and metabolism including public health considerations. Emphasizes modern developments in nutritional research.
V. R. Young

20.213 Endocrinology (A)

Prereq.: 7.05, 20.211
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, M. F. Holick

20.214 Advanced Nutritional Biochemistry: Micronutrients (A)

Prereq.: 20.212
G (1)
4-0-8

Discusses and evaluates advances in research concerning the function and metabolism of essential nutrients. Emphasizes 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)

Prereq.: 20.211
G (1)
4-1-7

Regulation of protein and nucleic acid metabolism emphasizing 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
G (1)
2-0-6

Biochemical, metabolic, and physiological function of the trace minerals in human and animal nutrition emphasizing iron, zinc, copper, selenium, manganese, and chromium. Also discusses issues of molybdenum, nickel, tin, and vanadium. Combined lecture and seminar format discusses and evaluates current research papers in trace mineral nutrition.
N. W. Solomons

Human and Clinical Nutrition

20.311 Advanced Human and Clinical Nutrition (A)

Prereq.: 20.212
G (2) **Next offered 1984-85**
4-0-8

Application of nutrition knowledge in the therapy and support of humans and in various physiological and pathological states. Nutritional requirements and status of humans. 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) and with genetic and other metabolic diseases, obesity, degenerative diseases, and the elderly. Alternate years.
V. R. Young, Staff

20.312 Clinical Nutrition in Practice (A)

Prereq.: 20.311
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

International Nutrition

20.410J Nutrition and National Development

(Same subject as 17.562J)
Prereq.: Permission of Instructor
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
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 US food policy. Attention then directed to bilateral and multilateral approaches to international food and nutrition issues. Concludes with an examination of the effectiveness of international institutional mechanisms established to deal with these problems. Permission of instructor required without 20.410J background.
M. B. Wallerstein

20.413 Social Sector Microeconomics and Planning (A)

Prereq.: Permission of Instructor
G (1)
2-0-7

Reviews microeconomic theory emphasizing issues of food, agricultural, and health economics. Introduces programming, planning models, and macroeconomics of developing countries. In final exercise, students criticize a development plan for a hypothetical country and formulate (in detail) a better one.
L. J. Taylor

20.414J The Political Economy of Food

(Same subject as STS 540J)
Prereq.: Permission of Instructor
G (2)
3-0-6

The world food economy, and the role of the US as the dominant cereal-exporting country. Changes in diet patterns, technical change, and income distribution in developing countries; how they are affected by food policy. Changes in advanced country consumption and production patterns. Requires independent research paper. Readings include works of economic and social history, government documents, anthropological and political studies, trade statistics, surveys of food consumption.
E. Rothschild, L. J. Taylor

Neuroendocrine Regulation and Endocrinology

20.511J The Human Nervous System: The Neurosciences I (A)

(20.514J)
(Same subject as 9.014J, HST 130J)
Prereq.: Permission of Instructor
G 1)
6-3-6

See description under subject HST 130J.
W. J. H. Nauta, E. Bizzi, N. Geschwind, A. M. Graybiel, A. North, S. Palay, V. Chan Palay, A. Rossier, T. Sabin, P. H. Schiller, H. R. Tyler, R. J. Wurtman

20.512J The Neurosciences II (A)

(Same subject as 9.015J)
Prereq.: Permission of Instructor
G (2)
6-0-9

Second semester subject of a two-semester sequence exposing graduate students to the broad range of contemporary topics in the neurosciences. Topics: 1) neurotransmission; 2) neurochemistry and neuropharmacology; 3) neuropsychology (somatosensory perception; memory; language; spatial capacities); 4) neuroendocrinology; and 5) development and plasticity of the nervous system.
R. A. North, R. J. Wurtman, M. J. Baum, S. Corkin, G. E. Schneider

20.516 Advanced Topics in Behavioral Biology (A)

Prereq.: 20.511J, 20.512J
G (1) **Not offered 1984-85**
2-0-4

Seminar on recent advances in psychopharmacology and behavioral endocrinology; primarily student presentations. Alternate years.
M. J. Baum

20.517 Advanced Topics in Neurotransmitter Biochemistry (A)

Prereq.: 20.512J
G (2) **Not offered 1984-85**
2-0-4

Seminar on recent advances in neurotransmitter biochemistry; presentations by staff, guest lecturers, and students.
R. J. Wurtman

20.518J Pathophysiology of the Nervous System (A)

(Same subject as 9.018J, HST 131J)
Prereq.: HST 130J
G (2)
3-0-6

See description under subject HST 131J.
M. A. Moskowitz, N. Geschwind

20.519 Advanced Topics in Neuropharmacology

Prereq.: 20.512J
G (2) **Next offered 1984-85**
2-0-4

Seminar on recent advances in the neuropharmacology and cellular neurophysiology of the mammalian nervous system; student presentations primarily. Alternate years.
R. A. North

20.521 Mechanisms of Drug Action (A)

Prereq.: Permission of instructor
G (2) **Not offered 1984-85**
3-0-9

Presents and discusses fundamental principles of pharmacology. Major areas to be covered: molecular mechanisms of drug action, particularly quantitative methods of studying interactions between drugs and receptors, the time course of drug action, basic principles of drug metabolism, and mechanisms underlying long-term drug effects such as physical dependence. Alternate years.
R. A. North

20.522 Cellular Neurophysiology (A)

Prereq.: 20.512J
G (1) **Next offered 1984-85**
3-0-9

Cellular-level electrophysiology. 1) Properties of excitable cells; linear and nonlinear equations describing behavior of membranes; 2) voltage and chemically gated channels; 3) neurophysiological aspects of synaptic transmission; 4) mathematical models of nerve cells in mammalian central nervous system and invertebrates. Alternate years.
R. A. North

Toxicology

20.611 General Toxicology (A)

Prereq.: 7.05
G (2)
2-0-6

Occurrence and mechanisms of action of toxic chemicals of health significance. Characterization of various forms of toxicity of importance in health risk estimation: acute and chronic effects, genetic effects, teratogenesis, and carcinogenesis. Extrapolation of toxicological data to humans in regulation of environmental chemicals.
G. N. Wogan

20.612 Biochemistry of Xenobiotics (A)

Prereq.: 5.42, 7.05
G (1) **Next offered 1984-85**
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. Emphasizes events occurring at the molecular level. Alternate years.
M. A. Marletta

20.613 Genetic Toxicology (A)

Prereq.: 7.03, 7.05
G (2) **Next offered 1984-85**
3-0-9

Genetic disease as a public health problem. Experimental approaches to determining the causes of human genetic change. Chemical induction of genetic change in chromosome number, chromosome structure, and gene structure. Roles of DNA repair and replication in determining the probabilities of genetic change. Alternate years.
W. G. Thilly

20.614 Toxicology of Nucleic Acid Damage (A)

Prereq.: 7.03, 7.05
G (2)
4-0-8

Studies chemical and biochemical reactions that product structural lesions in cellular macromolecules in relation to underlying mechanisms of toxicity, carcinogenicity, and mutagenicity. Emphasizes the theory that induced alterations in nucleic acid structure ultimately change the informational integrity of cells, particularly by disrupting replication and gene expression.
J. M. Essigmann

20.615 Cellular Toxicology: Chemical Reactions with Cell Membranes and Organelles (A)

Prereq.: 7.05
G (2) **Next offered 1984-85**
3-0-9

Examines effects of toxins on cellular processes, emphasizing both structural and functional alteration of cellular organelles and macromolecules. Topics: cellular entry of toxic compounds, modification of cell surface interactions and membrane transport properties, alteration of protein biosynthesis and processing, interactions with subcellular organelles, and cytoskeletal components. Toxins considered include tumor promoters, lectins, bacterial toxins, environmental pollutants.
M. R. Rosner

20.617 Pathobiology (A)

Prereq.: Permission of Instructor
G (2) **Next offered 1984-95**
4-2-4

Introduces pathology. Gross and histologic characteristics of organs and tissues of animals in health and disease. Emphasizes understanding of disease processes by integrating biochemical and morphologic correlates of injury by toxic and nutritional factors. Alternate years.
P. M. Newberne, A. E. Rogers

20.618 Laboratory Animals: Usage in Biological Experimentation

Prereq.: 7.01
G (2)
2-1-3

Introduces current concepts of anesthesia, surgery, disease, and experimental manipulation of the research laboratory animal. Emphasizes 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)

(Same subject as 14.285J, HST 902J)
Prereq.: Permission of Instructor
G (1) **Not offered 1984-85**
3-0-9

Examines tools available to economists and toxicologists for decision making in a regulatory environment. Uses case method 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

Biotechnology

20.721 Physical and Engineering Properties of Biomaterials (A)

Prereq.: 5.60, 10.13
G (1) **Next offered 1984-85**
3-0-6

Emphasizes the theories, principles, concepts, determination, and analysis of rheological properties of solutions, dispersions, suspensions, gels, emulsions, and solids with supporting discussions on thermal and surface properties. Considers these properties as related to biotechnology and other industrial processes and effect of these properties on quality criteria and process design. Permission of instructor required. Alternate years.
C. K. Rha

20.723 Fabrication and Structure Synthesis of Biomaterials (A)

Prereq.: 20.721
G (1) **Not offered 1984-85**
3-0-6

Fundamentals of biomaterials fabrication and structure synthesis including solvation, flocculation, emulsions, foams, gels, granular, plexilaminar networks, fibers and filaments. Emphasizes encapsulation, thermal treatment, extrusion, and spinning technology as applied to biotechnology and food processing. Selection of raw materials, fabrication methods, and processing conditions to obtain desired structural effects. Alternate years.
C. K. Rha

20.731 Chemistry of Proteins, Carbohydrates, and Lipids (A)

Prereq.: 7.05
G (2) **Next offered 1984-85**
3-0-6

Considers the constituents of foods and biological tissues from the perspective of the chemical reactions they undergo under environmental stress. Particular attention to oxidation of lipids, structure and degradation of carbohydrates, and degradative reactions on the side chains of proteins. Other topics include chemistry of degradation of vitamins, pigments, and flavors. Discusses relations of these reactions to stability and nutritional and toxicological potential of foods. Alternate years.
S. R. Tannenbaum

20.732 Physical Chemistry of Biomaterials (A)

Prereq.: 5.60
G (2)
3-0-6

Physicochemical principles governing the behavior of industrial biomaterials, including foods. Applications to representative industrial problems. Colloidal and surface phenomena. Conformational transition in biopolymers. Diffusion in polymers and in complex systems. Phase transformations in biomaterials. Kinetics of chemical reactions of significance in processing and storing foods and other biomaterials. Simulation of reactions occurring in processing and storage.
M. Karel, A. M. Klibanov

20.734 Applied Enzymology (A)

Prereq.: 7.05
G (1) **Next offered 1984-85**
3-0-6

Production and purification of commercial enzymes. Mechanisms of practically important enzymes. Protein stability and denaturation. Enzyme inactivation and approaches to stabilization of enzymes. Immobilized enzymes, coenzymes, and whole cells. Immobilized biocatalyst reactors. Enzymatic processes in heterogeneous systems. Fundamentals of practical applications of enzymes in food and chemical industries, in analyses and medicine; future trends. Economic, health, and legal aspects of the use of enzymes. Alternate years.
A. M. Klibanov

20.743 Applied Microbiology (A)

Prereq.: 20.721
G (2)
3-0-6

Discussions center on sporulating and toxin-producing microorganisms. Focuses on the physiology, biochemistry and genetics of sporulation and toxicolony. 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

20.752 Food Plant Visits (A)

Prereq.: Permission of Instructor
G (2)
2-0-2

Visits to selected food factories in the Boston area and associated lectures.
M. Karel

Biochemical Engineering

20.801 Biotechnology (A)

Prereq.: 7.03, 7.05
G (1)
3-0-9

Major study areas include quantitative descriptions of growth and control of eukaryotic and procaryotic cells, discussion of nutritional requirements and insights into major pathways of carbon metabolism. Genetics of industrial microorganisms are discussed. Topics inlcude strain construction by various procedures. Selected topics of current interest in biotechnology are also presented.
A. J. Sinskey

20.811J Biochemical Engineering (A)

(Same as 10.59J)
Prereq.: Permission of Instructor
G (2)
4-0-8

See description under subject 10.59J.
C. L. Cooney, D. I. C. Wang

20.812J Biochemical Engineering Laboratory (A)

(Same as 10.591J)
Prereq.: 20.811
G (2)
0-5-1

See description under subject 10.591J.
D. I. C. Wang, C. L. Cooney

20.821 Industrial Microbiology (A)

Prereq.: 7.21
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, emphasizing metabolic regulation of and biochemical pathways leading to fermentation products.
A. L. Demain

20.822 Industrial Microbiology Laboratory (A)

Prereq.: 20.821
G (1)
0-6-0

Laboratory exercise of selected topics presented in 20.821.
A. L. Demain

Seminars, Selected Topics and Research

20.904 Teaching Experience in Nutrition and Food Science

Prereq.: Permission of Instructor
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.
S. R. Tannenbaum

20.911 Seminar in Toxicologic and Nutritional Pathology (A)

Prereq.: Permission of Instructor
G (1)
2-0-2

20.912 Seminar in Toxicologic and Nutritional Pathology (A)

Prereq.: Permission of Instructor
G (2)
2-0-2

Systematic study of diseases in several animal species resulting from exposure to toxins or malnutrition, with particular attention to ongoing research projects. Requires research talks or papers.
A. E. Rogers, P. M. Newberne

20.921 Selected Topics in Nutrition and Food Science (A)

Prereq.: —
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.: —
G (1)
Arr.

20.942 Research Problems (A)

Prereq.: —
G (2)
Arr.

Directed research in the field of nutrition and food science.
Staff

21 Humanities

Literature

21.UR Research in Humanities

Prereq.: —
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
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, XXI-E, and XXI-S, 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
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, XXI-E, and XXI-S 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 (21.171-21.178), 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.

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 Foundations of Western Literature: Homer to Dante

Prereq.: —
U (1, 2) HUM-D
3-0-6

Careful reading and critical examination of literary texts, knowledge of which is essential to understanding the European tradition in imaginative literature. Stresses appreciation and analysis of works which came to represent the common cultural possession of the modern age. Readings include the Bible (selections from the Old and New Testaments), Homer, Aeschylus, Sophocles, Euripides, Aristotle (the *Poetics*), Horace, Virgil, Ovid, and Dante.
Term 1: *S. Mullaney*
Term 2: *Staff*

21.002 Classics of European Literature

Prereq.: —
U (1, 2) HUM-D
3-0-6

Masterworks of epic, drama, lyric, novel, and film. Includes works by such writers as Cervantes, Shakespeare, Donne, Milton, Molière, Goethe, Tolstoy, Chekhov, Yeats, Mann, and at least one film. Emphasizes 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.
Term 1: *Staff*
Term 2: *S. Dickman*

21.003 Introduction to Fiction

Prereq.: —
U (1, 2) HUM-D
3-0-6

Introduces prose narrative, especially the novel. Emphasizes 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: *L. Kampf, R. Perry, I. Tayler*
Term 2: *T. R. Merritt, Staff, I. Tayler*

21.004 Major Poets

Prereq.: —
U (1, 2) HUM-D
3-0-6

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: *Staff*
Term 2: *S. Tapscott*

21.005 Introduction to Drama

Prereq.: —
U (2) HUM-D
3-0-6

Critical reading of representative drama. Emphasizes 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.
A. R. Gurney, Jr.

21.006 Introduction to American Literature

Prereq.: —
U (1, 2) HUM-D
3-0-6

Surveys major American texts, stressing literary and ideological traditions and the emergence of a national literature. Principal readings in Emerson, Whitman, Hawthorne, Melville, Twain, Dickinson James, Wharton, Faulkner, Fitzgerald, Ellison, Stevens, Frost.
Term 1: *S. J. Tapscott, A. Lang, J. Hildebidle*
Term 2: *Staff, A. Lang, J. Hildebidle*

21.009 Shakespeare

Prereq.: —
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, S. Dickman*
Term 2: *P. S. Donaldson, S. Mullaney*

21.010 Literature and Film (Revised Unit)

Prereq.: —
U (1, 2) HUM-D
4-0-5

Close reading and viewing of literary and filmic masterpieces, with attention to narrative values. Emphasizes ways in which these are modified by the nature of media. Authors and directors vary with topic. Term 1: Crimes and Detection (Dostoevsky, Doyle, Hammett, Hawks, Hitchcock, others) Term 2: Heroism and the Heroic (Homer, Shakespeare, Dickens, Chaplin, Ford, others).
Term 1: *W. J. Paul*
Term 2: *A. C. Kibel*

Intermediate Subjects

Genres and Themes

21.021 Comedy

Prereq.: —
U (1, 2) HUM-D
3-0-6

Studies various works designed to make us laugh; investigates the culture that produced them, and the various theories of comedy. Authors and directors include: Aristophanes, Plautus or Terence, Chaucer, Shakespeare, Molière, Austen, Joseph Heller, Chaplin, Keaton, others.
Term 1: *W. J. Paul*
Term 2: *A. R. Gurney, Jr.*

21.022 Tragedy

Prereq.: —
U (1) 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.
H. Eiland

21.023 The Short Story

Prereq.: One literary subject
U (1) **Next offered 1984-85**
3-0-6

Studies 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.
A. C. Kibel

21.030 Popular Narrative: Fantasy and Science Fiction

Prereq.: One literary subject
U (1, 2)
3-0-6

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 Fantasy and Science Fiction in relation to American Culture. Topics vary from year to year. May be repeated once for credit, with permission of instructor. Term 1: Fantasy Fiction. Term 2: Science Fiction.
Term 1: *H. Eiland*
Term 2: *S. Mullaney*

21.031 The Film Experience

Prereq.: —
U (1, 2) HUM-D
3-0-6

Introduces 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: *D. Thorburn*
Term 2: *W. J. Paul*

21.032J American Television: A Cultural History

(Same subject as STS 625J)
Prereq.: One literary subject
U (1)
3-0-6

Television's evolution as a system of story telling and myth making from anthropological, literary, and cinematic perspectives. Centers on prime-time commercial broadcasting; also examines the medium's technological and economic history as well as the theoretical perspectives from which scholars and policymakers have perceived our television system. Much required viewing as well as readings in media theory and cultural interpretation.
D. Thorburn

21.033 Major Film Directors (New)

Prereq.: One literary subject
U (2)
3-2-4

Close study of films by major directors. Emphasizes cultural contexts and distinctive styles and themes of each director. Syllabus varies from year to year but includes films from different historical periods and, usually, a mix of American and international films by such directors as Chaplin, Lang, Hitchcock, Ford, Hawks, Renoir, Mizoguchi, Fellini. May be repeated for credit by permission of instructor. For 1983-84: Hitchcock, Lang, Hawks.
W. J. Paul

21.041 Women in Literature

Prereq.: One literary subject
U (2)
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, the Brontës, Gaskell, Hawthorne, Eliot, Dickens, Meredith, Hardy, and others.
Staff

21.042 Friendship, Love, and Desire (New)

Prereq.: One literary subject
U (1)
3-0-6

Changing significance of friendship and love in Western culture. Self and other in literary and historical perspective. Studies different values associated with emotions in personal, political, philosophical, religious, and psychological contexts in different ages. Readings in Plato, Aristotle, Augustine, Dante, Shakespeare, Goethe, Flaubert, Proust, Mann, Updike, and others. Syllabus varies.
D. M. Halperin

Periods of World Literature

21.060 Medieval Literature

Prereq.: One literary subject
U (1)
3-0-6

Introduces literature of the Middle Ages, concentrating on such central writers and works as St. Augustine, *The Song of Roland, Beowulf,* Dante, Chrètien de Troyes, Chaucer, and the Pearl-Poet. Secondary reading on the social context of medieval literature. Discussion, short papers.
S. Dickman

21.063 Renaissance Literature

Prereq.: One literary subject
U (2)
3-0-6

In alternate years, readings are organized around specific topics (Magic and the Arts of Government, Renaissance Self-Fashioning, Families and Fortunes) or genres (lyric, epic, drama). Works drawn primarily from the Italian and English Renaissance, and include such figures as Shakespeare, Ariosto, Machiavelli, More, Jonson, Spenser, Bacon, Wyatt, Donne.
P. S. Donaldson

21.065 Early Modern Literature: Drama and Society (Revised Content)

Prereq.: One literary subject
U (1)
3-0-6

Studies major English and European writers of 17th and 18th centuries, with alternating topics. For 1983-84, Drama and Society examines the cultural contexts of tragedy and satiric comedy: the deconsecration of kingship on stage; crises in dramatic and political authority; class hierarchies and their effects on women, arts, ideas of self. Readings: Webster, Jonson, Calderon, Dryden, Aphra Behn, Molière, Gay, Goldsmith.
S. Mullaney

21.070 Eighteenth-Century Literature: The Evolution of Bourgeois Culture

Prereq.: —
U (2)
3-0-6

Introduces England's Augustan age through representative authors and literary form. Emphasizes these cultural issues: commercialization of art, city vs country, rise of the middle class, travel and exploration, romantic love and marriage, growth of capitalism, party politics, gender stereotypes. Background readings, lectures, slide-shows, discussion period. Authors: Addison and Steele, Defoe, Swift, Astell, Pope, Montagu, Richardson, Fielding, Johnson.
R. Perry

21.071 Major English Novels

Prereq.: One literary subject
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 literary subject
U (1)
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.
S. J. Tapscott

21.078 The Realistic Novel

Prereq.: —
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, Dostoevsky.
A. C. Kibel

21.079 Modern Russian Literature and Its Historical Structure

Prereq.: —
U (2) 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, Tolstoy, Solzhenitsyn (Revised Content)

Prereq.: One literary subject
U (2)
3-0-9

Close examination of masters in the "grand tradition" of Russian prose fiction. Major novels studied in historical context. Topics for discussion: the writer as teacher and prophet; the relation between realism and symbolism; the artistic representation of political, philosophical, and religious ideas; literary culture as a "second government" in 19th- and 20th-century Russia.
D. M. Halperin

21.085 Twentieth-Century Fiction

Prereq.: One literary subject
U (1)
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 literary subject
U (2)
3-0-6

Reading and discussion of various modern plays, from Ibsen to Beckett. Emphasizes how these plays work on stage. Reading aloud of scenes in class encouraged, along with projects connected to Dramashop productions.
Staff

21.087 Modernist Poetry

Prereq.: One literary subject
U (1) **Next offered 1984-85**
3-0-6

Studies 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 figures as Roethke, Plath, Berryman, Wilbur, Rich, and Hughes.
S. J. Tapscott

21.088 Contemporary Literature

Prereq.: One literary subject
U (1) **Next offered 1984-85**
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.
S. J. Tapscott

American Literature

See also 21.006 Introduction to American Literature

21.101 The American Novel

Prereq.: —
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.
Term 1: *T. Wood*
Term 2: *J. Hildebidle*

21.103J Literature, Ideology, and National Experience in the US

(Same subject as STS 601J)
Prereq.: —
U (1) HUM-D
3-0-6

See description under subject STS 601J.
L. Marx

21.105 American Voices

Prereq.: —
U (1) **Next offered 1984-85**
3-0-6

Considers a variety of North Americans attempting to define the dream of success. Materials: "high literature," folktales, slave narratives, blues, films, songs, jokes, Indian narratives, oral history. Reading and listening include selections from the works of Benjamin Franklin, Miguel Piñero, Alice Walker, Black Elk, Linda Brent, Michael Gold, Studs Terkel, Maxine Hong Kingston. Restricted to 25 students.
L. Kampf

21.112 American Authors (Revised Content)

Prereq.: One literary subject
U (1)
3-0-6

Examines in detail the works of three or four American authors. Through close readings of poetry, novels, or plays, addresses such issues as literary influence, cultural diversity, the writer's career. Typically, readings include works by such writers as Twain, Melville, Dickinson, Cabell, Chopin, O'Neill, Faulkner, Baldwin, Frost. Format: Lecture-discussion, papers. Topic for 1983-84: See Literature Faculty *Supplement.*
J. Hildebidle

21.120 American Themes: Inventing America (Revised Content)

Prereq.: One literary subject
U (2)
3-0-6

Unifying themes in American culture. Topics vary according to instructor. For 1983-84: Inventing America. Examines the literary representations of America from "the city on the hill" to "the land of opportunity." Readings in such authors and texts as Winthrop, Thoreau, Hawthorne, Bellamy's *Looking Backward,* Skinner's *Walden Two,* Pynchon, others. Format: lecture, discussion.
A. Lang

Seminars

21.171 Literary Interpretation

Prereq.: Two subjects in literature
U (1) **Next offered 1984-85**
3-0-9

Introduces practice and theory of literary criticism. Seminar focuses on topics such as interpretation (the ways in which issues arising in the interpretation of dreams, folk-tales, sacred texts, works of visual art, and primitive cultures have influenced the practice of interpreting literary and narrative texts), history of critical methods and techniques, and continuity of certain subjects in literary history. Required of all majors in literature. Topics change from year to year. Limited to 12.
D. M. Halperin

21.172 Advanced Studies in Fiction

Prereq.: Two subjects in literature
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 1983-84: Term 1: Austen and the Brontës. Term 2: American Fiction Since World War II. Limited to 12.
Term 1: *I. Tayler*
Term 2: *Staff*

21.173 Advanced Studies in Drama

Prereq.: Two subjects in literature
U (1) **Next offered 1984-85**
3-0-9

Close study of two or three major dramatists, emphasizing 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. Limited to 12.
Staff

21.174 Advanced Studies in Poetry

Prereq.: Two subjects in literature
U (1, 2)
3-0-9

Extensive reading in a few major poets. Emphasizes the evolution of each poet's work, and questions of poetic influence and literary tradition. Topics for 1983-84: Term 1: Renaissance Poetry. Term 2: Contemporary Poets. Limited to 12.
Term 1: *P. S. Donaldson*
Term 2: *S. J. Tapscott*

21.175 Major Authors

Prereq.: Two subjects in literature
U (2)
3-0-9

Close study of a limited group of writers whose achievements are mutually illuminating. Emphasizes the ways in which generic conventions shape an author's treatment of particular themes. Topic for 1983-84: Chaucer and the *Canterbury Tales.* Limited to 12.
S. Dickman

21.177 Problems in Cultural Interpretation

Prereq.: Two subjects in literature
U (1)
3-0-9

Studies the relations between literary texts and the culture that encloses them. Emphasizes literature in its anthropological, sociological, and historical dimensions: 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. Topic for 1983-84: Outsiders and Heretics in American Literature. Limited to 12.
A. Lang

21.178 Advanced Studies in Ancient Literature

Prereq.: Two subjects in literature
U (2) **Next offered 1984-85**
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.
P. S. Donaldson

21.198 Special Topics in Literature

Prereq.: Any two subjects in literature
U (1)
Arr.

21.199 Special Topics in Literature

Prereq.: Any two subjects in literature
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 6 units; to count toward Humanities Requirement, 9 units are required. Exceptional 9-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-207.

All foreign language subjects I-IV are open to graduate students for credit.

For subjects in English as a Foreign Language see 21.325-21.339.

French

The indication of prerequisites for specific French offerings does not apply to students who have already accomplished the equivalent work. For further placement advice, attend the French Placement Session or consult with a field advisor in French.

Fundamental Language Subjects

21.201 French I

Prereq.: —
U (1, 2)
4-0-8

Introduction to the four basic language skills and to French culture. Emphasizes intensive oral training; practice in writing and reading; regular use of language lab. Conducted in French.
J. Hill

21.202 French II

Prereq.: French I
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

21.203 French III

Prereq.: French II
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. Continued use of language laboratory, aural and video. Conducted in French.
G. M. Furstenberg

21.204 French IV

Prereq.: French III
U (1, 2) HUM-D
4-0-8

Final subject in French language sequence. Prepares students for intermediate subjects in French literature and civilization. Reading and discussion of the contemporary novel, theatre, poetry. Perfecting of writing skills through frequent essays. Continued use of language laboratory, aural and video. Conducted in French.
I. de Courtivron

21.205 French Reading, Intensive

Prereq.: —
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

Intermediate Language, Literature, and Civilization Subjects

It it recommended but not required that students take one of the following five intermediate-level subjects before enrolling in 21.213 and above. All intermediate and advanced subjects are conducted entirely in French.

21.207 French Conversation: Intensive Practice (New)

Prereq.: French IV
U (1)
4-3-2

Systematic training in oral expression: communication skills, fluency, and idiomatic French. Audio and video tapes to improve conversational techniques and other forms of oral expression (debates, speeches, reports, interviews). Work in comprehension, phonetics, and intonation. Discussion material: newspapers, magazines, cartoons, films, and varied audio and video tapes dealing with issues in contemporary France and the French-speaking world. Intensive lab work. Special projects (video and other) by students. Limited to 16.
G. M. Furstenberg

21.208 Writing in French: Intensive Practice (New)

Prereq.: French IV
U (2)
3-0-6

Systematic acquisition of writing skills. Emphasizes enrichment of vocabulary, the mastery of complex grammatical structures, the refinement of style, and techniques of composition. Practice in different modes (descriptive, narrative, argumentative) and forms (newspaper articles, advertising, letters, technical and creative writing). Systematic exercises in grammar, vocabulary, and stylistics. Weekly papers, each focusing on a different writing mode and form.
G. M. Furstenberg

21.209 French Civilization I

(21.208)
Prereq.: French IV
U (1) HUM-D **Not offered 1984-85**
3-0-6

Investigates 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 of the Middle Ages, the Renaissance, the 17th Century, and the Enlightenment. Class presentations covering developments in painting, architecture, and music. Devotes special attention devoted to the improvement of French language skills.
J. Vanpée

21.210 French Civilization II

(21.209)
Prereq.: French IV
U (2) HUM-D **Next offered 1984-85**
3-0-6

Studies 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 literary, historical, and sociological texts, as well as slides, music, films. Special attention devoted to the improvement of French language skills.
K. J. Crecelius, I. de Courtivron

21.211 Introduction to French Literature

(21.210)
Prereq.: French IV
U (2) 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 Racine, Molière, Rousseau, Balzac, Hugo, Flaubert, Baudelaire, Rimbaud, Apollinaire, Duras. Special attention devoted to the improvement of French language skills.
Staff

Advanced Literature and Civilization Subjects

It is recommended, but not required, that students take one intermediate level subject before enrolling in advanced subjects.

21.213 French Classical Literature From Descartes to Molière (Revised Content and Unit)

Prereq.: French IV
U (2) **Next offered 1984-85**
3-0-6

Reading and interpretation of masterworks in 17th-century French theater (Corneille, Molière, Racine), poetry (Malherbe, La Fontaine), and philosophy (Pascal, Descartes). Studied in the context of social, historical, and intellectual currents during the eras of Richelieu and Louis XIV, and the evolution from the baroque to the classic aesthetic.
E. B. Turk

21.217 Introduction to French Poetry

(21.211)
Prereq.: French IV
U (1) HUM-D **Not offered 1984-85**
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, Valéry, Eluard, Char, Michaux.
R. E. Jones

21.218 Introduction to the French Short Story

(21.226)
Prereq.: French IV
U (1) HUM-D **Next offered 1984-85**
3-0-6

Studies 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.
K. J. Crecelius

21.220 Masterworks of the French 19th Century Novel

(21.216)
Prereq.: French IV
U (1) **Not offered 1984-85**
3-0-6

The golden age of the French novel. Emphasizes Romanticism, Realism, and Naturalism in Balzac, Stendhal, Sand, Flaubert, and Zola. Themes include the interaction of love, money, and politics in the newly developed bourgeois society of 19th-century France. Devotes attention to narrative techniques, representations of reality, and the influence of history and science.
K. J. Crecelius

21.222 The French Novel in the 20th Century

(21.217)
Prereq.: French IV
U (1) **Next offered 1984-85**
3-0-9

Techniques and themes of the modern novel in works by Gide, Proust, Colette, Mauriac, Cocteau, Yourcenar, Camus, and Sarraute. Themes include love, jealousy, adolescence, responsibility to self and to others. Emphasizes the search for identity in an increasingly fragmented and violent world.
I. de Courtivron

21.223 Modern French Drama

(21.218)
Prereq.: French IV
U (2) **Next offered 1984-85**
3-0-6

Studies the tragedians Claudel and Montherlant; the poetic fantasy of Giraudoux; the social and philosophical theater of Lenormand, Anouilh, Sartre, Camus; the avant-garde works of Jarry, Apollinaire, Cocteau; plays by Vian, Beckett, Ionesco, and Genet. Special attention to evolving concepts of the director, actor, audience, stage design, and music.
R. E. Jones

21.225 Representations of Love in French Literature

(21.227)
Prereq.: French IV
U (2) HUM-D **Next offered 1984-85**
3-0-6

Examines a wide variety of texts which deal explicitly with the theme and the problems of love. 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, Molière, Racine, Prévost, Laclos, Constant, Musset, Balzac, Flaubert, Duras.
J. Vanpée

21.226 Artistic and Intellectual Currents of Modern France: Literature and Ideology

(21.220)
Prereq.: French IV
U (2) HUM-D **Not offered 1984-85**
3-0-6

Traces the changing philosophical, political, and artistic currents of 20th-century France as reflected in significant fiction, essays, and films produced between World War I and the present. Writers and artists include Breton, Dali, Malraux, Sartre, Beauvoir, Camus, Sarraute, Robbe-Grillet, Resnais, Ophuls, Bernard-Henri Lévy, Wittig, Cixous. Emphasizes the role of art in creating and promotiong new values, and the movements of Surrealism, Existentialism, the New Novel, New Philosophy, and Feminism.
I. de Courtivron

21.228 French Film Classics

(21.212)
Prereq.: French IV
U (2) **Not offered 1984-85**
3-0-6

History and aesthetics of French cinema from the advent of sound to the present day. Treats films 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

21.229 The French New Wave Cinema

(21.301)
Prereq.: French IV
U (1) **Next offered 1984-85**
3-0-6

Examines 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.
E. B. Turk

German

The indication of prerequisites for specific German offerings does not apply to students who have already accomplished the equivalent work. For further placement advice, attend the German Placement Session or consult with a field advisor in German.

Subjects numbered 21.230 to 21.248 may be used to fulfill Institute requirements including concentrating and majoring in German.

Subjects numbered 21.249 to 21.253 may count to fulfill a concentration or a major in German only upon special arrangement with one of the Foreign Language concentration and major advisors. Contact Foreign Languages and Literatures Office, x4771.

Fundamental Subjects

21.230 German Review

Prereq.: Permission of Instructor
U (1, 2)
4-0-8

Reviews the grammar of German I and German II. Followed by some of the readings of German II. 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.
E. Waldstein

21.231 German I

Prereq.: —
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.
J. Davidson, C. J. Kramsch

21.232 German II

Prereq.: German I
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. Introduces the history and culture of German-speaking countries.
J. Rosellini

21.233 German III

Prereq.: German Review or German II
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.
M. Geisler, C. J. Kramsch

21.234 German IV

Prereq.: German III
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.
J. Davidson

21.235 Accelerated Elementary German (New)

Prereq.: Permission of Instructor
U (2)
8-4-12

Covers in **one** semester the material that is taught in German I and II in two. Develops writing, speaking, and listening skills. Open to any student with no German or the equivalent of less than a German II background (i.e., maximum of 1 year of high-school German).
D. Dollenmayer, E. Waldstein

21.236 German Drama Workshop (Revised Unit)

Prereq.: German III
U (2) **Next offered 1984-85**
3-3-6

Hands-on German drama subject. Studies several plays by one author or from one period, of which one is selected for rehearsal and final performance. Intensive pronunciation/intonation practice through instructor-monitored laboratory sessions and small-group rehearsals. No previous acting experience necessary. Conducted in German.
M. Geisler

21.237 Advanced German Conversation and Composition

Prereq.: German IV
U (2) **Not offered 1984-85**
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. Focuses 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.
C. J. Kramsch

21.238 German Reading, Intensive

(21.235)
Prereq.: —
G (1)
4-0-8

Introduces 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.
Staff

Advanced Subjects

21.239 Introduction to German Literature

(21.242)
Prereq.: German IV
U (1) HUM-D **Not offered 1984-85**
3-0-6

Readings from German prose fiction, poetry, and drama. Authors include Goethe, Brecht, T. Mann, Keller, Kafka, Rilke. Literary language as specialized 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. Conducted entirely in German, emphasizing reading, speaking, and writing skills.
E. Waldstein

21.240 German Romanticism: Fantasy vs Reality

(21.244)
Prereq.: German IV
U (2) HUM-D **Next offered 1984-85**
3-0-6

Origin and development of the German Romantic Movement (ca. 1797-1830). Emphasizes relation of Romantic themes — fantasy, sensuality, communality, androgyny — to social reality. Impact of the Romantic Movement on literary style. Genres include drama, novel, short prose, poetry, letters. Writers include Novalis, F. Schlegel, Tieck, Bonaventura, Chamisso, Achim and Bettina von Arnim, Brentano, Eichendorff, Rahel Varnhagen, Caroline Schlegel-Schelling, E. T. A. Hoffmann. Conducted entirely in German, emphasizing reading, speaking, and writing skills.
E. Waldstein

21.241 Literature and Society in the German Democratic Republic

(21.246)
Prereq.: German IV
U (1) **Not offered 1984-85**
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. Readings consist of selected works of fiction, drama, and poetry. Emphasizes the interrelationship of the economic, political, and cultural spheres. Conducted entirely in German, emphasizing reading, speaking, and writing skills.
J. Rosellini

21.242 German Short Fiction

(21.243)
Prereq.: German IV
U (2) HUM-D **Next offered 1984-85**
3-0-6

Short fiction in the 19th and 20th centuries (Novelle, Erzählung). Representative works read and discussed, emphasizing narrative strategy, esthetic structure, social concern, and historical context. Authors include Kleist, E. T. A. Hoffmann, Büchner, Schnitzler, Döblin, Musil, Grass, and Frisch. Conducted in German, emphasizing reading, speaking, and writing skills.
D. Dollenmayer

21.243 Heinrich Heine

(21.245)
Prereq.: German IV
U (1) **Next offered 1984-85**
3-0-6

Poet, satirist, "reporter," exile, friend of Marx and Rothschild. 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. Emphasizes Heine's role as literary and political figure in post-Napoleonic Germany. Conducted entirely in German, emphasizing reading, speaking, and writing skills.
M. Geisler

21.246 German Culture and Society: 1789-1918

(21.239)
Prereq.: German IV
U (2) HUM-D **Next offered 1984-85**
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. Readings include Goethe, Schiller, Hegel, Schopenhauer, Büchner, Marx, Engels, Nietzsche, Wagner, Bismarck, and Freud. Conducted entirely in German, emphasizing reading, speaking, and writing skills.
J. Rosellini

21.247 German Culture and Society: 1918-1933

(21.240)
Prereq.: German IV
U (1) HUM-D **Next offered 1984-85**
3-0-6

German culture between the two wars from late expressionism (Toller) to the end of the Weimar period. Emphasizes the "Neue Sachlichkeit" movement in literature (Kästner, Tucholsky, Döblin), and documentary forms (reportage). Sessions on film *(Caligari, Kameradschaft, Berlin),* art, architecture (Bauhaus), and music (Weill) of the period demonstrate the links between different art forms. Conducted entirely in German, emphasizing reading, speaking, and writing skills.
D. Dollenmayer

21.248 German Culture and Society: 1933-1949

(21.241)
Prereq.: German IV
U (2) HUM-D **Not offered 1984-85**
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, emphasizing reading, speaking, and writing skills.
J. Rosellini

21.249 Introduction to German Poetry

Prereq.: German IV
U (2) HUM-D **Not offered 1984-85**
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.
M. Dyck

21.250 Introduction to German Drama

Prereq.: German IV
U (2) HUM-D **Next offered 1984-85**
3-0-6

Introduces 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). Discusses recordings of German productions of about half the plays covered. Conducted primarily in German.
M. Dyck

21.251 Goethe

Prereq.: German IV
U (2) **Next offered 1984-85**
3-0-6

A succinct overview of Goethe's life and work, thought and science, followed by an intensive study of some major phase of his work. Includes: young Goethe. His poetry, prose (narrative, epistolary, autobiographical, essayistic), and drama, written before his sojourn in Italy. Emphasizes his key poems, *Dichtung and Wahrheit, Die Leiden des jungen Werther,* and *Urfaust.* Conducted primarily in German, with readings and lectures entirely in German.
M. Dyck

21.252 The Modern German Novel

Prereq.: German IV
U (1) **Next offered 1984-85**
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.
M. Dyck

21.253 The World of Kafka

Prereq.: German IV
U (2) **Not offered 1984-85**
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

Greek

21.255 Classical Greek I

Prereq.: —
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. Greek views of fate, love, death 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

Prereq.: Greek I
U (2) HUM-D
4-0-8

Emphasizes 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 its significance and thus to help motivate continued student interest. Emphasizes recognition rather than memorization. Also, selections from Greek mathematics, medicine, and astronomy.
H. A. T. O. Reiche

21.257 Greek Literature I

Prereq.: Permission of Instructor
U (2) **Not offered 1984-85**
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 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. Introduces 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

Prereq.: Greek Literature I
U (1) **Not offered 1984-85**
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

Prereq.: Greek Literature II
U (1) **Next offered 1984-85**
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

Prereq.: Greek Literature III
U (2) **Next offered 1984-85**
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

The indication of prerequisites for specific Russian offerings does not apply to students who have already accomplished the equivalent work. For further placement advice, attend the Russian Placement Session or consult with a field advisor in Russian.

Fundamental Subjects

21.261 Russian I

Prereq.: —
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 acquiring reading and writing skills. Extensive use of language laboratory.
J. Alissandratos

21.262 Russian II

Prereq.: Russian I
U (2)
4-0-8

Continuation of 21.261. Develops ability to use the language through systematic study of 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. Regular work in language laboratory.
Staff

21.263 Russian III

Prereq.: Russian II
U (1) HUM-D
4-0-8

Reading and discussion of historical texts, stories, and poems providing background for understanding Russian literature and contemporary Soviet culture. Reviews grammar with the help of oral and written exercises. Systematic study of word formation and other strategies to free student from dependency on the dictionary. Develops aural comprehension in the language laboratory. Compositions based on readings and recordings integrate communication skills and help retain content.
J. Alissandratos

21.264 Russian IV

Prereq.: Russian III
U (2) HUM-D
4-0-8

Reading of literary and expository texts selected to provide an understanding of Soviet life and culture. Emphasizes development of skill and confidence in reading unedited texts. Aural comprehension developed through brief lectures on cultural topics as well as through taped materials. Discussion and brief papers based on readings. Attention to problems of grammar and style, with a view to improving facility in oral and written expression.
J. Alissandratos

Advanced Subjects

21.265 Advanced Spoken and Written Russian

Prereq.: Russian IV
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. Emphasis varies in alternate years. Extensive use of taped materials. Conducted in Russian.
Staff

21.268 Russian Culture and Civilization

Prereq.: Russian IV
U (2) HUM-D **Next offered 1984-85**
3-0-6

Russian culture and intellectual history from its beginnings to the present based on original literary and historical texts, music, and art. Russian vs Western concepts of "culture" and "civilization." Controversy about the role of Peter the Great; "Westernizers" vs "Slavophiles." Serfdom and the Russian nobility; the Russian intelligentsia. The role of folklore in Russian high culture. Conducted in Russian, emphasizing language skills. Individual oral and written reports on a wide choice of topics.
K. Pomorska

21.269 Introduction to Russian Literature I

Prereq.: Russian IV
U (2) **Not offered 1984-85**
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*. Introduces critical method and literary terminology, as the texts are analyzed both historically and structurally. Conducted in Russian.
K. Pomorska

21.270 Pushkin and His Successors

Prereq.: Russian IV
U (2) HUM-D **Next offered 1984-85**
3-0-9

Introduces the elements of composition and stylistics and acquaints the student with the foundations of modern Russian literature through the most important and characteristic works of Pushkin and his successors, mainly Turgenov and Chekhov. Among works analyzed are *Eugene Onegin* by Pushkin, *Asja* and mystical stories by Turgenev, *The Darling* and *In the Cart* by Chekhov. Conducted in Russian
K. Pomorska

21.271 Contemporary Russian Prose and Poetry

Prereq.: Russian IV
U (1) **Not offered 1984-85**
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. Conducted in Russian.
K. Pomorska

Spanish

The indication of prerequisites for specific Spanish offerings does not apply to students who have already accomplished the equivalent work. For further placement advice, attend the Spanish Placement Session or consult with a field advisor in Spanish.

Fundamental Language Subjects

21.275 Spanish I

Prereq.: —
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.
J. W. Harris

21.276 Spanish II

Prereq.: Spanish I
U (1, 2)
4-0-8

Continuation of Spanish I. Increased practice in reading. Conducted in Spanish whenever practical.
Staff

21.277 Spanish III

Prereq.: Spanish II
U (1, 2) HUM-D
4-0-8

Aims at consolidation and expansion of skills in oral comprehension, speaking, reading, and writing. Uses short texts, taped interviews, and movies to study specific social issues of current interest in Hispanic culture.
D. Morgenstern

21.278 Spanish IV

Prereq.: Spanish III
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.
D. Morgenstern

21.279 Spanish Conversation

Prereq.: Spanish II
U (2) **Next offered 1984-85**
3-0-6

Gives students the necessary language skills to perform successfully in Spanish in a variety of social situations. Focus on oral communication. Uses popular media for listening practice; other materials include newspapers and magazines. Arranges systematic exchanges with native speakers. 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

Intermediate Subjects

Language

21.281 Intermediate Spanish Conversation and Composition

Prereq.: Spanish IV
U (2) **Not offered 1984-85**
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.
M. Delgado

21.282 Spanish for Bilingual Students

Prereq.: Fluency in a Spanish dialect
U (1) HUM-D **Next offered 1984-85**
3-0-9

Designed for students of Hispanic background brought up in the US. Expands oral and written grammar study and increases contact with standard Spanish; studies recent fiction and poetry as well as specific historical, social, economic, and political aspects of Mexican-American, Puerto Rican, and Cuban cultures. Many of the non-literary readings are in English; class discussions in Spanish.
D. Morgenstern

Culture

These are intended as first courses in the literatures of the Spanish language. They provide general information needed for more advanced work, and they develop reading skills necessary for the transition from language to literary subjects. Not open to native speakers. Conducted in Spanish. Given alternate years.

21.284 An Introduction to Latin American Culture

Prereq.: Spanish IV
U (1) HUM-D **Not offered 1984-85**
3-0-6

Overview of Latin America's cultural and literary development from the Discovery and Conquest to the present. Addresses through a study of literary texts, film, art, and music the questions of racial and cultural heterogeneity in Latin America, the area's psychological relationship to Europe and the US, and particular ways in which the society experiences tradition and social change.
E. Garrels

21.285 Introduction to Spanish Culture

Prereq.: Spanish IV
U (2) HUM-D **Next offered 1984-85**
3-0-6

Studies 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.
M. Resnick

Advanced Subjects

21.286 Latin American Literature 1492-1898: Creation of a Continent

(21.292)
Prereq.: Spanish IV
U (2) HUM-D **Not offered 1984-85**
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 Colón, Bernal Dias del Castillo, Sor Juana Inés de la Cruz, Esteban Echeverria, José Hernández, Richardo Palma, and José Marti. Conducted in Spanish.
E. Garrels

21.287 Twentieth Century Latin American Literature: The Alchemist's Laboratory

(21.293)
Prereq.: Spanish IV
U (1) HUM-D **Next offered 1984-85**
3-0-6

Through reading 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 demagoguery and mass media. Authors studied include Dario, Vallejo, Quiroga, Neruda, Arguedas, Rulfo, Borges, and García Márquez. Conducted in Spanish.
E. Garrels

21.288 The Modern Short Story in Spain and Latin America

(21.287)
Prereq.: Spanish IV
U (1) **Next offered 1984-85**
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, students write original stories based on analyses of narrative techniques employed by such authors as Borges, Cortázar, Martín Gaite, Aub, and Peri Rossi. Conducted in Spanish.
M. Delgado

21.290 Literature and Social Conflict: Perspectives on Modern Spain

Prereq.: Spanish IV
U (2) HUM-D **Not offered 1984-85**
3-0-6

Considers how major literary texts illuminate principal issues in the evolution of modern Spanish society. Emphasizes 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, and the Spanish Civil War. Authors studied include: Pérez Galdós, Pardo Bazán, Unamuno, Ortega y Gasset, Salinas, Lorca, La Pasionaria, and Falcon. Conducted in Spanish.
M. Resnick

21.291 The Family in Spanish American Literature

Prereq.: Spanish IV
U (2) **Next offered 1984-85**
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, Villaverde, Bombal, de la Parra, as well as Sarmiento's autobiography. Conducted in Spanish.
E. Garrels

21.292 Cervantes and His Age (New)

Prereq: Spanish IV
U (1) **Not offered 1984-85**
3-0-6

Critics have long recognized Spain as the birthplace of the novel and have seen in *Don Quijote de la Mancha* the prototype for this genre. Concentrates on *Don Quijote* but also considers the author Cervantes as an outstanding example of the humanist in 16th-century Spain and Europe. Attention to Cervantes' humor and irony as well as his ideas on religion, justice, love, language, and artistic creation.
M. Delgado

21.293 History of the Spanish Language (New)

Prereq.: Permission of Instructor
U (2) **Next offered 1984-85**
3-0-6

Starts with the modern languages and proceeds to successively earlier stages. Includes general concepts of language change; specific phonological, morphological, and syntactic changes in the history of Spanish; the place of Spanish among Romance tongues; modern dialects; reading of representative texts of earlier periods. Discussion and readings in English and Spanish. Spanish III or equivalent normally provides sufficient preparation.
J. W. Harris

Literature in Translation

21.296 Introduction to European and Latin American Fiction

Prereq.: —
U (1) HUM-D **Next offered 1984-85**
3-0-6

Studies great works of European and Latin American fiction. Attention to a variety of forms: the short story, novel, dialogue, and documentary. Emphasizes way in which the unique history of each country shaped the imaginative responses of its writers. Authors read include Flaubert, Borges, Brecht, Goethe, Cervantes, Laclos, Tolstoy, Stendahl, García Marquez, and Colette.
M. Resnick

21.297 Sex Roles in Fiction: Europe and Latin America

(21.300)
Prereq.: —
U (1) HUM-D **Not offered 1984-85**
3-0-9

Examines the representation of sexual roles in fiction. Studies works by European and Latin American authors in their cultural and historical contexts. Themes emphasized: bourgeois women, women rebels, and redefinition of sex roles. Comparative analysis of works by: Laclos, Fontane, Molière, Sor Juana Inés de la Cruz, Zola, Stefan, Garcia Lorca, Wolf, Wittig, and Puig. Materials used include films by: Godard, Buñuel, Saura, M. v. Trotta.
M. Resnick, L. Kampf

21.298 The Don Juan Legend

Prereq.: Permission of Instructor
U (2) HUM-D **Next offered 1984-85**
3-0-6

Analyzes 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. Syllabus includes plays, stories, poems, operas, and films. One part of the syllabus focuses on Don Juan's counterpart, the femme fatale. Places attention on the notion of "machismo" (its elaboration and demystification) and on the critique of traditionalist representations of male-female relations organized according to patterns of activity/passivity, force/repression, seduction/submission.
E. B. Turk

21.299 New Women's Voices (New)

Prereq.: —
U (1) **Next offered 1984-85**
3-0-6

Contemporary European women writers and characters they create. Socialization of women in several patriarchal cultures, strategies of adaptation and/or rebellion, relationship to love and work, and search for identity. Experimentations with new narrative techniques to convey women's experiences. Simone de Beauvoir, Hélène Cixous, Oriana Fallaci, Lydia Falcone, Ingeborg Bachman, Angelika Mechtel, Christa Wolf, Genoveva Forest, and Monique Wittig. Screening and discussion of films by von Trotta and Varda.
I. de Courtivron, E. Waldstein

21.300 Evil and Decadence in Literature

(21.297)
Prereq.: —
U (2)
3-0-6

Studies evil and decadence in literature, starting with Job and Petronius. Emphasizes French and English authors including the Marquis de Sade, Mrs. Radcliffe, Byron, Shelley, Laclos, Baudelaire, Rimbaud, Flaubert, Lautreamont, Huysmans, Swinburne, Wilde, Gide, Proust, Firbank, Corvo, Genet, Huxley, Golding. Students encouraged to read some of the texts in the original.
R. E. Jones

21.301 The Occult, Mysticism, Religious Heresy, and Literature (New)

Prereq.: —
U (1) **Not offered 1984-85**
3-0-9

Studies religious beliefs alternative to Christianity and their influence on Western literature of the last 200 years. The Tarot, doctrines of the Gnostics, Manicheans, Bogomiles, Cathars, Illuminists, Theosophists, Free Masons, Swedenborgians. Readings to be chosen from works by Blake, Restif, Byron, Hugo, Balzac, Nerval, Baudelaire, Tolstoi, Strindberg, Yeats, Jung, Dinesen, Kafka, Tryon, Fowles. Also related themes in art and music.
R. E. Jones

21.302 Slavic Civilization: Magic, Vampires, and Witches

(21.312)
Prereq.: —
U (2) HUM-D **Not offered 1984-85**
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. Compares slavic folk heroes 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. Emphasizes common Slavic linguistic and cultural heritage. Students encouraged to read some of the works in the original.
J. Alissandratos

21.304 The German Cinema

(21.307)
Prereq.: —
U (1) **Not offered 1984-85**
4-0-5

Overview of the German film since its beginnings, emphasizing the New German Cinema of the 70s. Weekly screenings. Lectures and discussions deal with technical and aesthetic as well as socio-historical problems. Students keep weekly reaction journal based on thorough analysis of films as well as readings on social and historical background. Directors include: Lang, Ruttmann, Pabst, Schlöndorff, Wenders, Herzog, Fassbinder, Lilienthal, M. v. Trotta. Conducted in English. Films shown with English subtitles.
M. Geisler

21.306 German Literature in Translation

(21.304)
Prereq.: —
U (1) HUM-D **Next offered 1984-85**
3-0-6

Major representative works of German literature. Each work studied both within its specific socio-historical context and against the general cultural development of German-speaking countries. Readings from the 16th century (Luther), the Enlightenment (Lessing), Classicism (Goethe), Romanticism (Novalis), Realism (Fontane), the earlier 20th century (T. Mann, Hesse, Brecht, Döblin, Lasker-Schüler) and post-1945 works in both Germanies, Austria, and Switzerland (Frisch, Weiss, Handke, Grass, C. Wolf). Students encouraged to read some of the works in the original.
E. Waldstein

21.307 Modern German Novels in Translation

(21.308)
Prereq.: —
U (2) **Not offered 1984-85**
3-0-6

20th-century fiction from Germany, Austria, and Switzerland. Emphasizes major themes (bourgeois conventions and rebellion against them, role of the artist, individual and collective guilt, the metropolis, World War II and its aftermath), development of novel form, narrative structure, social and historical context. Authors include Thomas Mann, Kafka, Döblin, Grass, Christa Wolf. Showing of a film version of at least one novel.
D. Dollenmayer

21.308 Seminar in Kafka

(21.309)
Prereq.: One subject in any literature
U (1)
3-0-6

A thorough study of Kafka's novels, longer stories, microstories, and autobiographical writings. The human condition according to Kafka in the Age of Anxiety and beyond. Followed by a more concentrated study of the Kafka canon and mystique in exegetic terms ranging from theological and philosophical through the more strictly literary to psychological and sociological. Participants write one major paper (20 to 40 pages) and make one oral report. Readings in translation.
M. Dyck

21.309 German Avantgarde Theatre

(21.310)
Prereq.: —
U (2)
3-0-6

Innovative practitioners and theorists on the German stage from the turn of the century to the present time. Naturalism, impressionism, expressionism; epic theatre; variously transmuted new forms of comedy and satire; experimental, documentary, and political drama. Hauptmann, Wedekind, Hofmannsthal, Toller, Hasenclever, Kaiser, Sternheim, Brecht, Weiss, Zuckmayer, Frisch, Durrenmatt, Handke, Hacks, and others. Readings in translation.
M. Dyck

21.310 Masterpieces of the Hispanic Tradition (New)

Prereq.: —
U (1) HUM-D **Next offered 1984-85**
3-0-6

Major works of Hispanic literature and film, including the *Poem of The Cid*, Cervantes' *Don Quijote*, Lorca's *House of Bernarda Alba*, García Márquez's *One Hundred Years of Solitude*, short stories by Borges, and films by Buñuel. Traces development of Hispanic culture through focus on fanaticism, honor, and the grotesque, as well as on humor as a way to cope creatively with the world or the escape from it.
M. Resnick

21.311 Latin American Literature: Civilization vs Barbarism

(21.319)
Prereq.: —
U (2) HUM-D **Next offered 1984-85**
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, emphasizing 20th-century novels and short stories. Authors include Borges, Garcia Márquez, Cortázar, Carpentier, and Rulfo.
E. Garrels

21.313 Religious Trends in Soviet Thought and Literature

(21.314)
Prereq.: —
U (1) **Next offered 1984-85**
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 mystical philosophy on the poets Mayakovsky and Blok; and Christianity in Bulgakov's fiction. The hero as zealot: Pasternak and *Doctor Zhivago*. Traces of medieval tradition in Pasternak and Solzhenitsyn. Students encouraged to read some texts in the original.
K. Pomorska

21.314 Tolstoy: An Approach to Biography and Creativity (New)

Prereq.: Permission of Instructor
U (1) HUM-D **Not offered 1984-85**
3-0-9

Presents Tolstoy's work and personality in the context of the revolutionary reforms of the 1860s as well as within the framework of the *fin de siècle*. Also shows Tolstoy as a unique cultural and psychological phenomenon, in Russia and the world. Emphasizes the experimental aspect of Tolstoy's prose, focusing on his "literature of fact" and the technique of montage. Besides two autobiographies, short stories, and *Sebastopol Sketches*, analyzes major novels *War and Peace*, *Anna Karenina*, and *Resurrection*.
K. Pomorska

21.315 Seminar on Tolstoy's *War and Peace*

(21.317)
Prereq.: Permission of Instructor
U (2) **Next offered 1984-85**
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; his 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. Students with a knowledge of Russian encouraged to read some texts in the original.
K. Pomorska

21.316 The Roots of Russian Literature

(21.318)
Prereq.: —
U (2) HUM-D **Next offered 1984-85**
3-0-6

Roots of 19th- and 20th-century Russian Literature in medieval literature and folklore. Emphasizes themes, genres, and character types that originate in early times and recur in modern reworkings. Includes theme of writer as prophet; genres of chronicle, fairy tale, saint's life, and epic; folklore and saintly characters. Students encouraged to read assignments in Russian.
J. Alissandratos

21.317 Russian Novel of the 19th Century

(21.316)
Prereq.: —
U (2) HUM-D **Not offered 1984-85**
3-0-6

The development of the novel in Russia in the context of the evolving European novel. Emphasizes three major fictional modes: the historical, the psychological, and the satirical/realist novel and their European counterparts. Gives attention to the larger historical and social issues which determined the creative milieu of Pushkin, Lermontov, Gogol, Tolstoy, Dostoévsky. Their relation to Sterne, Byron, Walter Scott. Students with a knowledge of Russian encouraged to read some texts in the original.
K. Pomorska

Senior Seminar

21.320 Senior Seminar for Majors in Foreign Language and Literature

Prereq.: —
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. Gives special attention 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.: —
U (1) HUM-D
3-0-6

See description under subject 24.900J.
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
U (2)
3-0-6

See description under subject 24.901J.
J. W. Harris

21.324 Workshop in Translation

Prereq.: Permission of Instructor
U (1) **Next offered 1984-85**
3-0-6

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. Critically examines models of translation, both classical and contemporary. Gives attention to linguistic problems of translation. Students complete a translation project which they elaborate in consultation with the faculty. Knowledge of any second language at an intermediate level or above is usually sufficient.
C. V. Chvany

English as a Second Language

21.325 English I: English as a Second Language

Prereq.: Placement test or Permission of Instructor
U (1)
3-0-6

Reviews fundamental grammatical structures of English through study of four language skills: listening comprehension, speaking, reading, and writing. Class activities develop better understanding and use of English structures essential for active and accurate communication. Language laboratory program coordinated with and supplementary to class work.
K. J. Irving

21.326 English II: English as a Second Language

Prereq.: Placement test or Permission of Instructor
U (1, 2)
3-0-6

Extends study of basic grammatical structures in English to more complex structural patterns. Consolidates and continues practice in speaking, listening, reading, and writing. Activities, which include language laboratory work, reinforce understanding of English and lead to increased ability to communicate in English.
K. J. Irving

21.327 English III: English as a Second Language (Revised Unit)

Prereq.: Placement test or Permission of Instructor
U (1, 2)
3-0-6

Expands and continues study of complex grammatical structures in English. Improves and refines fluency and style by focusing on precision in the use of complex language patterns in oral and written communication as well as by integrating reading and language laboratory assignments. Examines the subtle interaction of structure and meaning and aims to develop skills sufficiently to allow proficient functioning in English.
S. Flynn

21.331 Development of Listening and Speaking Skills: English as a Second Language (Revised Unit)

Prereq.: Placement test or Permission of Instructor
U (1, 2)
3-3-3

Provides intensive practice in oral communication and listening comprehension for students who have mastered the complex grammatical structures of English. Practice with presenting topics to class using various approaches and styles. Gives some consideration to appropriate teaching styles. Especially valuable for those who intend to teach or lecture in English. Language laboratory assignments supplement class work.
S. Flynn

21.333 Expository Writing I for Undergraduates: English as a Second Language

Prereq.: Placement test or Permission of Instructor
U (1)
3-0-6

Reading, discussing, summarizing, and paraphrasing articles and essays in non technical fields. Provides practice in basic writing skills by focusing on development of clear, well-organized paragraphs and essays. Also gives attention to vocabulary development and grammar.
K. J. Irving

21.334 Expository Writing II for Undergraduates: English as a Second Language

Prereq.: Placement test or Permission of Instructor
U (1, 2)
3-0-6

Formulating, organizing, and presenting ideas clearly in writing. Reviews basic principles of rhetoric. Focuses on development of a topic, thesis, choice of appropriate vocabulary, and sentence structure to achieve purpose. Develops idiomatic prose style. Gives some attention to grammar and vocabulary usage.
S. Flynn

21.336 Expository Writing for Graduate Students: English as a Second Language

(21.335)
Prereq.: Placement test or Permission of Instructor
G (2)
3-0-6

Extensive writing assignments in English essays to practice the rhetorical and stylistic patterns under consideration. Topics progress from the basics of sentence structure through transitions and paragraph formation to organization of entire essay. Devotes some attention to other kinds of writing: grant proposals, thesis precis, job applications, and letters.
C. Sawyer-Laucanno

21.337 Workshop in Writing for Science and Engineering: English as a Second Language

(21.336)
Prereq.: Placement test
G (1, 2)
3-0-6

Analysis and practice of various forms of scientific and technical writing, from abstracts to journal articles. Detailed analysis of problems of conveying technical information to a specialist audience. Comparable to 21.760 but methods designed to deal with special problems of those whose first language is not English.
C. Sawyer-Laucanno

21.338 Workshop in Writing for the Social Sciences and Architecture: English as a Second Language

(21.337)
Prereq.: Placement test
G (1)
3-0-6

Advanced subject focusing on techniques, format, and prose style necessary for research papers. Emphasis on writing as required in fields such as Economics, Political Science, and Architecture. Methods designed to deal with special problems of those whose first language is not English.
C. Sawyer-Laucanno

Special Topics

21.348 Special Topics in Foreign Languages and Literatures

Prereq.: —
U (1)
Arr.

21.349 Special Topics in Foreign Languages and Literatures

Prereq.: —
U (2)
Arr.

Advanced work in foreign languages and literatures for students wishing to pursue topics or projects not provided for by regular subject offerings. Before registering, student must plan course of study with appropriate instructor in the Section and secure the approval of the Section Head. Normal maximum credit is 6 units. Nine-unit projects are occasionally approved. If the work is to count toward the HASS Requirement, it must carry 9 units. Six-unit projects count toward the HASS Requirement only by special petition to the Institute Committee on Curricula.

History

For other subjects related to history in addition to those given below, see 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: Near East and Greece

Prereq.: —
U (1) HUM-D
3-0-6

The cultural and political history of the ancient Near East and Greece down to Alexander the Great. Topics include: the evolution of urban societies and empires; religion, science, and technology; East-West contacts; rise of the polis and democracy; slavery; emergence of new art and literary forms. Readings of primary texts (e.g., Near Eastern myths, Homer, Thucydides) and a textbook.
H. A. T. O. Reiche

21.351 The Ancient World II: Rome

Prereq.: —
U (2) HUM-D
3-0-6

Roman republic in origin, structure, function. Roles of traditionalism, improvisation, Greek humanism. Outer success, yet internal polarization. Manipulation and terror as political instruments. Pompey, Cicero, Caesar, Augustus in ancient and modern perspective. Definitions of triumph and decline. Rostovzeff on proletarization. Why no industrial revolution in third century? Conflict of religions, Orthodoxy as value in theology and Roman law. Wide sampling of historians, ancient and modern.
H. A. T. O. Reiche

21.352 The Middle Ages I

Prereq.: —
U (1) HUM-D
3-0-6

Transitions from late Antiquity to the "First Europe," roughly from 300–1000 AD. Examines changes in late Roman ideas and institutions to those which became Gallo-Roman and then distinctively European. The issues of "civilization" and "barbarism," decline of literacy and urban centers, rise of the Church, Charlemagne, Vikings and Moslems, and the formation of feudal society.
R. M. Douglas

21.353 The Middle Ages II

Prereq.: —
U (2) HUM-D
3-0-6

Europe from the Viking-Magyar invasions through the phenomena of expansion 1050–1300: population growth, "agricultural revolution," revival of towns and trade, advent of a merchant class; feudal monarchies, Crusades, rise of universities and the formation of new elites. The civilization of the High Middle Ages treated as an unstable unity.
R. M. Douglas

21.356 History of the Western World I: 1500-1815

Prereq.: —
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.
T. H. Mahoney

21.357 History of the Western World II: 1815-1970

Prereq.: —
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.
T. H. Mahoney

21.360 European Social History in the 19th and 20th Centuries

Prereq.: —
U (2)
3-0-6

Studies the large-scale social and economic forces that changed the character of European society. Analyzes changes in: population, diet, and health standards; mass migrations; class and family structures, roles of women and children; conditions of labor. The emergence of mass social and revolutionary movements in response to these changes is a major theme.
W. B. Watson

21.361 Europe, 1917-1965: The Era of Mass Politics

Prereq.: —
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. The consequences of runaway inflation and world depression; causes of World War II; mobilization; and the structure of post-war Europe.
W. B. Watson

Special Subjects and Seminars

21.365 The Renaissance in Italy

Prereq.: —
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, emphasizing 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.: —
U (2)
3-0-9

Introduction to modern historical writing, emphasizing 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

21.369 Marx, Darwin, and Freud

Prereq.: —
U (1)
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, in history and philosophy of the cultural sciences, and in social thought.
B. Mazlish

21.370 Anarchism

Prereq.: —
U (2)
3-0-6

Readings from the classics of European and American Anarchism, and the study of anarchistic and anarchosyndicalist movements in Europe and the utopian anarchistic communities in the US. Examines all branches and versions of anarchism, from radical individualists to collectivist communitarians and various anarchistic critiques of modern industrial, bureaucratic society.
W. B. Watson

21.371J The Industrial Revolution: A Social and Cultural History (1750–1850)

(Same subject as STS 315J)
Prereq.: —
U (2) **Next offered 1984–85**
3-0-6

Examines the industrial revolution itself and its impact on society and culture. Focuses attention on the intellectual, emotional, artistic, literary, and social effects, including implications for demographic and class structure and for the family. Presentations, where possible, 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.: —
U (1) **Next offered 1984–85**
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.
D. B. Ralston

21.373 Modern Spain, 1469–1939 (New)

Prereq.: —
U (1) **Next offered 1984–85**
3-0-6

Development of modern Spain from union of Castile and Aragon to triumph of General Franco in Spanish Civil War. Topics: growth and collapse of empire, struggle to establish a modern state, liberal experiment and oligarchic reaction, *pronunciamiento*-style rebellions, rule of new elites, collapse of monarchy and the Republican experiment, polarization and civil war.
W. B. Watson

21.374 Vienna and Versailles (New)

Prereq.: —
U (2)
3-0-6

Two modern attempts to construct an enduring peace for Europe and the world following the wars of the French Revolution and Napoleon and World War I. Compares the ideas, institutions, and personalities dominating the architects of Vienna with their counterparts a century later at Versailles.
T. H. Mahoney

21.375 The Making of Russia in the Worlds of Byzantium, Mongolia, and Europe (ca. 850-1800)

Prereq.: —
U (2) **Next offered 1984–85**
3-0-9

Kievan state, tsardom of Muscovy, 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.
R. E. MacMaster

21.376 Imperial and Revolutionary Russia: Culture and Politics

Prereq.: —
U (1) HUM-D
3-0-9

Analyzes Russia's social, cultural, political heritage, Eurasian imperialist and autocratic, ca. 1850. Reform, modernization—and national catastrophe: World War I, 1917 Revolution, Civil War of 1918–1921. Emphasizes emergence of radicalism (Populism, Communism) as a political culture: its role in the making of a new order, the USSR, in the Russian empire and in world history. Larger cultural themes concerning revolutionary consciousness; films, literature, social thought.
R. E. MacMaster

21.377 The Soviet Union: A Communist Society in Historical Perspective

Prereq.: —
U (2)
3-0-9

Marxism-Leninism, totalitarianism, and modernization in post-revolutionary Russia. 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. Problems of evaluating the changing Soviet Union and other Communist regimes, especially China.
R. E. MacMaster

21.378J Seminar in the Historical and Political Evolution of the Soviet Union

(Same subject as 17.609J)
Prereq.: Permission of Instructor
U (2)
3-0-6

A reading subject on the history and politics of the Soviet Union. Emphasizes internal developments rather than foreign policy. Students discuss the readings weekly. All required readings are in English, but supplementary readings in Russian are available for those students wishing them. Open to advanced undergraduates with some previous work in the Soviet area. Meets with 17.609 and 17.610.
L. R. Graham

21.379 Spanish Civil War, 1936-39

Prereq.: —
U (2)
3-0-6

Examines how traditional conflicts in Spanish society erupted into civil war, almost immediately provoking a worldwide response. Examines 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

21.380 Hitler and Germany Since Bismarck

Prereq.: —
U (1) **Next offered 1984–85**
3-0-9

Bismark, Kaiser Wilhelm II, the Weimar Republic: belated nation-building and industrialization, total war, revolution (left and right). The millenarian ideas, new political style, and rise of Nazism. The regime: from the friendly fascist internal German phase (to about 1938) to that of totalitarianism, imperialist aggression and world war, terrorist and racist (the destruction of the European Jews) genocide. The Germanies since 1945: culture, politics, economies, society.
R. E. MacMaster

21.386 History and Psychoanalysis: Life-History

Prereq.: —
U (1)
3-0-6

Applies psychology, especially psychoanalysis, to understanding of history. Emphasizes 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

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.: —
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: 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, and the crisis of the 1850s; secession and the Civil War.
P. Maier

21.391 American History Since 1865

Prereq.: —
U (2) HUM-D
3-0-6

A survey of American history since Reconstruction. Topics: Reconstruction and the "racial settlement" of the late 19th century; immigration; agricultural, industrial, and commercial development, populism and progressivism; World War I and its aftermath; the New Deal; World War II and the Cold War; growth of the modern Presidency and the expansion of the role of government; the Civil Rights Movement; Vietnam and beyond.
J. Dittmer

Chronological Series

21.400 Colonial America

Prereq.: —
U (1) **Next offered 1984–85**
3-0-6

British North American history to about 1763 emphasizing the development of society and politics. Topics: the discoveries of America, earliest settlements, the Old British Empire, insurrections and witchcraft, slavery, the colonial wars, economic and social change, religion, politics and ideology before the American Revolution. Readings draw upon recent scholarship, much of which is interdisciplinary, and include writings from the colonial period.
P. Maier

21.401 The American Revolution

Prereq.: —
U (2)
3-0-6

English and American backgrounds of the Revolution; issues and arguments in the Anglo-American conflict; Colonial resistance and the beginnings of Republicanism; the Revolutionary War; constitution writing for the states and nation; 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.
P. Maier

21.402 The Establishment of the American Republic, 1790-1850

Prereq.: —
U (1) **Next offered 1984–85**
3-0-6

Examines 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.
Staff

21.403 The Civil War and Reconstruction

Prereq.: —
U (2) **Next offered 1984–85**
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 after Appomattox.
Staff

21.404 America in the Progressive Era, 1877-1917

Prereq.: —
U (1) **Next offered 1984–85**
3-0-6

The American response to industrialization and modernization between Reconstruction and World War I. 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.
J. Dittmer

21.405 America in the Twenties and Thirties, 1917-1941

Prereq.: —
U (1)
3-0-6

American politics, society, and culture during World War I, the 1920s, and the Great Depression. Afro-American and Southern history also receive attention. Topics: impact of the war on American society, failure of postwar 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.
J. Dittmer

21.406 America Since World War II, 1941 to the Present

Prereq.: —
U (2)
3-0-6

The transformation of American politics and society during and after World War II. Topics: the deepening American involvement in world affairs; expansion of the role of government; the civil rights movement, the new left, and the women's movement; political and cultural crises of the 1960s and 1970s. Readings include historical studies, contemporary literature and journalism, accompanied by films.
J. Dittmer

Topical Series

21.409 American Ideas and Culture: From the Puritans to the Civil War

Prereq.: —
U (1) HUM-D
3-0-6

American thought and culture from the 17th-century Puritans to the Civil War, as expressed in the work of various classic American major writers, thinkers, artists (e.g., Edwards, Franklin, Jefferson, Adams, Madison, Emerson, Whitman) and as embodied in American institutions, social life, and law. The influence of social structure and material circumstance on ideas in America. The emergence of the fundamental myths of American culture.
A. D. Kaledin

21.410 American Ideas and Culture: From the Civil War to WWI

Prereq.: —
U (1) **Next offered 1984–85**
3-0-6

American intellectual and cultural life in an era of intense social and economic dislocation, studied mainly through the ideas of major figures and movements of the period. "Victorian" culture in the Gilded Ages; the influence of Darwin and Freud on American thought; the response of religion to science and the new urban-industrial culture; "Progressive" ideas about reform, class, social order, and justice; changing ideas about race, women, black Americans, the immigrant; developments in literature, art, architecture, and popular culture.
A. D. Kaledin

21.411 American Ideas and Culture: The Modern Age, 1920-1980

Prereq.: —
U (2)
3-0-6

American thought and culture from the Jazz Age and the "Lost Generation" of the 1920s through the Counterculture of the 1960s and the new conservatism of the 1970s. Developments in popular culture and in religious and political thought; changing ideas about men, women, sexuality, and ethnicity; the effect of technology on American cultural life and institutions. Examines the current sense of crisis.
A. D. Kaledin

21.412J American Urban History I

(Same subject as 11.013J)
Prereq.: —
U (1) HUM-D
3-0-6

See description under subject 11.013J.
R. M. Fogelson

21.413J American Urban History II

(Same subject as 11.014J)
Prereq.: —
U (2)
3-0-6

See description under subject 11.014J.
R. M. Fogelson

21.416 Women's History

Prereq.: —
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

21.418 The Civil Rights Movement (New)

Prereq.: —
U (1)
3-0-6

Examines the civil rights movement in the South from the mid-1950s to the late 1960s from the points of view of activists, observers, and scholars. Also devotes some attention to movement-related activities in other parts of the US.
J. Dittmer

21.431 Thomas Jefferson and His Age (New)

Prereq.: —
U (1)
3-0-9

Intensive study of the ideas and life of Thomas Jefferson and, through him, of political, intellectual, and cultural issues central to his era. Considerable attention to the ideas of John Adams and Alexander Hamilton, and to the Jeffersonian tradition in the 19th and 20th centuries.
A. D. Kaledin

Special Subjects and Seminars

21.432 Religion in America

Prereq.: —
U (2)
3-0-6

A history of religious life and thought in America, emphasizing the 19th and 20th centuries. Main topics: developments in the major churches; the evangelical-revivalist tradition from Jonathan Edwards to Billy Graham; original American religions (e.g., Mormonism); recent religious developments (e.g., Eastern religions, therapeutic faiths, born-again Christianity, satanic cults). The place of religion in American culture and politics.
A. D. Kaledin

21.433J Industrialization and Cultural Change in 19th-Century America

(Same subject as STS 310J)
Prereq.: —
U (2)
3-0-6

See description under subject STS 310J.
M. R. Smith

21.435 The American Psyche

Prereq.: —
U (2)
3-0-6

A study of 1) the American national characters, i.e., the question of identity, starting with the examination of the concept itself and then of efforts (e.g., by Tocqueville, Erikson) to describe and analyze such a presumed character; and 2) the application of psychological approaches to 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).
B. Mazlish

21.439 Fortress America: The Rise of the American Military, 1945-1975

Prereq.: —
U (2) **Next offered 1984-85**
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. Topics: ideological and political justifications for military establishments, changing force structures, changing role of military institutions in foreign policy, defense budgets, impacts of defense spending.
W. B. Watson

21.449 Seminar in American Studies

Prereq.: —
U (2) **Next offered 1984–85**
3-0-9

Introduces students to the problems and issues in the interdisciplinary study of American culture. Devoted either to classic works of scholarship in the field of American studies or to a particular problem or theme. Topic for 1984–85: American popular culture since 1945. TV, movies, rock and country music, comedy, "amusement" parks, popular fiction, pop-cult "stars." Theories of popular culture. The relationship of popular to literary culture. Requires a major research project of all participants.
A. D. Kaledin

History of Africa, East Asia, Latin America, and the Middle East

History of Africa

21.450 The History of Africa

Prereq.: —
U (1) **Next offered 1984–85**
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 The History of 20th-Century Africa: Nationalism and Nation-Building

(Same subject as 17.551J)
Prereq.: —
U (2) HUM-D **Next offered 1984–85**
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.: —
U (2) **Next offered 1984–85**
3-0-6

Political and historical problems of South Africa, Namibia, Zimbabwe, and other countries of southern Africa. Particular attention paid to the development of *apartheid* in South Africa and to its possible future abolition. Also closely examines the liberation struggle in southern Africa, its successes and failures. Role of American and European policy toward southern Africa looked at critically. Analyzes the position of American corporations.
R. I. Rotberg

21.455J The History and Politics of the Third World Through the Novel

(Same subject as 17.553J)
Prereq.: —
U (1) **Next offered 1984–85**
3-0-6

Studies history, society, and politics of the black third world through a selected examination of a dozen critical novels. Authors read include Abrahams, Achebe, Armah, Cary, Lamming, Hutchinson, Mulaisho, Naipaul, Ngugi, Oyonyo, Beti, Sembene, Brink, Gordimer, Paton, and Jacobson.
R. I. Rotberg

21.457J Research Seminar in Imperialism and Colonialism

(Same subject as 17.564J)
Prereq.: Permission of Instructor
G (1)
3-0-6

Topics in the economic, social, and cultural bases of imperialism and colonialism, its theory and practice. Substantial written work expected.
R. I. Rotberg

21.458 Modern Imperialism (New)

Prereq.: —
U (1)
3-0-6

The expansion of Western culture over virtually the entire world was the product of nationalism and the Industrial Revolution. In examining the expansion of the West, the subject examines contrasting national imperial models emphasizing the British in India, the French in North Africa, the Germans in East Africa, and the Americans in the Philippines.
T. H. Mahoney

History of East Asia

21.460 East Asian History: China

Prereq.: —
U (1) HUM-D
3-0-6

History of Chinese civilization from the Shang through the Ching dynasties (1500 BC–1911 AD). Topics: the origins of Chinese civilization; Confucianism and Taoism; the early empire; the effects of Buddhism; the Tang-Sung transition; popular literature; Ch'ing conquest and the late empire; 19th-century rebellion and decline.
P. C. Perdue

21.461 East Asian History: Japan

Prereq.: —
U (2) HUM-D
3-0-6

History of Japanese civilization from its origins to the present, concentrating on the period of rapid transformation from the late Tokugawa period through the end of the American occupation (1800-1954). One major theme is the distinctiveness of Japanese society and the nature of foreign influences on it.
P. C. Perdue

21.462 Social and Economic Transformation in China, 900-1850

Prereq.: —
U (1)
3-0-6

The long-term processes of social and economic change from the Sung to the Ching dynasties. Examines the roles of geography, regional variation, demographic change, commerce and state economic policy, advances in technology, and transformation of agriculture; landlords, tenants, and social relations on the land; popular culture, forms of collective action. Concludes with discussion of the contemporary legacy of this period's trends.
P. C. Perdue

21.463 The Chinese Revolution: 1850-1976

Prereq.: —
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. Includes comparison of Mao's revolutionary practice with theories of revolution, Marxist and non-Marxist.
P. C. Perdue

History of Latin America

21.470 Latin American History

Prereq.: —
U (1) **Next offered 1984-85**
3-0-6

Survey of Latin America from the Conquest to the present. Analyzes 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.
P. H. Smith

21.471 History of Mexico

Prereq.: —
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

History of the Middle East

21.480 The Middle East From the Rise of Islam to World War I

Prereq.: —
U (1) HUM-D
3-0-6

Surveys Middle Eastern history. Part I examines the Classical Age of Islam (600–1300) through themes of Arab expansion and adaptation. Stresses nomadic-urban encounters, sociopolitical institutions, religious sects, cultural-scientific achievements and their transmission to Europe. Part II examines later Islamic states (post 1300), especially the Ottoman Empire and its background, to modern Middle East. Emphasizes Europe's dramatic expansion after 1800 and Middle Eastern responses to the European challenge, including rise of modern nationalisms.
P. S. Khoury

21.481 The Middle East in the 20th Century

Prereq.: —
U (2) HUM-D
3-0-6

Surveys major political, socioeconomic, and cultural changes in the post-World War I Middle East through the lenses of religion, state, and nationalism. Investigates interwar independence struggles against Europe, followed by the emergence of American and Soviet influence, radical nationalist and socialist movements, and the growth of modern states and societies after 1945. Concludes with examination of four contemporary problems in historical perspective: Arab-Israeli conflict, oil and regional security, Islamic revivalism, and the Iranian revolution.
P. S. Khoury

21.482J The 'Islamic' City: History, Culture, and Form

(Same subject as 4.683J)
Prereq.: —
G (2)
3-0-6

See description under subject 4.683J.
P. S. Khoury, W. L. Porter, Y. Tabbaa

21.483 Nationalism and Revolution in the Middle East

Prereq.: —
U (1)
3-0-6

The Middle East's experience with nationalism in the 20th century. Examines theories and varieties of nationalism, imperialism, and revolution. Focus on Arab nationalism: its origins; character of independence movements; rise of radical pan-Arabism and relationship with radical Islamic and Marxist movements; special place of Palestinian nationalism; and retreat from pan-Arabism after 1970. Comparisons with Turkish, Iranian, and other third world nationalisms.
P. S. Khoury

21.484 Modern Egypt: State and Society in Transition (1800 to Present)

Prereq.: —
U (2) **Next offered 1984–85**
3-0-6

Examines process of colonization/decolonization, interplay of human and physical environment, and role of Islam in shaping the character of state and society in independent Egypt. Explores kinds of change Nasser's "revolution" (1952–70) produced, with attention to the army in politics, urban and rural society, lure of Arab nationalism/socialism, and superpower rivalry. Ends with assessment of "de-Nasserization" in 1970s and implications of Sadat regime's economic and political liberalization, pro-American orientation, and "peace" with Israel.
P. S. Khoury

21.490 Special Topics in History

Prereq.: —
U (1)
Arr.

21.491 Special Topics in History

Prereq.:—
U (2)
Arr.

Individual supervised work for students who wish to study topics not covered in the regular history offerings. Before registering for this subject a student must plan a course of study with some member of the History Section and secure the Section Head's approval. Normal maximum is 6 units; to count toward the Humanities Requirement, 9 units are required. Nine-unit projects are occasionally approved.
P. Maier

Anthropology/Archaeology

21.50 Introduction to Anthropology

Prereq.: —
U (1) HUM-D
4-0-8

Cultural differences and anthropology, approached through case studies of societies from different levels of social complexity: hunter-gatherers, tribal peoples, peasants, complex societies. One case study of a complex society — e.g., ancient Maya, Inca, or Mesopotamia -- drawn from archaeological research. Field methods and theory in anthropology and archaeology. Impact of change on small-scale societies.
J. Howe

21.501 Crossing Cultural Boundaries

Prereq.: —
U (1) HUM-D **Next offered 1984-85**
3-0-9

How do we experience and understand other cultures? By examining anthropological research techniques, reading personal accounts of fieldwork, and carrying out their own research projects, students consider the problem of gaining systematic knowledge about other people. Equips students to more critically assess social scientists' claims about human behavior and culture.
J. E. Jackson

21.502 Controversies and Core Ideas in Anthropology

Prereq.: —
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, structuralism. Emphasis on the origin and subsequent development and elaboration of basic ideas, and on the social and historical contexts of these ideas.
J. E. Jackson

21.503 Paths to Civilization

Prereq.: —
U (2) HUM-D
3-0-6

Evolution of humankind and rise of complex societies and empires examined comparatively in a number of different culture areas. Focus on human evolution, domestication of plants and animals, development of sedentary life, origins of the state, spread of civilization. Ecological adaptation, technology, trade, religion, and the "great man" examined as agents of cultural change. Areas considered: the Americas, Europe, Southwest Asia, Africa, Indus region, China.
A. Steinberg

21.504 Approaches to Archaeology

Prereq.: —
U (1)
2-4-6

Studies various analytical techniques and approaches used to "tease" the past out of archaeological remains. Lectures and discussions on methods of archaeology and their theoretical underpinnings. Weekly lab sessions devoted to analyzing artifacts and data, and testing the tools of archaeology. Topics: surveying and locating sites, excavation strategies, dating techniques, analyzing ceramic and lithic artifacts, studying organic remains, statistics, uses of inference, and experimental archaeology.
S. P. DeAtley

21.505 Anthropology and Technology

Prereq.: —
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

21.506J Seminar on Technology and Development

(Same subject as 17.330J, 22.94J)
Prereq.: —
G (2)
3-0-9

See description under subject 17.330J.
Staff

21.507 Human Origins and Adaptations

Prereq.: —
U (2)
3-0-6

Examines the dynamic interrelations among physical and behavioral traits in humans and environment, culture, and social practices to provide an integrated framework for studying human biological diversity. Topics: issues in evolution and adaptation; fossil and cultural evidence for human evolution from earliest times through the Pleistocene; evolution of tool use, social behavior and organization; territoriality and aggression; sex roles; concepts of race.
S. P. De Atley

21.510 Anthropology and Speculative Fiction

Prereq.: —
U (1) **Next offered 1984–85**
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.
J. E. Jackson

21.511 Magic, Shamanism, and Witchcraft: The Dynamics of Belief and Practice

Prereq.: —
U (2) **Next offered 1984-85**
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.
J. Howe

21.512 Myth, Ritual, and Symbolism

Prereq.: —
U (2) **Not offered 1984-85**
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.: —
U (1) HUM-D **Next offered 1984-85**
3-0-6

New religions and religious movements, the conditions that inspire them, their effect on society. Messianism, apocalypse, revelation, cults, schismatic and unorthodox sects, nativism, revitalization, revivalism. Examples from the US (revivalism, communal sects, cults), from Europe (medieval heresies and messianism), and from third world societies (the Iroquois Handsome Lake Religion, the Ghost Dance, Cargo Cults, military messiahs).
J. Howe

21.520 Mexican Society and Development

Prereq.: —
U (2)
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

21.541J The Archaeology of Technology (New)

(Same subject as STS 400J)
Prereq.: —
U (1)
3-0-6

Technologies of ancient and pre-industrial societies as revealed by excavation, scientific analysis of artifacts, ethnohistory. Case studies of technologies include cloth production among the Inca, building in imperial Rome, Iron Age metallurgy of East Africa. Comparisons to illuminate interactions of technologies with cultures; the role played by materials processing, labor organization, and ideology in the development of industries; the formation of technological styles.
H. N. Lechtman

21.542 Culture and the Visual Arts

Prereq.: —
U (1) HUM-D **Next offered 1984–85**
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

21.543 Mathematics and Computers in Archaeological Data Analysis (New)

Prereq.: Permission of Instructor
G (1, 2)
2-4-3

Lecture-laboratory subject offered by the Center for Materials Research in Archaeology and Ethnology. Applies mathematical, statistical, and computer science techniques in the analysis of archaeological data. Includes elementary probability theory, logic of scientific induction, research design and sampling techniques, multivariate methods of data analysis, computerized data files. At least one prior college-level course in statistics or computer science is desirable. Senior undergraduates may enroll after consultation with the instructor.
H. N. Lechtman

21.544 Materials in Ancient Societies: Metals (Revised Content)

Prereq.: Permission of Instructor
G (1)
3-6-3

Seminar-laboratory subject offered by the Center for Materials Research in Archaeology and Ethnology. Role of materials and technologies in the development of ancient societies; major focus on scientific analysis of archaeological artifacts. Topics: ore formation, extraction, and smelting; alloying; nonindustrial techniques of manipulating metal into desired forms. Laboratories involve metallographic examination and analysis of excavated metal artifacts. Senior undergraduates may enroll after consultation with the instructor.
H. N. Lechtman

21.546 The Archaeology of Industrial Revolutions

Prereq.: —
U (2)
3-3-3

Cross-cultural inquiry into the process of industrialization, considering the varieties of technological innovation and community formation at manufacturing sites in the European Middle Ages, 18th-century Britain, and the New World (Colonial, Post-Revolutionary). Discusses the theory and practice of industrial archaeology as a human science; case studies; fieldwork at key industrial sites; the relation of industrial archaeology to museums, public agencies, private enterprise, and historic preservation.
M. Folsum

21.550 The Ancient Andean World

Prereq.: —
U (1) **Next offered 1984-85**
3-0-6

Examines development of Andean civilization which culminated in the extraordinary empire established by the Inca. Archaeological, ethnographic, and ethnohistorical approaches. Particular attention to the unusual topography of the Andean area, its influence upon local ecology, and the characteristic social, political, and technological responses of Andean people to life in a topographically "vertical" world. Characteristic cultural styles of prehistoric Andean life.
H. N. Lechtman

21.551 The First Americans

Prereq.: —
U (2)
3-0-6

Indian cultures in North America from Paleo-Indian entry into the New World over 10,000 years ago to European contact. Includes: Pleistocene Paleo-Indian big game hunters; development of regional differences among Indian groups; major pre-Columbian cultures (e.g., Southwestern Cliff Dwellers, Southeastern Moundbuilders); art and ritual (e.g., rock art, ancient astronomy); relation of prehistoric Indian cultures to modern Indian groups.
S. P. De Atley

21.552 Origins of Civilization — The Aztec, Maya, and their Ancestors

Prereq.: —
U (1)
3-0-6

Ancient societies of Mexico and Central America, from the earliest times to the Aztec and Maya in 1500 AD. Emphasizes understanding major changes in human life in the New World, the origin of complex societies from simple beginnings. The change from gathering to agriculture, evolution of corn from wild grasses. Origin of pottery, other technological innovation. Origin of cities, states, and empires.
Staff

21.553 Origins of Civilization — Middle East

Prereq.: —
U (2) **Next offered 1984–85**
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, examines why such complex societies arose in this area. Considers 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.
A. Steinberg

21.554 Origins of Civilization — Egypt

Prereq.: —
U (1)
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.
Staff

21.555 Origins of Civilization — China

Prereq.: —
U (1) **Next offered 1984–85**
3-0-6

The emergence of one of the world's longest lived "great societies" viewed through both the archaeological and documentary evidence. Topics: evolution of the state; place of various technologies in the perpetuation of a ruling elite; forms of urbanization; feudalism; 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 the empire. Visits to local museums, oral reports included in class work.
A. Steinberg

21.556 Archaeology of the Greek and Roman World

Prereq.: —
U (2)
3-0-6

Discusses major archaeological sites and problems selected from either the Greek or Roman world. Emphasizes what can be learned from the archaeological materials about these complex societies and how the archaeology helps to flesh out the historical context. Focus on major palace sites, sanctuaries, and urban settlements with a consideration of archaeological methodology, including how sites are chosen and excavated, and how materials are analyzed. Visits to local museums.
A. Steinberg

21.559 The Decline of Empires

Prereq.: —
U (2) **Next offered 1984–85**
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. Considers frontiers, military power, bureaucracy, ruling elites, religions, population growth, raw materials and markets, and urbanization. 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.: —
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

21.583 Language and Culture

Prereq.: —
U (1)
3-0-6

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

21.584 Agrarian Society

Prereq.: —
U (2) HUM-D **Next offered 1984-85**
3-0-6

Rural society and culture in three epochs, ancient, medieval, and modern. Central focus on conternporary peoples; background and perspective from ancient (Mesopotamia, Mexico, Greece, China) and feudal cases. Emphasizes rural-urban relations, state control of labor, political rights, religion, and land. Community and family structure, religious ideology, value systems. Agrarian social movements from millenarian uprisings to peasant revolution.
M. Diskin

21.585 American Communes and Utopias

Prereq.: —
U (2) **Next offered 1984–85**
3-0-6

Examines the communal movement of the 19th and 20th centuries through case studies of Shaker, Oneida, Hutterian, Mormon, and several modern planned communities, rural and urban, religious and secular. Issues include: philosophical underpinnings; architecture; degree of economic sharing; sexual, marital, and family arrangements; private and communal spheres; government; religion; relations with the larger society.
J. E. Jackson

21.586 Sex Roles: A Comparative Perspective

Prereq.: —
U (1)
3-0-9

Examines 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.
J. E. Jackson

21.587 Organizing Modern Society

Prereq.: —
U (1)
3-0-6

Anthropological approaches to understanding the groups and organizations in which the members of modern societies live and work. Corporations, bureaucracies, families, political parties, factions, networks, followings. Comparison of modern industrial societies, especially Japan and the US. Topics: how work groups develop distinctive cultures, how groups train and socialize new members, how elites maintain their privileges and hierarchies.
S. Traweek

21.589J Anthropology of Industrial Society

(Same subject as STS 500J.)
Prereq.: —
U (2)
3-0-6

Overview of anthropological studies of the US, Japan, and other industrial societies. Topics: the modern corporation, the defense, research, and service industries, the modernization of agriculture, and the effects of industrialization on small towns and rural communities. Emphasizes the relationship of self, family, community, and work in industrial societies, especially at times of crisis. Consult J. Howe.

21.592 Food, People, and Culture

Prereq.: —
U (2) **Next offered 1984-85**
3-0-6

Anthropological perspectives on food and nutrition. Cultural variation in diet, the food quest in different environments. Effects of kinship, politics, and ritual on obtaining and distributing food. Food as symbol, political tool, and index of wealth. Case studies of hunter-gatherers, agriculturalists, herders. Technology, adaptation, evolution of human diet. The current food crisis.
Staff

21.594J Camera and Culture

(Same subject as STS 626J)
Prereq.: —
U (2) **Next offered 1984-85**
3-0-6

See description under subject STS 626J.
S. Traweek

21.597 Colonialism, Development, and Nationalism: The Impact of the State on Traditional Societies

Prereq.: —
U (2) **Next offered 1984–85**
3-0-6

This joint MIT-Wellesley seminar investigates how traditional peoples of small-scale societies and peasant communities are incorporated into nation-states in directions favored by the dominant national society. Discusses tribalism as a feature of nationalism; development, dependency, and internal colonialism; linguistic and ethnic conflict in pluralistic societies.
J. E. Jackson

21.598 Special Topics in Anthropology/Archaeology

Prereq.: Any two subjects in Anthropology or Archaeology
U (1)
Arr.

21.599 Special Topics in Anthropology/Archaeology

Prereq.: Any two subjects in Anthropology or Archaeology
U (2)
Arr.

Topics in anthropology or archaeology not included in other subjects. Students electing this subject must secure the approval of the chair of the Anthropology/Archaeology Program. Normal maximum is 6 units; to count toward Humanities Requirement, 9 units are required. Exceptional 9-unit projects occasionally approved.
J. Howe

Music

The music subjects described below are grouped within five areas: introductory subjects, history/literature, theory/composition, performance, and seminars/tutorials.

Although most students start with 21.60 or 21.601, those who have vocal or instrumental training or extensive exposure to music are encouraged to begin at a higher starting level.

Introductory Subjects

21.60 Listening to Music

Prereq.: —
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 emphasis on aural perception of the musical experience. 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 Fundamentals of Music

(21.611)
Prereq.: —
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, keyboard, or sight-singing skills included.
S. Erdely, C. Von Canon

21.602 Basic Musicianship

(21.612)
Prereq.: —
U (1, 2)
3-2-4

An integrated approach to basic musicianship, which aims at deepening students' understanding of fundamental musical processes. Work includes many kinds of listening exercises, group sight-singing, in-class instrumental performance, and a keyboard laboratory for elementary score reading and beginning keyboard harmony. Intended for students who are familiar with notation and have some instrumental/listening experience. Students with considerable experience in performance and basic theory should try to begin with 21.641.
J. Coppock, M. Howe

21.605 Exploring Musical Structure

(21.616J)
Prereq.: —
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. Limited to 15.
J. S. Bamberger

21.615 Musical Acoustics

Prereq.: —
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. 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.
Staff

History/Literature

21.621 Western Music to 1750 (Revised Content)

Prereq.: Permission of Instructor
U (1) HUM-D
3-0-6

European art music from its foundation in antiquity through the Christian Middle Ages, the Italian Renaissance, and the Baroque. Written assignments offer the opportunity to write about the music itself and about topics in the history of musical style.
T. C. Aarset

21.622 Western Music after 1750

Prereq.: Permission of Instructor
U (2) HUM-D
3-0-6

A chronological survey of European art music during the Classic, Romantic, and Modern periods. Compositions analyzed in detail, and placed within their historical context. Most written assignments analyze musical works, so score-reading ability is helpful.
L. E. Lindgren

21.625 Vivaldi, Bach, and Handel

(21.601)
Prereq.: Permission of Instructor
U (2) 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 societal and intellectual developments of the time in Italy, Germany, and England. Score-reading ability helpful.
L. E. Lindgren

21.626 Haydn, Mozart, and Beethoven

(21.602)
Prereq.: Permission of Instructor
U (2)
3-0-6

A study of 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

21.627 Schubert to Mahler

(21.603)
Prereq.: Permission of Instructor
U (1)
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

21.628 Twentieth-Century Music

(21.623)
Prereq.: Permission of Instructor
U (2)
3-0-6

A survey of major musical trends that evolved in our century. Begins with Debussy, Strauss, Reger, and the post-Romantic and Impressionistic movements in music, continues with the 12-tone school of Schoenberg, the Neo-Classical and Folklorist trends as represented in the works of Stravinsky, Bartok, and Kodaly, and concludes with related movements embodied in the compositions of Milhaud, Hindemith, Prokofieff, Copland, Sessions, Stevens, and composers now active in the Boston area.
S. Erdely

21.631 Symphonic Music

(21.605)
Prereq.: Permission of Instructor
U (2) HUM-D **Next offered 1984–85**
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.
S. Erdely

21.632 Chamber Music

Prereq.: Permission of Instructor
U (1) **Not offered 1984–85**
3-0-6

A survey of the literature for various single-instrument-per-part combinations of strings, winds, keyboard, and voices. Focus through papers and recordings on history, influences, structure, and changing performance practices. Where possible, live performances in class by students, guests, and MIT Chamber Players.
M. A. Thompson

21.633 Theater Music

Prereq.: Permission of Instructor
U (2) **Next offered 1984–85**
3-0-6

A chronological survey of musical drama, beginning with the medieval *Play of Daniel* and ending with the Broadway musical *Sweeney Todd*. Most of the semester devoted to operatic masterpieces from Mozart through Verdi. Focus on the changing ways in which music has interpreted and enriched dramatic texts.
L. E. Lindgren

21.635 American Music

(21.607)
Prereq.: Permission of Instructor
U (1) HUM-D **Next offered 1984-85**
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.
L. E. Lindgren

21.636 Jazz

(21.608)
Prereq.: Permission of Instructor
U (1) HUM-D
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.
M. Harvey

21.637 Traditional Music in America

(21.624)
Prereq.: 21.601 or 21.602
U (1) HUM-D **Not offered 1984–85**
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 on historical and broad cultural significance of this repertoire. Permission of instructor required.
S. Erdely

Theory/Composition

21.641 Harmony and Counterpoint I

Prereq.: 21.601 or 21.602
U (1, 2)
3-3-6

Basic writing skills in music of the common-practice period (Bach to Brahms). Work includes regular written assignments leading to the composition of short pieces, analyzing representative works from the literature, keyboard laboratory, and sight-singing choir.
E. Cohen, J. Coppock, Staff

21.642 Harmony and Counterpoint II

Prereq.: 21.641
U (1, 2)
3-3-6

A continuation of Harmony and Counterpoint I, including chromatic harmony and modulation, more elaborate contrapuntal textures, keyboard laboratory, and sight-singing choir.
E. Cohen, Staff

21.643 Writing in Tonal Forms

Prereq.: 21.642
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 Ländler and songs, Schumann small piano pieces and songs, and Chopin Preludes and Mazurkas.
E. Cohen

21.644 Advanced Writing

(21.670)
Prereq.: 21.643
G (1, 2)
3-0-6

A study of compositional procedures during the early years of the 20th century. Emphasis on written and analytical 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 expected to attend the weekly graduate seminar in composition.
E. Cohen

21.648 Jazz Harmony and Arranging

(21.645)
Prereq.: 21.602 and 21.636
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. Permission of instructor required.
M. Harvey

Performance

21.651 Early Music Society

Prereq.: Permission of Instructor
U (1, 2)
2-2-2

Study and performance of Medieval, Renaissance, and Baroque music. Each term focuses on one repertory and one research or performance problem. May be elected twice for credit. Twelve units needed for subject to count toward Institute Requirement in Humanities, Arts, and Social Sciences, by routine petition to COC.
T. C. Aarset

21.653 MIT Choral Society

Prereq.: Permission of Instructor
U (1, 2)
2-2-2

Rehearsal and performance of choral repertoire through participation in the MIT Choral Society. Four additional meetings (TBA) devoted to the analysis of the music in preparation. Each term covers music from a different style period. May be elected twice for credit. Twelve units needed for subject to count toward Institute Requirement in Humanities, Arts, and Social Sciences, by routine petition to COC.
J. S. Oliver

21.655 Chamber Music Society

Prereq.: Permission of Instructor
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. Twelve units needed for subject to count toward Institute Requirement in Humanities, Arts, and Social Sciences, by routine petition to COC.
M. A. Thompson, J. L. Buttrick

21.657 MIT Symphony

Prereq.: Permission of Instructor
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. Twelve units needed for subject to count toward Institute Requirement in Humanities, Arts, and Social Sciences, by routine petition to COC.
D. M. Epstein

21.659 Advanced Music Performance (New)

Prereq.: Permission of Instructor
G (1, 2)
Arr.

For students who are involved in special performing projects with MIT faculty, or who wish to further their instrumental or chamber music prowess through intensive study. Open to graduate or undergraduate students who demonstrate considerable technical and musical skills, and who wish to develop them at an advanced level. Coordinator:
M. A. Thompson

Seminars/Tutorials

21.661 Beethoven (Revised Content)

(21.638)
Prereq.: 21.642
G (1)
3-0-6

For students with a basic knowledge of harmony, counterpoint, and score reading. Background in serious instrumental study also desirable. Examines the evolution of Beethoven's thematic, harmonic, and structural style through a close study of his works. Looks at how he was viewed by his contemporaries, and at the changing comprehension of his music in the past 175 years. Readings, class and concert performances, both student and professional.
J. L. Buttrick

21.665 Advanced Musical Analysis

Prereq.: 21.642
G (1)
3-0-6

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. Study of scores, listening to recordings, readings, and a research paper constitute out-of-class work. Permission of instructor required.
D. M. Epstein

21.666 Structure of Musical Time

Prereq.: Permission of Instructor
G (2)
3-0-6

Study of musical time in its structure, affect, articulation, pacing, interaction with pitch. A multifaceted focus, 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. Research projects, discussions, and reports. Background in music theory necessary.
D. M. Epstein

21.667 Research Methods of Oral Music

(21.662)
Prereq.: Permission of Instructor
G (2) **Next offered 1984–85**
3-0-6

Examines 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.
S. Erdely

21.668 Cognitive Aspects of Musical Development and Learning (A)

(21.953J)
Prereq.: Background in music theory, some familiarity with cognitive psychology
G (1) **Next offered 1984–85**
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

21.671 Digital Music Processing (A) (Revised Content and Unit)

(21.647)
Prereq.: 21.642, 21.615
G (1)
3-4-5

Digital audio processing as an artistic music production tool. Analysis, resynthesis of musical instrument tones. Nonlinear and linear-predictive synthesis. Perceptually based synthesis using the auditory transform. Digital recording, processing, editing. Digital reverberation, ambiance control. Music-encoding languages, procedurally defined scores, performer-like interpretation. Real-time synthesis on array processors under gestural control. Human-machine interaction in music performance. Assignments, synthesis projects.
B. L. Vercoe

21.672 Writing for Computer Performance (A) (Revised Content)

(21.648)
Prereq.: 21.643, 21.671
G (2)
3-6-3

For those whose writing of music reaches a point where they can exploit digital audio as a new performance medium. Continues audio processing techniques, for realizing an original composition by end of term. Examines representative works, and stylistic relation between instrumental and electronic writing. Methods of integrating these media, as found in works of Davidovsky and Boulez. Directed composition of an original computer-synthesized work, and preparation for its performance in an end-of-term public concert.
B. L. Vercoe

21.681 Music Composition (A)

(21.671)
Prereq.: 21.644
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

21.682 Computer Music Composition (A)

(21.672)
Prereq.: 21.672
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, 21.692 Special Topics in Music

Prereq.: Any two subjects in Music
U (1, 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 Dean of Humanities and Social Science. Humanities credit for Special Topics subjects awarded only by indi-

vidual petitions to the Committee on Curricula. Normal maximum is 6 units; to count toward Humanities Requirement, 9 units are required. Exceptional 9-unit projects occasionally approved.
Staff

21.693, 21.694 Advanced Topics in Music
(A)
(New)

Prereq.: Permission of Instructor
G (1, 2)
Arr.

Opportunity for advanced study of musical topics not covered by the regular subject listings. Includes experimental subjects offered by permanent and visiting faculty. Students seeking an individual program of study with a particular faculty member must also obtain the approval of the chairman of the Music Section.
Staff

21.695 Research in Music
(New)

Prereq.: 21.671
G (1, 2, S)
Arr.

Directed research on problems occurring in the production, perception, or cognition of music, aided by the techniques and discipline of science and engineering. Individual or group work. Available also to research assistants for non-thesis work. May be repeated for credit with permission. Coordinator:
B. L. Vercoe

Theatre and Dance: Performance

Subjects in Theatre and Dance offer an opportunity for practical experience in the production and performance of plays and dance. For subjects dealing with literature of the theatre see 21.005, 21.009, 21.021, 21.022, 21.086, 21.173 in Literature; 21.214, 21.218, 21.236, 21.250, 21.288, 21.298, and 21.306, 21.310 in Foreign Languages and Literature; and 21.748 in the Writing Program. These subjects, plus the ones described below, constitute the Drama Program, a field of concentration (see Chapter 6).

21.700 Acting I

Prereq.: —
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

21.701 Acting II

Prereq.: 21.700
U (2)
3-0-6

Extension and application of basic acting techniques established in 21.700 (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. 21.700 or equivalent acting experience required. Graded Pass/Fail.
Staff

21.702 Theatre Arts: Elementary Stagecraft and Production Studies

Prereq.: —
U (1)
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

21.703 Performance Workshop in Drama

Prereq.: —
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 also involved. Permission of Instructor required.
R. N. Scanlan

21.704 Performance Workshop in Dance

Prereq.: —
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, some of which are included in informal performances at the end of each term. Relevant readings assigned; one paper required.
B. Soll

M.I.T. ANNUAL CATALOGUES AND BULLETINS
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Traditions 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 (21.708) and The Greeks (21.709) are considered foundation subjects. It is recommended that one or both of them be taken before other subjects in this program.

21.708 The Bible

(21.710)
Prereq.: —
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. Stresses the place of the Bible as foundation-text for central religious, political, sexual, and ethical ideas in Western culture. Comparative readings in related traditions (Canaanite, Egyptian, Gnostic). Examination of selected instances of the Biblical tradition in later art, music, literature.
Term 1: *Staff*
Term 2: *R. E. Jones*

21.709 The Greeks

(21.711)
Prereq.: —
U (1, 2) HUM-D
3-0-6

Close study, through translations, of major ancient Greek texts: *Iliad* or *Odyssey*, tragedy and comedy, history, philosophy. Focus on the historically changing perceptions of human excellence, justice, and the locus, individual and/or collective, of human salvation — if any. Collateral attention to standards of beauty embodied in Greek art and architecture (slides and Boston Museum of Fine Art).
Term 1: *D. M. Halperin*
Term 2: *H. A. T. O. Reiche*

21.710 The East Asian Tradition: Past and Present (New)

Prereq.: —
U (1) HUM-D **Next offered 1984–85**
3-0-6

Examines major documents defining the traditions of East Asia (China, Japan, Korea, and Vietnam). Texts examined include philosophical, religious, literary works (classical and popular), and important social documents. Emphasizes China, with examples from Japan. Readings include Confucius, Lao Tzu, popular novels, magistrate's casebooks, peasant rebel literature, and discussion of China's response to the West.
P. C. Perdue

21.711 The Islamic Tradition: Past and Present (New)

Prereq.: —
U (2) HUM-D **Next offered 1984–85**
3-0-6

Examines the way Muslims, from the Arab world to India, have interpreted their tradition through literary, historical, and scientific writings, and art forms. Topics: Islam's absorbtion of foreign cultural traditions, their modification and transformation; orthodoxy vs *Shi'ism* and *Sufism;* the "decline" of civilization; Islamic modernism's response to the rise and expansion of the West; the West's view of Islam through the literature of Orientism, and its critics.
P. S. Khoury

21.712 The Romans

Prereq.: —
U (2) HUM-D
3-0-6

"Humanism" as an attempt by Rome's leaders to reconcile their tradition of public service to Senate and empire with the intellectual and moral sophistication of Greek culture. Time frame: the century from Scipio the Younger to Augustus. Special emphasis: Cicero's oscillation between Pompey and Caesar. Extensive readings in Cicero, Caesar, Plutarch, and Lucretius.
H. A. T. O. Reiche

21.713 Major Medieval Texts

Prereq.: —
U (1) HUM-D **Next offered 1984-85**
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. Selects examples 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.: —
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.: —
U (1) HUM-D **Next offered 1984-85**
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.: —
U (1) HUM-D
3-0-6

Studies 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.
Staff

21.717 The Modern Period: 1900-1970

Prereq.: —
U (2) HUM-D **Next offered 1984-85**
3-0-9

Role of the individual and the artist in modern society dominated by politics, war, and technology. Topics: reactions to 19th-century values; and especially those of Marx and Freud; role of myth; concepts of illusion and reality; sexual revolution and its implications; new humanism in art, music, philosophy, and literature. Authors read: Dinesen, Breton, Gropius, Marinetti, Gide, Proust, Pirandello, Jung, Giraudoux, O'Neill, Joyce, Eliot, Kafka, Malraux, Brecht, Beckett, Lawrence, Lessing, and Solzhenitsyn.
W. Watson

21.718 The Americans

Prereq.: —
U (1) HUM-D **Next offered 1984-85**
3-0-9

Major themes of the American imagination as revealed in American literature, historical writing, and American art from the 17th century through the 19th century. The development of American identity and mythology. Ideas about the land, nature, purpose, the Indian, society and the individual, freedom and community. Among authors read: Bradford, Jefferson, Franklin, Crevecoeur, Emerson, Cooper, Whitman, Parkman, Henry Adams. Among artists viewed: Copley, Allston, 19th-century landscape painters, Eakins, and Homer.
A. D. Kaledin

The Writing Program

The subjects listed below are grouped in the three major areas of The Writing Program: 1) Exposition and Rhetoric; 2) Creative Writing; and 3) Science and Technical Communication. Within each area, introductory, intermediate, and advanced subjects are offered. Introductory subjects are designed for students with little or no experience in writing; intermediate subjects are designed for students who have mastered the elements of sentence and paragraph structure; advanced subjects are designed for experienced writers who wish to develop greater competence in one or more special forms of writing.

Exposition and Rhetoric

Introductory

21.730 Expository Writing

Prereq.: —
U (1, 2)
3-0-6

For students who wish to write correct, clear, and effective prose. Attention to constructing effective sentences and paragraphs. Weekly writing assignments. Students' writing is discussed frequently in class. Readings include essays that exhibit a wide range of rhetorical techniques.
M. Richardson, Staff

21.731 Writing and Experience (New)

Prereq.: —
U (1, 2)
3-0-6

Students study sentence mechanics, paragraphing, punctuation, and word choice, as well as the mechanisms by which poets, fiction writers, and essayists transform their experiences into scenes, voices, and arguments. In weekly workshops, students present their writing to members of the group; extensive revising required.
E. Chodakowska, Staff

21.732 Introduction to Technical Communication (New)

Prereq.: —
U (1, 2)
3-0-6

Students intensively review the elements of sentence and paragraph structure; special problems in organizing and condensing technical information; and strategies for writing technical descriptions, definitions, classifications, and analyses. Other topics include writing to different audiences and preparing brief proposals, lab reports, and graphics. Several short writing assignments, frequent revisions, and two short oral presentations required.
D. Dobrin, J. Paradis, Staff

Intermediate

21.735 Writing and Reading the Essay

(21.750)
Prereq.: —
U (1, 2) HUM-D
3-0-9

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; frequent conferences. Central concerns are possibilities and techniques of the essay; historical forms such as sermons, meditations, diaries, letters, polemics.
B. Avishai, H. Ritvo

21.738 Words

(21.751)
Prereq.: —
U (2)
3-0-6

Designed to increase appreciation of the verbal resources of English and improve skill in exploiting them. Considers such topics as the historical roots of the modern vocabulary, specialized and technical vocabularies, socially loaded language, the connection between word choice and tone, words as symbols. Regular written assignments stress the way that ideas are shaped by words.
H. Ritvo

21.740 Writing Biography and Autobiography

(21.745)
Prereq.: —
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

Advanced

21.745 Advanced Essay Workshop

(21.784)
Prereq. : Permission of Instructor
U (2)
3-0-9

For students with experience in writing nonfictional prose. Advanced study of rhetorical strategies and techniques of prose style. Considerable writing and revision required. In addition to analyzing the work of class members, students read and discuss the work of distinguished essayists chosen to represent a range of prose styles, subjects, and biographical patterns.
B. Avishai, H. Ritvo

Creative Writing

Introductory

See subject 21.731.

Intermediate

21.755 Writing and Reading Short Stories

(21.743)
Prereq.: —
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 contexts.
F. Conroy, I. Karmel

21.757 Fiction Workshop

(21.740)
Prereq.: —
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. Conroy, F. Howe

21.759 Writing Science Fiction

(21.746)
Prereq.: —
U (1)
3-0-6

Students write and read science fiction and analyze and discuss stories written for the class. Emphasis on developing clear, lucid prose. The content of the stories is 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

21.760 Writing and Reading Poems

(21.744)
Prereq.: —
U (1, 2) HUM-D
3-0-6

Examination of the formal structural and textual varieity 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.
R. Becker, F. Howe, M. Kumin

21.762 Poetry Workshop

(21.741)
Prereq.: —
U (1, 2)
3-0-6

For students with some previous experience in poetry writing. Frequent assignments stress use of language, diction, word choice, line breaks, imagery, mood, and tone. Considers the functions of memory, imagination, dreams, poetic impulses. Throughout the semester, students examine the work of published poets. Revision stressed.
R. Becker, F. Howe

21.765 Experimental Forms Workshop

(21.742)
Prereq.: —
U (2)
3-0-6

Exploration of experimental writing in nontraditional forms, such as prose poems and concrete poetry. Major emphasis on discussing students' writing. Reading includes selections from Blake, the French surrealists, the prose poems of Rimbaud and Michaux, and contemporary American writers who use experimental forms.
F. Howe

Advanced

21.768 Plays and Playwriting

(21.748)
Prereq.: —
U (1) **Next offered 1984-85**
3-0-6

Students explore approaches to writing dramatic scenes and short plays. Each student is asked to write at least one competent one-act play during the semester, in addition to several shorter scenes.
A. R. Gurney, Jr.

21.770 Advanced Fiction Workshop

Prereq.: Permission of Instructor
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

21.771 Advanced Poetry Workshop

Prereq.: Permission of Instructor
U (2)
3-0-6

For students experienced in writing poems. Regular reading of published contemporary poets and weekly submission of manuscripts for class review and criticism. Expects students to do a substantial amount of rewriting and revision. Classwork supplemented with individual conferences.
M. Kumin

21.773 Writing Longer Fiction

Prereq.: Permission of Instructor
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). Class discussions of students' own work with emphasis on revision.
I. Karmel

Science and Technical Writing

Introductory

See subject 21.732.

Intermediate

21.777 The Scientific Essay

(21.762)
Prereq.: —
U (1, 2) HUM-D
3-0-6

Students explore prominent writing about science and technology from the Renaissance to the present. They examine the style, purpose, and context of historically important papers and essays. Discussion includes the role of communication in science, the rise of scientific journals, and ethical issues in scientific writing. Readings include works by Newton, Darwin, Einstein, and contemporary authors. Several short assignments and a longer essay on a general or semi-technical subject required.
B. Gastel, D. Dobrin, J. Paradis

21.780 Scientific and Engineering Writing

(21.760)
Prereq.: —
U (1, 2)
2-0-7

Introduction to the forms, functions, and style of technical documents: weekly sessions include grammar and composition reviews, editing workshops, and discussion of the scientific publication process. Short assignments — including abstracts, proposals, progress reports, and memos — build toward a written term paper and oral presentation on a technical or semi-technical subject. Students should have completed, or be working on, research that they can write about.
D. Dobrin, J. Paradis, C. Sides, J. Yates

21.782 Science Journalism

(21.763)
—
U (1, 2)
3-0-6

A practical introduction to the craft of science journalism: examines important issues in communicating technical information to the public, such as the relationship among science, technology, and the media. Presentations by professional science journalists are featured. Students write weekly exercises, some of which are submitted for publication. Writing competence required.
E. Chu, B. Gastel, R. Goodell

Advanced

21.783 Science Writing Workshop

(21.791)
Prereq.: 21.763
U (2)
3-0-6

Students write magazine articles on science, technology, and science politics, emphasizing controversial social and scientific issues. Discussion covers works by contemporary science writers, public attitudes toward science, ethical issues in investigative writing, and problems in press coverage of controversial subjects. Regular reading of selected newspapers and magazines also required. Permission of instructor required for students without 21.763 background.
B. Gastel, R. Goodell

21.790 Naturalist Writing

(21.781)
Prereq.: —
U (1)
3-0-6

Students 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 on general and semi-technical subjects.
J. Paradis

21.792 Science Writing Internship

Prereq.: 21.763
U (2)
3-0-9

Part-time internships in Boston-area media are arranged for students wishing to develop professional writing and publishing skills. Students also attend a weekly seminar (which often features guest presentations by science journalists) and write a final report on the intern experience. Permission of instructor required.
B. Gastel, R. Goodell

21.793 Advanced Workshop in Scientific and Engineering Writing

Prereq.: Permission of Instructor
G (1, 2)
2-0-4

Offers graduate students who have writing projects under way an intensive review and steo-by-step practice in technical writing. Examines major types of technical documents and reviews organization, grammar, style, format, graphics, and the scientific publishing process. Writing and revising assignments are adapted to the preparation of one or two major documents.
D. Dobrin, J. Paradis

21.798, 21.799 Special Topics in Writing

Prereq.: —
U (1, 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 6 units; to count toward Humanities Requirement, 9 units are required. Exceptional 9-unit projects occasionally approved.
J. Paradis

Interdisciplinary Subjects

21.901J Reading Seminar in Humanities, Science, and Technology I

(Same subject as STS 130J)
Prereq.: —
U (1)
2-0-7

21.902J Reading Seminar in Humanities, Science, and Technology II

(Same subject as STS 131J)
Prereq.: —
U (2)
2-0-7

See description under subjects STS 130J, STS 131J.
Term 1: *M. Krieger*
Term 2: *A. C. Kibel*

21.903J Project Seminar on the Context of Research

(Same subject as STS 132J)
Prereq.: —
U (1, 2)
3-0-6

See description under subject STS 132J.
L. Trilling

21.914 Sports and Physical Training

Prereq.: Permission of Instructor
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
U (2)
3-0-6

Role and responsibility of individuals who challenge the assumptions of the established political and social order. Discussion of current issues that have given rise to action and protest. Visiting lectures by activists. Questions of individual commitment, and the available alternatives for action. Limited enrollment.
N. A. Chomsky, L. Kampf

21.916 Contemporary Issues in Politics and Ideology

Prereq.: —
U (2)
3-0-6

Selected topics in domestic and international affairs. Emphasizes their relationship to US political, economic, and ideological institutions. Critical analysis of capitalist ideology. Considers strategies for social change.
N. A. Chomsky

21.917 Seminar I: International Students and Participation in Development

Prereq.: —
U (1)
Arr.

Identification of and searching for solutions to common problems (social, economic, political, technological, and professional) faced by International students and other individuals seeking integration into a different culture. Examines current theories of development, of practical alternatives, the role of technology in social change. Humanities credit for this subject awarded only by individual petitions to the Committee on Curricula. Normal maximum is 6 units; to count toward Humanities Requirement, 9 units are required.
Staff

21.918 Seminar II: International Students and Participation in Development

Prereq.: —
U (2)
Arr.

Further examines issues emerging from the experiences and problems in 21.917. Explores methodological issues in the study of the development process, alternatives in technology, personal and professional basis for work in home societies, and alternatives available shaping the development process. Humanities credit for this subject awarded only by individual petitions to the Committee on Curricula. Normal maximum is 6 units; to count toward Humanities Requirement, 9 units are required.
Staff

The following Wellesley subject is offered at MIT:

Wellesley Religion 108
Introduction to Asian Religions

Prereq.: —
U (2) HUM-D
3-0-9

Introduces 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

21.930J Ancient Cosmology

(Same subject as STS 223J)
Prereq.: —
U (1) HUM-D
3-0-6

Evidence for, and astronomical database of, archaic cosmology. Myth, alignments, ritual as prenumerate, technical languages in oral culture. Algebraic, geometric, numerate, musical, biological, socio-juridical models in pre-Socratic philosophy: Anaximander, Pythagoreanism, Heraclitus, Parmenides, Zeno, Empedocles, Democritus, in Plato's *Timaeus,* and Aristotle. Collateral readings in modern secondary literary and in works by Von Dechend, Karl Popper, Schroedinger, Collingwood, D'Arcy Thompson, T. S. Kuhn.
H A. T. O. Reiche

21.991 Special Topics in Interdisciplinary Studies

Prereq.: Any two subjects in Humanities
U (1)
Arr.

21.992 Special Topics in Interdisciplinary Studies

Prereq.: Any two subjects in Humanities
U (2)
Arr.

Special topics involving interdisciplinary study sponsored by members of the Department of Humanities or Institute faculty. Subjects vary 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 6 units; to count toward Humanities Requirement, 9 units are required. Exceptional 9-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
Ancient and Medieval Studies
Drama
Film and Media Studies
Latin American Studies
Russian Studies
Women's Studies

22 Nuclear Engineering

Undergraduate Subjects

22.UR Undergraduate Research Opportunities Program

Prereq.: —
U (1, 2)
Arr.

The Undergraduate Research Opportunities Program is an excellent way for undergraduate students to become familiar with the Department of Nuclear Engineering. 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. 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.: —
U (1)
2-0-4

Surveys 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.: —
U (1)
3-0-9

School-Wide Elective Subject. Description given at end of this chapter on SWE page.
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.: —
U (1)
3-0-6

See description under subject 17.465J.
T. R. I. Greenwood

22.006 Computer Models of Engineering Systems

Prereq.: 18.02, 8.01
U (1) SD
3-0-9

School-Wide Elective Subject. Description given at end of this chapter on SWE page.
B. Schumacker

22.02 Introduction to Applied Nuclear Physics

Prereq.: 8.02, 18.02
U (1) SD
3-0-9

Introduces nuclear physics emphasizing those aspects which are applied in nuclear engineering. Elementary quantum theory; properties of atomic nuclei; natural and induced radioactivity; cross sections for nuclear reactions; alpha-, beta-, and gamma-decay. Nuclear models: shell-model, liquid-drop model, nuclear fission. Slowing down and diffusion of neutrons. Neutron induced chain reactions. Thermonuclear reactions and the possibility of energy from nuclear fusion. Introduces radiation dosimetry.
S. H. Chen

22.021 Nuclear Reactor Physics

Prereq.: 22.02, 18.03
U (1, 2)
4-0-8

Introduces 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. Emphasizes 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.
K. F. Hansen

22.03 Engineering Design of Nuclear Power Systems

Prereq.: —
U (1) SD
3-0-9

Introduces nuclear engineering applied to power plant design: basic principles of nuclear physics, reactor physics, and environmental health physics; engineering and heat transfer principles. Description of various reactor types (LWR, LMFBR, etc.). Emphasizes reliability and reactor safety methods for improving design and operation of future reactors.
C. D. Heising

22.031 Engineering Analysis of Nuclear Reactors

Prereq.: 22.03, 18.03
U (1, 2)
4-0-8

Engineering analysis of nuclear reactors, emphasizing 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
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 with 22.33, but assignments differ.
K. F. Hansen

22.04 Radiation Effects and Uses

Prereq.: —
U (2) SD
2-1-9

Current problems in science, technology, health, and environment which involve radiation effects and their utilization. Medical and industrial applications of radioisotopes. Radiations in research. Laboratory demonstrations of methods and instruments in radiation measurements. Material presented in an essentially descriptive manner and suitable for students interested in a general appreciation of the physical phenomena and their uses.
A. C. Nelson

22.05 Introduction to Engineering Economics

Prereq.: —
U (2) **Next offered 1984-85**
3-0-9

Introduces methods used by engineers for the economic analyses of alternatives. Time-value-of-money mechanics; present worth and rate-of-return methodology; dealing with depreciation and taxes, inflation, and escalation; levelized cost; replacement and retirement problems. Component cost modeling, economy-of-scale and learning-curve effects. Cost-risk-benefit analysis, insurance, and other probabilistic applications. Examples from many engineering disciplines.
M. J. Driscoll

22.061 Controlled Fusion Power

Prereq.: 8.03, 18.03
U (1)
3-0-9

Introduces controlled fusion concepts: 1) fundamental plasma physics required to understand fusion reactors; 2) basic methods of producing and confining fusion plasmas; 3) description and critique of proposed fusion reactor schemes. Includes appropriate reviews of electromagnetic theory and other necessary skills to prepare students for more specialized fusion studies in the Department of Nuclear Engineering. Meets three lecture hours a week with 22.610 but with different assignments and quizzes.
L. M. Lidsky, J. P. Freidberg

22.069 Undergraduate Plasma Laboratory

Prereq.: 8.02
U (1) LAB
1-8-3

Basic engineering and scientific principles associated with experimental plasma physics. Investigates 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 with 22.69, but assignments differ.
I. H. Hutchinson, L. M. Lidsky

22.070J Materials for Nuclear Applications

(Same subject as 3.070J)
Prereq.: 3.091 or 3.14 or 22.071
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 with 22.70J but assignments differ.
R. G. Ballinger

22.071J Physical Metallurgy Principles for Engineers

(Same subject as 3.071J)
Prereq.: 3.091
U (1)
3-0-9

Thermodynamics and stability of alloy phases. Diffusion-controlled rate processes. Defect properties and mechanical properties. Emphasizes structural evolution, structure-property relations, and the common features among various materials. Introduces quantitative analysis in physical metallurgy for engineering materials. Meets with 22.71J, but assignments differ.
I-W. Chen

22.08 Energy

Prereq.: —
U (1)
3-0-9

Energy from a holistic viewpoint. Provision, rational utilization and conservation, environmental effects, policy, and impact on other sectors. Resources, technologies of conversion and utilization. Assessment of both deployed and proposed energy systems and technologies. Includes economic, social, and historic perspectives. Intended for third- and fourth-year students interested in entering the energy field. Meets with 22.81, but some assignments differ.
D. J. Rose

22.084 Inventions and Patents

Prereq.: 14.02
U (1)
3-0-6

School-Wide Elective Subject. Description given at end of this chapter on SWE page.
R. H. Rines

22.085 Introduction to Technology and Law

Prereq.: —
U (1)
3-0-9

School-Wide Elective Subject. Description given at end of this chapter on SWE page.
J. D. Nyhart

22.088J Human Factors in Design

(Same subject as 2.18J, 9.39J)
Prereq.: Permission of Instructor
U (2)
3-1-8

See description under subject 2.18J.
D. D. Lanning, T. B. Sheridan, A. Hein

22.09 Introductory Nuclear Measurements Laboratory

Prereq.: 22.02
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 with 22.29, but assignments differ.
S. H. Chen

22.091 Special Topics in Nuclear Engineering

Prereq.: —
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. Topics and hours arranged to fit students requirements.
J. E. Meyer

22.092 Engineering Internship

Prereq.: —
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.
R. G. Ballinger

Nuclear Physics

22.111 Nuclear Physics for Engineers I (A)

Prereq.: 22.02
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
G (2) **Next offered 1984-85**
3-0-9

Continuation of 22.111 emphasizing 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
G (1, 2)
3-0-9

Introduces 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. Emphasizes the nuclear physical bases of reactor design and their relation to reactor engineering problems.
K. F. Hansen, N. C. Rasmussen

22.212 Nuclear Reactor Physics II (A)

Prereq.: 22.211
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
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. Applies homogenization, synthesis, finite element, response matrix techniques and nodal methods to reactor analysis.
A. F. Henry

22.22 Nuclear Reactor Dynamics (A)

Prereq.: 22.212, 18.075
G (2) **Next offered 1984-85**
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.
E. P. Gyftopoulos, A. F. Henry

22.29 Nuclear Measurements Laboratory (A)

Prereq.: *22.211*
G (2)
2-6-4

Basic principles of interaction of nuclear radiations with matter. Principles and methods for detection and energy determination of gamma rays, neutrons and charged particles. Experiments on gas-filled, scintillation, and semiconductor detectors: nuclear electronics such as pulse amplifiers, multichannel analyzers, and coincidence techniques: applications to neutron activation analysis. X-ray fluorescence analysis, thermal neutron cross sections, and radiation dosimetry. Meets with 22.09, but assigments differ.
S. H. Chen

Nuclear Reactor Engineering

22.311 Energy Engineering Principles

Prereq.: —
G (1)
3-0-9

Fundamentals of engineering thermodynamics, fluid flow, heat transfer, and elasticity. 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
G (1, 2)
3-0-9

Engineering principles of nuclear reactors emphasizing 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, J. E. Meyer

22.313 Advanced Engineering of Nuclear Reactors (A)

Prereq.: *22.212*, 22.312
G (2)
3-0-9

Advanced topics in nuclear engineering emphasizing thermo-fluid dynamic design methods and criteria for thermal limits of various reactor types. Fundamentals of transient heat transfer and fluid flow under operational and accidental conditions: LOCA and Core Heatup analyses. Detailed analysis of fluid flow and heat transfer in complex geometries.
N. E. Todreas

22.314J Structural Mechanics in Nuclear Power Technology (A)

(Same subject as 1.56J, 2.084J, 3.82J, 13.14J, 16.261J)
Prereq.: Permission of Instructor
G (1)
3-0-9

Structural components in nuclear power plant systems: their functional purposes: operating conditions: mechanical-structural design requirements. Combines mechanics techniques with models of material behavior to determine adequacy of component design. Effects considered include mechanical loading, hydraulic forces, elevated temperatures, neutron irradiation, and seismic effects.
J. E. Meyer, O. Buyukozturk

22.32 Nuclear Power Reactors (A)

Prereq.: 22.211, 22.312
G (1)
3-0-9

A descriptive survey of engineering and physics aspects of current nuclear power reactors. Discusses design details 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. Compares reactor characteristics both in class and by individual student projects. Discusses development problems and assesses potentials for future improvements.
D. D. Lanning

22.33 Nuclear Engineering Design (A)

Prereq.: 22.212, 22.312
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 with 22.033, but assignments differ.
K. F. Hansen

22.34 Engineering Economics of Energy Options (A)

Prereq.: Permission of Instructor
G (1) **Next offered 1984-85**
3-0-9

Principles of engineering economics with energy-related applications. Comparison of alternatives using discounted cash flow methods. Nuclear reactors and their fuel cycle compared to fossil-fired units, solar and renewables, and conservation. The economic characteristics of electric utility systems examined and compared to decentralized options such as cogeneration. Discusses the elements of environmental impact analysis and cost-risk-benefit assessment.
M. J. Driscoll

22.35 Nuclear Fuel Management (A)

Prereq.: 22.211
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
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.
M. S. Kazimi, P. Griffith, W. M. Rohsenow

22.37 Environmental Impacts of Electricity (A)

Prereq.: Permission of Instructor
G (2)
3-0-9

Assesses the various environmental impacts of producing thermal and electric power with currently available technology. Compares impacts 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.: Permission of Instructor
G (1)
3-0-9

Principles of the methods of reliability analyses including fault trees, decision trees, and reliability block diagrams. Discusses the techniques for developing the logic diagrams for reliability assessment, the mathematical techniques for analyzing them, and statistical analysis of required experience data. Discusses practical examples of their application to nuclear power reactors and other industrial operations. Open to qualified undergraduates.
N. C. Rasmussen

22.39 Nuclear Reactor Operations and Safety (A)

Prereq.: 22.211, 22.311
G (2)
Arr.

Principles of operating nuclear reactor systems in a safe and effective manner. Emphasizes light water reactor systems with transient response studies including degraded core recognition and mitigation. Consequence analysis and risk assessment. Lessons from past accident experience. NRC licensing and regulations. Demonstrations: operation of the MIT Research Reactor; use of a PWR concept simulator. Optional laboratory section involves a project at the Nuclear Reactor Laboratory.
D. D. Lanning, C. D. Heising

22.40J Advanced Reliability Analysis and Risk Assessment (A)

(Same as 13.63J)
Prereq.: 22.38, 22.82, 1.143 or 13.622J
G (2)
3-0-9

Extended application and use of reliability and probabilistic risk analysis methods. Methods for common mode failure analysis and treatment of dependencies. Bayesian statistics applied to systems reliability and safety problems. Error/sensitivity analysis. Time dependent reliability analysis, Markov models, systems availability, and systems performance. Replacement and maintenance strategy development. Case studies of safety analyses in nuclear and nonnuclear areas.
C. D. Heising, E. G. Frankel

Numerical and Mathematical Methods

22.41 Numerical Methods of Radiation Transport (A)

Prereq.: 18.076, 22.212
G (2) **Next offered 1984-85**
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. Discusses iteration techniques for solution of coupled difference equations. Group projects on solving original transport problems by design and implementation of computer codes.
S. Yip

22.42 Numerical Methods in Engineering Analysis (A)
(Revised Content)

Prereq.: Permission of Instructor
G (1)
3-0-9

Applications of digital computers to the solution of engineering problems. Reviews specific mathematical techniques (linear algebra, interpolation, finite difference equations). Numerical solution of ordinary differential equations. Fundamentals of consistency, convergence, stability, and accuracy. Numerical solution of elliptic, parabolic, and hyperbolic partial differential equations. Special topics from nuclear reactor physics, heat transfer, and fluid dynamics. Applications emphasized through assignments requiring use of computer.
A. L. Schor

22.43 Advanced Numerical Methods in Engineering Analysis (A)
(Revised Content)

Prereq.: 22.42
G (2)
3-0-9

Advanced computational methods. Emphasizes solution of multidimensional problems. Modern iterative techniques. Solution of nonlinear equations. Numerical methods in two-phase flow. Finite element methods with applications to incompressible and compressible flows. Introduction to numerical turbulence modeling. Additional special topics, varying with interests of the class and covering latest developments. Assignments and group projects requiring use of computer. Permission of instructor required for students without 22.42 background.
A. L. Schor

22.51 Radiation Interactions and Applications (A)

Prereq.: 8.05
G (1) **Next offered 1984-85**
3-0-9

Basic principles of interaction of electromagnetic radiation, thermal neutrons, and charged particles with matter. Introduces classical electrodynamics, quantum theory of radiation field, time-dependent perturbation theory, transition probabilities and cross sections describing interaction of various radiations with atomic systems. Applications include theory of gas lasers, Rayleigh, Raman and Compton scattering, photoelectric effect, photocount statistics, and use of thermal neutron scattering as a tool in condensed matter research.
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
G (1)
4-0-8

Principles of radiation production and interactions. Radiation dosimetry emphasizing 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. Requires a comprehensive term paper and presentation.
G. L. Brownell, Staff

22.56J Principles of Medical Imaging (A)

(Same subject as 2.761J, HST 561J)
Prereq.: Permission of Instructor
G (2)
4-0-8

See description under subject 2.761J.
G. L. Brownell, P. P. Lele, Staff

22.57J Radiation Biophysics (A)

(Same subject as HST 568J)
Prereq.: 8.271 or 22.111
G (1)
4-0-8

Effects of ionizing radiation, ultraviolet radiation, and heat on biological materials, cells and tissues. Examines *in vivo* and *in vitro* mammalian systems, and explores mathematical models for cell survival emphasizing prediction. Microstructural damage to cell components such as membranes, organelles, enzymes, and DNA studied. Radiation syndromes in man, mutagenesis, and carcinogenesis also investigated.
A. C. Nelson

22.571J General Thermodynamics I (A)

(Same subject as 2.451J)
Prereq.: Permission of Instructor
G (1)
3-0-9

See description under subject 2.451J.
E. P. Gyftopoulos, G. P. Beretta

22.572J Quantum Thermodynamics (A)

(Same subject as 2.452J)
Prereq.: Permission of Instructor
G (2)
3-0-9

See description under subject 2.452J.
E. P. Gyftopoulos, G. P. Beretta

Plasmas and Controlled Fusion

22.610 Controlled Fusion Power (A)

Prereq.: Permission of Instructor
G (1)
3-0-9

Introduces controlled fusion concepts: 1) fundamental plasma physics required to understand fusion reactors; 2) Basic methods of producing and confining fusion plasmas; 3) description and critique of proposed fusion reactor schemes. Includes appropriate reviews of electromagnetic theory and other necessary skills to prepare students for more specialized fusion studies in the Department of Nuclear Engineering. Meets three lecture hours a week with 22.061 but with different assignments and quizzes.
L. M. Lidsky, J. P. Freidberg

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
G (1)
3-0-9

See description under subject 8.613J.
K. Molvig, A. Bers, M. Porkolab

22.612J Introduction to Plasma Physics II (A)

(Same subject as 6.652J, 8.614J)
Prereq.: 6.651J or 8.613J or 22.611J, 18.075
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.
K. Molvig, A. Bers, R. C. Davidson

22.615J MHD Theory of Magnetic Fusion Systems I (A)

(Same subject as 6.653J)
Prereq.: 22.611J or 6.651J or 8.613J
G (1)
3-0-9

Development of ideal MHD theory and application to magnetic fusion systems. Description of equilibria of tokamaks, RFPs, stellarators and EBTs emphasizing axisymmetric systems described by the Grad-Shafranov equation. Formulation of stability problem utilizing the Energy Principle. Description of ideal MHD instabilities such as kink, sausage, interchange, and ballooning modes. Applications inlcude the Suydam and Mercier criteria and the Kruskal-Shafranov limit.
J. P. Freidberg, R. R. Parker

22.616 MHD Theory of Magnetic Fusion Systems II (A)

Prereq.: 6.653J or 22.615J
G (2)
3-0-9

Continuation of 22.615J. Theory and application of nonideal MHD theory including: resistive instabilities, tearing modes, resistive interchanges, nonlinear saturation, with applications to sawtooth oscillations and major disruption in a tokamak; finite Larmor radius stabilization of ideal MHD modes and rotationally driven instabilities; finite Larmor radius effects on resistive instabilities; the Kruskal-Oberman Energy Principle for the Guiding Center MHD plasma and its application to simple axisymmetric mirrors, non-axisymmetric mirrors and the tandem mirrors.
J. P. Freidberg, R. R. Parker

22.621 Thermonuclear Reactor Design (A)

Prereq.: 22.311; 22.610 or 22.611J
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
G (1) **Next offered 1984-85**
3-5-4

A class project with the goal of integrating the wide range of plasma physics, technology, and economic constraints involved in the design of large scale fusion research devices such as beam driving neutron sources, torsatron scaling experiments, copper coil ignition experiments. Usually follows the entire design process from project definition to formal presentation.
L. M. Lidsky, D. R. Cohn, B. D. Montgomery, J. E. C. Williams, J. E. Meyer

22.63 Engineering Principles for Fusion Reactors

Prereq.: Permission of Instructor
G (1) **Next offered 1984-85**
3-0-9

Introductory subject for advanced undergraduate and graduate students. Vacuum engineering based on considerations of free molecular flow, surface physics and standard design practices, magnetic field generation by normal cryogenic and superconducting coils, high voltage engineering and practice, production of high power ion, electron and neutral beam systems, microwave engineering for plasma systems, applications to fusion systems. Open to qualified undergraduates.
L. M. Lidsky, D. R. Cohn, B. D. Montgomery, J. E. C. Williams

22.64J Plasma Kinetic Theory (A)

(Same subject as 8.621J)
Prereq.: 8.613 or 16.59J
G (1)
3-0-9

See description under subject 8.621J.
T. H. Dupree

22.65J Advanced Topics in Plasma Kinetic Theory (A)

(Same subject as 8.622J)
Prereq.: 8.621J or 22.64J
G (2)
3-0-9

See description under subject 8.622J.
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
G (2) **Not offered 1984-85**
3-0-9

Transport theory analyzes the processes by which particle energy, momentum, and mass diffuse across the magnetic field. Develops the collisional classical and neoclassical transport theory of tokamaks (and stellarators) including the theory of MHD equilibrium, particle orbits and Fokker Planck operators, for the hydrogenic and impurity ions, as well as injected and alpha particles. Emphasizes connection to experimental confinement and achievement of high beta.
D. J. Sigmar

22.67 Plasma Diagnostics (A)

Prereq.: 22.611J or 6.651J or 8.613J
G (2)
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.
I. H. Hutchinson, L. M. Lidsky

22.69 Plasma Laboratory (A)

Prereq.: 22.611J or 6.651J or 8.613J or 22.63
G (1)
1-4-4

Introduces 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 with 22.069, but assignments differ.
I. H. Hutchinson, L. M. Lidsky

Nuclear Materials

22.70J Materials for Nuclear Applications (A)

(Same subject as 3.711J)
Prereq.: 22.71J or 3.71J or 3.14
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 with 22.070J, but assignments differ.
R. G. Ballinger

22.71J Physical Metallurgy Principles for Engineers (A)

(Same subject as 3.71J)
Prereq.: Permission of Instructor
G (1)
3-0-9

Thermodynamics and stability of alloy phases. Diffusion-controlled rate processes. Defect properties and mechanical properties. Emphasizes structural evolution, structure-property relations, and the common features among various materials. Quantitative analysis in physical metallurgy for engineering materials. Meets 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
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.
R. G. Ballinger

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
G (2)
3-0-9

Unified treatment based on governing principles in defect structures, thermodynamics and kinetics of equilibrium and nonequilibrium systems. Discusses phenomena of radiation effects in metals and nonmetals used in fission reactors, fusion reactors, nuclear waste encapsulation, and ion beam technology. Topics include defect generation, damage evolution, radiation enhanced and induced rate processes, radiation effects on mechanical and physical properties.
I-W. Chen

22.75J Radiation Effects in Reactor Structural Materials (A)

(Same subject as 3.75J)
Prereq.: 3.71J or 22.71J
G (2) **Next offered 1984-85**
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

22.76 Introduction to Nuclear Chemical Engineering (A)

Prereq.: 22.311 or 10.302
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.
M. Miller

22.77 Nuclear Waste Management (A)

Prereq.: Permission of Instructor
G (2)
3-0-9

Introduces scientific and engineering aspects of the management of spent fuel, reprocessed high-level waste, mill tailings, low-level wastes, and retired nuclear facilities. Fundamental processes and governing equations of radiation and radionuclide transport. Design principles and evaluation methods for geologic waste disposal systems. Interim storage, processing, and transportation technologies. Review of nuclear waste management regulation. Open to qualified undergraduates.
R. K. Lester

General

22.81 Energy Assessment (A)

Prereq.: Permission of Instructor
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. For graduate students entering specific energy fields or fields in which energy is important, and who desire a holistic overview. Meets with the undergraduate subject 22.08, but assignments differ.
D. J. Rose

22.82 Engineering Risk-Benefit Analysis (A)

Prereq.: 18.02
G (2)
3-0-6

School-Wide Elective Subject. Description given at end of this chapter on SWE page.
A. W. Drake, A. R. Odoni

22.821 Engineering Systems Analysis (A)

Prereq.: Permission of Instructor
G (1)
3-0-6

School-Wide Elective Subject. Description given at end of this chapter on SWE page.
R. de Neufville, J. P. Clark

22.83 The Finite Earth: Agendas for a Global Society

Prereq.: Permission of Instructor
G (2)
3-0-6

Explores interaction of issues such as global food supply, energy, material resources, the global environment, and socio-economic processes affecting the creation of a just, sustainable, and participatory society, especially in relation to less-industrial societies. Lectures and discussion group format plus term paper.
A. Strout, D. J. Rose

22.84 Nuclear Energy Policy Analysis (A)

Prereq.: Permission of Instructor
G (2) **Not offered 1984-85**
3-0-9

Technology assessment and policy analysis of nuclear fuel power problems. 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 include: nuclear waste management, nuclear fuel supply, development of advanced reactor and fuel cycle systems, relationships between nuclear power and nuclear weapons, proliferation. Term paper required.
R. K. Lester

22.85J Case Studies in Energy, Technology, Economics, and Management

(Same subject as 6.687J)
Prereq.: —
G (2)
3-0-9

Gives students with diverse backgrounds an opportunity to study the multidimensional (i.e., technological, economic, and environmental) nature of complex energy issues in a concrete context. Class is divided into working groups for specific case studies. Investigates one or more topics of current interest involving fossil fuel, nuclear, and renewable energy sources.
D. C. White, M. M. Miller

22.86 Entrepreneurship

Prereq.: —
G (2)
4-0-5

School-Wide Elective Subject. Description given at end of this chapter on SWE page.
D. G. Jansson

22.87J Current Issues in Engineering

(Same subject as 1.485J, 3.562J, 6.941J, 13.682J)
Prereq.: —
G (1)
3-0-6

See description under subject 1.485J.
T. H. Lee

22.88J Cases and Projects in Engineering Management (A)

(Same subject as 1.486J, 3.563J, 6.942J, 13.683J)
Prereq.: 22.87J
G (2)
3-1-5

See description under subject 1.486J.
T. H. Lee

22.89 Basic Electronics

Prereq.: —
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.
Staff

22.901-22.904 Special Problems in Nuclear Engineering (A)

Prereq.: Permission of Instructor
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.: —
G (1)
2-0-1

22.912 Seminar in Nuclear Engineering

Prereq.: —
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
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
G (2)
2-0-1

Continuation of 22.913.
R. K. Lester

22.92 Advanced Engineering Internship

Prereq.: 22.092
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.
R. G. Ballinger

22.93 Teaching Experience in Nuclear Engineering (A)

Prereq.: Permission of Department
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. E. Todreas

22.94J Seminar on Technology and Development

(Same subject as 21.506J, 17.330J)
Prereq.: Permission of Instructor
G (2)
3-0-9

See description under subject 17.330J.
N. Choucri, Staff

24 Linguistics and Philosophy

Philosophy

24.UR Undergraduate Research

Prereq.: —
U (1, 2)
Arr.

Undergraduate research opportunities in Linguistics and Philosophy. For further information consult the Departmental Coordinators:
S. J. Keyser: Linguistics,
E. W. McCann: Philosophy

24.00 Introduction to the Problems of Philosophy

Prereq.: —
U (1, 2) HUM-D
3-0-6

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: *J. J. Thomson*
Term 2: *S. Bromberger*

24.01 Contemporary Moral Issues

Prereq.: —
U (1) HUM-D
3-0-6

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 around moral questions of the justifiability of taking life, including euthanasia, abortion, and capital punishment, as well as problems associated with human rights, privacy, and affirmative action. Readings from great writers in the history of philosophy as well as from contemporary philosophers and Supreme Court cases.
J. W. DeCew

24.03 Logic, Language, and Values

Prereq.: —
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: *G. S. Boolos*
Term 2: *J. T. Higginbotham*

24.04 Moral and Legal Responsibility (New)

Prereq.: —
U (2) HUM-D
3-0-6

Introduces that area of philosophy which deals with what is involved in holding people responsible for what they do and what they cause. Questions: May anyone ever properly be held responsible or at fault for anything? Is freedom of the will necessary for responsibility or blame? What, if anything, is the justification for punishment? Under what conditions should a legal system hold a person liable for the damage he or she causes? Readings include classical and contemporary writings and some selected judicial opinions.
J. J. Thomson

24.05J Nature of Scientific Knowledge

(Same subject as STS 205J)
Prereq.: —
U (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?
T. S. Kuhn

24.07 Classics in the History of Philosophy

Prereq.: —
U (1) HUM-D
3-0-9

Introduction to philosophy through its history. Readings in the works of such philosophers as Plato, Aristotle, Aquinas, Descartes, Hume, and Kant. 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

24.08 The Human Mind

Prereq.: —
U (1) HUM-D
3-0-6

Introduces that part of philosophy concerned with the mind, with special attention to the role of science in the study of the mind. Questions discussed: Do people always act selfishly? Is human reason inherently defective? Are social and intellectual differences due to genetic differences? Are some ideas innate? Are the two hemispheres of a human brain really the brains of two different persons? Will computers ever think — indeed, are we, ourselves, computers?
N. Block

24.09J Classics in Political Philosophy

(Same subject as 17.113J)
Prereq.: —
U (1) HUM-D
3-0-6

Introduction to conceptions of social justice through a close study of classical works in the history of political philosophy that present complete and systematic accounts of human nature and just association. Readings: Plato's *Republic,* Hobbes' *Leviathan,* Rousseau's *Social Contract,* and Marx's *German Ideology.*
J. Cohen

24.111 Philosophy of Biology (New)

Prereq.: —
U (1)
3-0-9

Introduces methodological and conceptual issues of biology. Topics: creationism: sociobiology; nature vs nurture; whether Mendelian genetics is reducible to molecular biology; teleological explanation in biology; what a species is; the units of selection; the logical status of the principle of natural selection; adaptation and optimization.
N. Block

24.114 Philosophy in Literature of the 20th Century

Prereq.: —
U (2)
3-0-9

Philosophical problems as they occur in great works of literature. Emphasizes courtly, romantic, and naturalistic theories of love as well as literary myths about male and female sexuality. Readings in both philosophy and literature.
I. Singer

24.116J Introduction to Cognitive Science

(Same subject as 9.62J)
Prereq.: —
U (1)
3-0-9

See description under subject 9.62J.
D. N. Osherson

24.118 Concepts of Life and Death

Prereq.: —
U (1)
3-0-9

Problems of human experience approached through philosophical analysis. Questions about the nature of love, sex, death, the meaning of life, and the creation of values. Readings from contemporary philosophy as well as the life sciences.
I. Singer

24.119 Minds and Machines

Prereq.: —
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

24.131 20th-Century Philosophy: The Concept of Love (New)

Prereq.: —
U (1)
3-0-9

Introduces aspects of moral philosophy in the 20th century, focusing upon writings about the nature of love by Santayana, Freud, Bergson, Sartre, Buber, and other major authors. Emphasizes growth of Neoplatonic, naturalistic, and existentialist philosophies in the 20th century.
I. Singer

24.151 Introduction to Philosophy of Language

Prereq.: —
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

24.171 Introduction to Phenomenology (New)

Prereq.: —
U (2) **Not offered 1984-85**
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 Sartre.
G. C. Rota

24.172 Being and Time (New)

Prereq.: —
U (1) **Next offered 1984-85**
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."
G. C. Rota

24.200 Ancient Philosophy

Prereq.: One Philosophy subject
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.
E. W. McCann

24.202 Modern Philosophy: Descartes to Kant

Prereq.: One Philosophy subject
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.
E. W. McCann

24.208 Wittgenstein

Prereq.: One Philosophy subject
U (2) **Next offered 1984-85**
3-0-6

Study of Wittgenstein's later philosophy, with special attention to his views about language, knowledge, and the nature of philosophy.
P. G. Horwich

24.211 Theory of Knowledge

Prereq.: One Philosophy subject
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.
H. Field

24.221 Metaphysics

Prereq.: One Philosophy subject
U (1) **Next offered 1984-85**
3-0-9

Study of basic metaphysical issues concerning existence, the mind-body problem, personal identity, causation and its implications for freedom. Classical as well as contemporary readings.
J. W. DeCew

24.231 Ethics

Prereq.: One Philosophy subject
U (2)
3-0-9

Systematic study of central theories in ethics, including egoism, act and rule utilitarianism, intuitionism, emotivism, rights theories, and contractualism. Discussion and readings also focus on problems associated with moral conflicts, justice, the relationship between rightness and goodness, objective vs subjective moral judgments, moral truth and relativism.
J. W. DeCew

24.233J Political Philosophy

(Same subject as 17.105J)
Prereq.: One Philosophy subject
U (1)
3-0-9

See description under subject 17.105J.
J. Cohen

24.235 Philosophy of Law

Prereq.: One Philosophy subject
U (2)
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. Permission of instructor required for students without the above prerequisite.
J. W. DeCew

24.241 Logic I

Prereq.: —
U (1)
3-0-9

Introduction to the aims and techniques of formal logic. The logic of truth-functions and quantifiers. The concepts of validity and truth and their relation to formal deduction. Applications of logic and the place of logic in philosophy.
G. S. Boolos

24.242 Logic II

Prereq.: 24.241
U (2) **Next offered 1984-85**
3-0-9

The central results of modern logic: the completeness of predicate logic, recursive functions, the incompleteness of arithmetic, the unprovability of consistency, the indefinability of truth, the Skolem-Löwenheim theorem, nonstandard models. Permission of instructor required for students without the above prerequisite.
G. S. Boolos

24.251 Philosophy of Science

Prereq.: One Philosophy subject
U (1) **Next offered 1984-85**
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

24.272J Rise of Scientific Cosmology: Aristotle to Newton

(Same subject as STS 224J)
Prereq.: —
U (2) **Next offered 1984-85**
3-0-9

Centering on theories of terrestrial and celestial motion, the subject traces the development of ideas about the physical universe from classical antiquity to the 17th-century foundation of modern science. Readings emphasize selections from the original scientific sources, especially: Aristotle, the Scholastics, Copernicus, Galileo, Descartes, Huyghens, and Newton.
T. S. Kuhn

24.292 Special Topics in Philosophy

Prereq.: Any two subjects in philosophy
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
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

24.400 Proseminar in Philosophy I (A) (New)

Prereq.: Permission of Instructor
G (1)
6-0-18

24.401 Proseminar in Philosophy II (A) (New)

Prereq.: Permission of Instructor
G (2)
6-0-18

Advanced study of the basic problems of philosophy, intended for first-year graduate students in philosophy.
R. L. Cartwright, Staff

24.410 Topics in the History of Philosophy (A)

Prereq.: Permission of Instructor
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 1983-84: Kant's *Critique of Pure Reason.*
E. W. McCann

24.501 Problems in Metaphysics (A)

Prereq.: Permission of Instructor
G (2)
3-0-9

Metaphysical problems centering around a number of interrelated philosophical issues about abstract entities, space and time, and possibility. Readings from both classical and contemporary sources.
H. Field

24.502 Space, Time, and Causality (A)

Prereq.: Permission of Instructor
G (2) **Next offered 1984-85**
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.
P. G. Horwich

24.511 Problems in Theory of Knowledge (A)

Prereq.: Permission of Instructor
G (2) **Next offered 1984-85**
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

24.518 Problems of Mental Representation (A)

Prereq.: Permission of Instructor
G (2)
3-0-9

Topics: the case for mental representation; doubts about the intelligibility of mental representation; the relation between internal language and external language; where does meaning come from, mental representations or beliefs; the syntactic theory of the mind; conceptual role semantics and procedural semantics; narrow content; the two-factor theory of the meaning of mental representations.
N. Block

24.521 Topics in Philosophy of Mind (A)

Prereq.: Permission of Instructor
G (1)
3-0-9

This year, discussion centers on relations between the phenomenology of Husserl and his expositors and recent developments in cognitive science and philosophical psychology. Special references to representational theories of mental states and processes, and to problems about the content of propositional attitudes. Readings drawn largely from secondary sources. Focus is analytical rather than historical.
J. A. Fodor, J. J. Thomson

24.601 Topics in Moral Philosophy (A)

Prereq.: Permission of Instructor
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. W. DeCew

24.603 Twentieth-Century Ethics (A)

Prereq.: Permission of Instructor
G (1) **Next offered 1984-85**
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.
J. W. DeCew

24.611J Political Philosophy (A)

(Same subject as 17.106J)
Prereq.: Permission of Instructor
G (1)
3-0-9

See description under subject 17.106J.
J. Cohen

24.715 Intentionality and Logic (A) (New)

Prereq.: 24.241
G (1) **Not offered 1984-85**
3-0-9

Formal systems for analysis of modality and intentional discourse (proportional attitudes). Criticisms and comparisons, both technical and philosophical. Background in Frege and Russell; Kripke's theory of models for modal logic; possible-worlds semantics; Montague's IL; Church's lambda-calculi, and Sense and Denotation; relative interpretability of the systems; extensions by Barwise, Kaplan, and others.
J. T. Higginbotham

24.727 Logic and Language (A)

Prereq.: Permission of Instructor
G (1) **Next offered 1984-85**
3-0-9

Philosophical issues in logic and the analysis of language; the role of logical and linguistic analysis in philosophy, as exemplified in contemporary and near-contemporary work, roughly from Carnap (1937) onward. Topics and reading given special emphasis may vary from year to year.
J. T. Higginbotham

24.801 Philosophy of Mathematics (A)

Prereq.: Permission of Instructor
G (2) **Next offered 1984-85**
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

24.853 Philosophy of Scientific Development (A)

Prereq.: Permission of Instructor
G (2) **Next offered 1984-85**
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?
T. S. Kuhn

24.855 Problems in Philosophy of History (A)

Prereq.: Permission of Instructor
G (2) **Not offered 1984-85**
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 (A)

Prereq.: —
G (1)
Arr.

24.892 Special Graduate Topics in Philosophy (A)

Prereq.: —
G (2)
Arr.

Open to qualified graduate students in philosophy who wish to pursue special studies or projects.
Staff

Linguistics

24.900J The Study of Language

(Same subject as 21.321J)
Prereq.: —
U (1) HUM-D
3-0-6

What is language? What does knowledge of a language consist of? How do children learn languages? Is language unique to humans? Why are there many languages? How do languages change? Is any language or dialect superior to another? How are speech and writing related? Context for these and similar questions provided by basic examination of internal organization of sentences, words, and sound systems. Assumes no prior training in linguistics.
S. Bromberger, J. W. Harris, W. O'Neil, J. R. Ross

24.901J Language and Its Structure

(Same subject as 21.322J)
Prereq.: 24.900J
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.
J. W. Harris

24.915 Elements of Linguistic Theory (A) (New)

Prereq.: —
G (1)
3-0-9

Fundamental aspects of major branches of linguistic research: phonology, syntax, semantics, pragmatics. Foundational issues: organization of grammar, interaction of components, relation to psychology and theory of knowledge. Primarily for nonlinguists with a professional interest in linguistics. Undergraduates with permission of instructor only.
S. Bromberger, N. A. Chomsky, M. Halle, J. T. Higginbotham

24.921 Special Graduate Topics in Linguistics (A)

Prereq.: —
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.: —
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
G (2) **Not offered 1984-85**
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
G (2) **Next offered 1984-85**
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.
W. O'Neil, S. J. Keyser

24.941 Topics in the Grammar of a Non-Indo-European Language (A)

Prereq.: 24.951
G (1)
3-0-6

24.942 Topics in the Grammar of a Non-Indo-European Language (A)

Prereq.: 24.951
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.
Staff

24.943 Studies in American Indian Linguistics (A)

Prereq.: Permission of Instructor
G (1) **Next offered 1984-85**
3-0-9

24.944 Studies in American Indian Linguistics (A)

Prereq.: Permission of Instructor
G (2) **Next offered 1984-85**
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 in which the language is spoken. 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 preferred.
K. L. Hale

24.945 Language Typology (A)

Prereq.: Permission of Instructor
G (2) **Next offered 1984-85**
3-0-9

Detailed cross-linguistic examination of selected subsystems of grammar in relation to the problem of constraining theories of linguistic knowledge. Concentrates on a coherent set of topics in languages representing the typological diversity known to exist in the world — e.g., base structure, the lexicon and morphology, transformational systems, anaphora, case, agreement, logical operators, quantifiers, and modality.
K. L. Hale

24.949J Seminar on Language Acquisition (A) (New)

(Same subject as 9.601J)
Prereq.: Permission of Instructor
G (2) **Not offered 1984-85**
3-0-9

See description under subject 9.601J.
S. Pinker

24.951 Introduction to Linguistics I: Syntax (A)

Prereq.: 24.901J
G (1)
3-0-9

Introduction to theories of syntax which underlie work currently being done within the lexical-functional and government-binding frameworks. Organized into three interrelated parts, each focused upon a particular area of concern: 1) phrase structure, 2) the lexicon, and 3) principles and parameters. Grammatical rules and processes constitute a focus of attention throughout the course, serving to reveal both modular structure of grammar and interaction of grammatical components.
J. McCloskey

24.952 Introduction to Linguistics III: Theory of Grammar (A)

Prereq.: 24.951
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.
L. Rizzi

24.956 Introduction to Linguistics IV: Universal Grammar (A)

Prereq.: 24.951
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.
L. Rizzi

24.957 Introduction to Linguistic Theory at an Advanced Level (A)

Prereq.: Permission of Instructor
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 compared with other cognitive systems; relations of form, meaning, and language use. 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
N. A. Chomsky

24.958 Linguistic Structure (A)

Prereq.: 24.952 or 24.957
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
G (1)
3-0-9

An intensive group tutorial/seminar for discussion of research being conducted by participants. No auditors allowed.
Staff

24.961 Introduction to Linguistics II: Phonology

Prereq.: —
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
G (2)
3-0-9

Continuation of 24.961. Special emphasis on problem solving.
M. Halle

24.964 Theory of Phonology (A)

Prereq.: 24.961
G (2)
3-0-9

Phonological representations, the organization of the phonological component, morphology. The relation of structure, function, and change.
M. Halle

24.965 Morphology (A)

Prereq.: Permission of Instructor
G (1) **Next offered 1984-85**
3-0-9

Structure of the lexicon and its function in grammar. Properties of word-formation rules. Problems of selection, productivity, compositionality. Systems of inflectional categories: case, tense. Phonological aspects of word structure: allomorphy, cyclic phonology, constituent structure, boundaries. Detailed analysis of languages with complex morphology.
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
G (1) **Not offered 1984-85**
2-2-8

See description under subject 6.542J.
M. Halle, D. H. Klatt

24.967 Relational Grammar

Prereq.: An introductory course in syntax
G (2)
3-0-9

Architecture of basic clauses. Hierarchies of such grammatical relations as subject, direct object, and indirect object, as well as such grammatico-semantic actants as locative, instrumental, beneficiary. Laws governing changes of grammatical relations: promotions, ascensions, replacements by dummy elements. Patterns of clause merger in causativization and predicate raising. Critiques of other current syntactic theories from the perspectives of relational grammar and nondiscrete grammar. Permission of instructor required for students without the above prerequisite.
J. R. Ross

24.968J Speech Communication (A)

(Same subject as 6.541J)
Prereq.: Permission of Instructor
G (2) **Next offered 1984-85**
3-0-9

See description under subject 6.541J.
M. Halle, S. J. Keyser, K. N. Stevens

24.969 Workshop in Phonology (A)

Prereq.: Permission of Instructor
G (1)
3-0-9

An intensive group tutorial/seminar for discussion of research being conducted by participants. No auditors will be allowed.
Staff

24.971 Formal Foundations of Linguistic Theory

Prereq.: —
U (1)
3-0-9

24.972 Formal Foundations of Linguistic Theory (A)

Prereq.: Permission of Instructor
G (1)
3-0-9

Introduction to the theory of computation, formal languages, and definability, with special emphasis on topics most pertinent to linguistic research. Automata and Turing machines, phrase-structure and categorical grammars, inductively definable languages, undecidable problems, basic concepts of parsing and complexity theory.
J. T. Higginbotham

24.973 Topics in Logic and Semantics (A)

Prereq.: Permission of Instructor
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
G (2) **Not offered 1984-85**
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.
S. J. Keyser, W. O'Neil

24.992 Survey of General Linguistics I

Prereq.: *24.951, 24.961*
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
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 Transporation Studies

CTS 100J Transportation Systems Analysis (A)
(Revised Content and Unit)

(Same subject as 1.201J)
Prereq.: 1.03
G (1)
3-0-6

See description under subject 1.201J.
N. H. M. Wilson, G. A. Kocur

CTS 110J Applied Microeconomic Analysis (A)

(Same subject as 1.147J, 14.110J)
Prereq.: 14.01 or 1.01J
G (1)
3-0-6

See description under subject 14.110J.
C. Winston

CTS 150J Transportation Demand and Activity Analysis (A)

(Same subject as 1.202J)
Prereq.: 1.147J; CTS 100J or 1.201J or 1.20
G (2)
3-0-6

See description under subject 1.202J.
S. R. Lerman, M. E. Ben-Akiva

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
G (1)
2-9-10

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, and other health-related occupations. Enrollment limited.
F. A. Jenkins, Jr., L. Gehrke, Associates

HST 020 Bone and Connective Tissue (A)

Prereq.: Permission of Instructor
G (2)
1-2-4

Growth and development of normal bone and joints, the process of mineralization, 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, W. C. Hayes, 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
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
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
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, electro-diffusion of ions and active transport. c) Excitable cell membranes, action potential models of the axon. d) Homeostasis; principles of feedback control systems; case studies. Weekly problem assignments.
F. M. H. Villars, R. J. Cohen, T. F. Weiss, D. J. Litster

HST 060 Endocrinology (A)

Prereq.: 7.01, 7.05
G (2)
6-0-6

Physiology and pathophysiology of the human endocrine system. Four hours of lecture each week concern individual parts of the endocrine system. Topics also include assay techniques, physiological integration, etc. At frequent clinic sessions, patients are presented who demonstrate clinical problems considered in the didactic lectures. Enrollment limited, permission of instructor required.
W. Kettyle, S. H. Ingbar

HST 070 Human Reproductive Biology (A)

Prereq.: 7.01, 7.05
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, I. Schiff, C. Millette, Associates

HST 080 Hematology (A)

Prereq.: 7.05
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, R. D. Rosenberg, W. H. Churchill

HST 090 Cardiovascular Pathophysiology (A)

Prereq.: 7.01 or 18.01, 18.02
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
G (2)
3-0-9

Same as HST 090 but without the laboratory.
W. H. Abelmann, R. J. Cohen, J. Fallon, W. Gamble, R. G. Mark

HST 100 Respiratory Pathophysiology (A)

Prereq.: 7.01, 7.05, 8.01
G (1)
1-2-5

Lectures, seminars, and labs which cover the development of the lung, its histology and cellular function, physics of gases, physiology and gas exchange as it relates to health and disease. Problems of gas transport and acid base balance are reviewed; pathophysiology of common respiratory disorders presented. Sessions with patients with lung disease. 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
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, R. Cotran, A. Leaf, H. Rennke, L. Fang, J. V. Bonventre

HST 120 Gastroenterology (A)

Prereq.: 7.01, 7.05, 8.01
G (2)
3-6-4

Presents the anatomy, physiology, biochemistry, biophysics, and bioengineering of the gastrointestinal tract and associated pancreatic, liver, and biliary systems. Emphasis on the molecular and pathopysiological basis of disease where known. Covers gross and microscopic pathology and clinical aspects. Formal lectures given by core faculty with some guest lectures by local experts. Selected seminars conducted by students with supervision by faculty. Enrollment limited. Permission of instructor required.
M. C. Carey, D. Antonioli, R. H. Schapiro, J. R. Wands, J. L. Madara

HST 130J The Human Nervous System The Neurosciences I (A)

(Same subject as 9.014J, 20.511J)
Prereq.: Permission of Instructor
G (1)
6-3-6

Encompasses: 1) the gross anatomy, internal organization, and fine structure (light- and electron-microscopic) of the mammalian nervous system; 2) the neurophysiology of the visual system and motor system;
3) neuropathology; and 4) selected subjects in neuropharmacology, neuroendocrinology, and pathophysiology. Includes five clinical demonstrations. Enrollment limited.
W. J. H. Nauta, E. Bizzi, N. Geschwind, A. M. Graybiel, A. North, S. Palay, V. Chan-Palay, A. Rossier, T. Sabin, P.H. Schiller, H. R. Tyler, R. J. Wurtman

HST 131J Pathophysiology of the Nervous System (A)

(Same subject as 9.018J, 20.518J)
Prereq.: HST 130J
G (2)
3-0-6

Discussion of physiological and biochemical mechanisms of peripheral and central nervous systems' diseases. Lectures emphasize advances in the basic sciences as they apply to the muscular dystrophies, myasthenia gravis, peripheral neuropathies, pain and nociception, suprasegmental control of movement, multiple sclerosis, Alzheimer's and Huntington's diseases, epilepsy, sleep and biological rhythms, strokes, and disorders of emotion and language. Enrollment limited. Permission of instructor required.
M. A. Moskowitz, N. Geschwind

HST 141 Molecular Basis of Some Clinical Disorders (A)

Prereq.: 7.05
G (1)
4-0-6

Conducted as a seminar to 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 tutorials and supervision by faculty. 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 170 Immunology

Prereq.: 7.05
G (1)
4-0-8

A version of General Immunology 7.73 limited to HST students in the Biomedical Sciences Curriculum.
L. A. Steiner, H. N. Eisen, M. L. Gefter

HST 190 Statistical Planning and Analysis of Biomedical Investigations (A)

Prereq.: Knowledge of calculus
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.
J. Anderson

HST 200 Physical Diagnosis and Introductory Clinical Experience (A)

Prereq.: Permission of Instructor
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. 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. Muller, Associates

HST 201 Introduction to Clinical Medicine and Medical Engineering I (A)

Prereq.: HST 010, HST 030, HST 060, HST 090, HST 100, HST 110, HST 130J, 7.05
G (1)
9-27-12

Full-time, required subject for students in MEMP doctoral program. Students 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) investigate a variety of important diagnostic instruments and techniques from both the engineering and clincal points of view. Permission of instructor required.
R. G. Marks, J. B. Cadigan, Jr., W. H. Abelmann, Associates

HST 202 Introduction to Clinical Medicine and Medical Engineering II (A)

Prereq.: HST 201
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 and June.
R. G. Mark, C. Hatem, Associates

HST 203 Clinical Experience in Medical Engineering (A)

Prereq.: HST 201, HST 202
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 204 Diagnostic Medicine/Technology Interface (A)

Prereq.: HST-200
G (2)
3-0-4

Interdisciplinary seminar dealing with techniques currently in use or in development for the diagnostic assessment of structural and/or functional abnormalities in human organ systems. Emphasis on imaging, including optical, radiological, and nuclear imaging.
J. A. Parker, W. H. Churchill, Associates

HST 210 Innovation and Conceptual Design for the Solution of Technical Problems in Clinical Medicine (A)

Prereq.: Permission of Instructor
G (1)
3-0-6

Multidisciplinary approach to technical problem solving in clinical medicine. Case-study approach based on solving real problems in medical engineering and medical physics, with current problems posed by physicians from area hospitals. Problems and proposed solutions presented in seminar setting for evaluation. Generally, it is possible to arrange follow-up of promising conceptual designs outside of class, often as a research topic.
J. C. Weaver, A. C. Nelson, H. Hechtman, F. Schoen

HST 500J Physics I

(Same subject as 8.013J)
Prereq.: —
U (1)
5-1-6

See description under subject 8.013J.
Staff

HST 501J Physics II

(Same subject as 8.023J)
Prereq.: 8.01 or 8.012 or 8.013J; 18.01
U (2)
5-1-6

See description under subject 8.023J.
Staff

HST 521J Biomedical Transport Phenomena (A)

(Same subject as 10.49J)
Prereq.: 10.301, 10.302
G (2)
2-0-5

See description under subject 10.49J.
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
G (1) **Next offered 1984-85**
4-1-7

See description under subject 2.76J.
P. P. Lele, F. R. Morgenthaler

HST 531J Non-Ionizing Radiations in Biomedical Sciences (A)

(Same subject as 2.762J)
Prereq.: Permission of Instructor
G (1) **Not offered 1984-85**
4-1-7

See description under subject 2.762J.
P. P. Lele, Staff

HST 541J Quantitative Physiology: Cells and Tissues

(Same subject as 2.791J, 6.021J)
Prereq.: 2.02 or 6.002 or 6.071; 8.02; 18.03
U (1)
4-2-6

See description under subject 6.021J.
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
U (1)
3-2-7

See description under subject 6.022J.
B. B. Mikić, R. G. Mark, R. 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
U (2)
3-2-7

See description under subject. 6.023J.
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
G (1)
3-0-9

See description under subject 6.561J.
A. J. Grodzinsky

HST 550J Computers and Patient Care

(Same subject as 6.523J)
Prereq.: —
G (2)
2-0-4

An overview of present and potential uses of computers in patient care applications. 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 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
G (1)
4-0-8

See description under subject 22.55J.
G. L. Brownell, Staff

HST 561J Principles of Medical Imaging (A)

(Same subject as 2.761J, 22.56J)
Prereq.: Permission of Instructor
G (2)
4-0-8

See description under subject 2.761J.
G. L. Brownell, P. P. Lele, Staff

HST 568J Radiation Biophysics (A)

(Same subject as 22.57J)
Prereq.: 8.271 or 22.111
G (1)
4-0-8

See description under subject 22.57J.
A. C. Nelson

HST 570 Biomedical Instrumentation Electronics

Prereq.: Permission of Instructor
G (S)
6-6-6

Intended to introduce modern biomedical instrumentation electronics through a series of classroom exercises and major laboratory 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.
S. K. Burns

HST 580 Principles of Biomedical Measurements (A)

Prereq.: Permission of Instructor
G (2)
3-0-9

Fundamental principles of biomedical measurements. Concepts underlying transducers and their interface to biological systems. Emphasis on present and emerging approaches relevant to clinical medicine, biomedical research, and biotechnology. Topics include noise, temperature, pressure, sound, flow, bioelectric potentials, chemical electrodes, ISFETs, blood gas measurements, biochemical assays, bioassays, and microbiological measurements.
J. C. Weaver

HST 581J Measurements in Medicine and Biomedical Research (A except VI)

(Same subject as 6.565J)
Prereq.: 6.003, 6.041, HST 542J
G (2)
2-5-5

Medical engineering concepts and methods for effective acquisition and use of information obtained via measurements on living subjects. Practical exposure to biomedical measurements and transducers with emphasis on understanding their limitations and utility in medicine and biomedical research. Laboratory investigations in areas of current interest in medicine and biomedical research and into transduction principles and their practical application in the biomedical setting. Enrollment limited.
R. G. Mark, E. D. Trautman

HST 582J Biomedical Signal Processing (A)

(Same subject as 16.356J)
Prereq.: 6.003
G (2)
3-6-3

Principles of processing and enhancing physiological information for use in medicine. Emphasis on understanding characteristics of present and experimental medical technology using examples taken from the field of cardiology. Basic principles and algorithms used in data acquisition and display, filtering, and feature extraction covered. Laboratory exercises include hands-on experience with minicomputers.
R. V. Kenyon

HST 583J Implantable Microelectronic Instrumentation (A)

(Same subject as 6.777J)
Prereq.: Permission of Instructor
G (1)
2-3-7

Design of implantable microelectronic instrumentation — tissue and signal characteristics, electrical sensors, power supply, low power, low noise integrated circuits filtering, multiplexing, encoding, transmission of data, fabrication of implants. Other topics — biocompatibility testing and current electronic instrumentation for the cardiovascular system, neural system, and other systems. Laboratory involves design, fabrication, and testing of implantable microelectronic instrument.
D. J. Edell

HST 590 Biomedical Engineering Seminar

Prereq.: —
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.
D. J. Edell

HST 591 Biomedical Engineering Student Research Seminar

Prereq.: —
G (1, 2)
2-0-0

Development of professional speaking skills in the communication of research progress. Students present their research, emphasizing clear statement of the goals, significance, and current status of their work. Confidential, written feedback given by each member of the audience. Required of all students affiliated with the HST Biomedical Engineering Center.
J. C. Weaver

HST 598 Special Topics in Medical Engineering and Medical Physics

Prereq.: —
U (1, 2, S)
Arr.

For undergraduates desiring to carry on substantial projects of their own choosing in Medical Engineering or Medical Physics. Work may be of experimental, theoretical, or design nature. Coordinator:
E. G. Cravalho

HST 599 Special Topics in Medical Engineering and Medical Physics (A)

Prereq.: Permission of Instructor
G (1, 2, S)
Arr.

Assigned reading and special problems or research on special topics, either theoretical, experimental, or clinical. Arranged on individual basis with instructor. Coordinator:
E. G. Cravalho

HST 900 Topics in the Economics of Health Care (A)

Prereq.: Permission of Instructor
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.: 14.01
U (2)
3-0-6

See description under subject 14.21J.
P. Temin

HST 902J Current Economic and Regulatory Problems in Toxicology (A)

(Same subject as 14.285J, 20.619J)
Prereq.: Permission of Instructor
G (1) **Not offered 1984-85**
3-0-9

See description under subject 20.619J.
J. E. Harris, S. R. Tannenbaum

HST 903J Health Economics Seminar (A)

(Same subject as 14.286J)
Prereq.: 14.04
G (2)
3-0-9

See description under subject 14.286J.
J. E. Harris

HST UR Undergraduate Research in Health Sciences and Technology

Prereq.: —
U (1, 2, S)
Arr.

Extended participation in the work of a faculty member or research group. Research is arranged by mutual agreement between the student and a member of the faculty of the Harvard-MIT Division of Health Sciences and Technology, and may continue over several terms. Registration requires submission of a written proposal, signed by the faculty supervisor. A summary report must be submitted at the end of each term.
A. C. Nelson

SEM Undergraduate Seminar

SEM 311 Undergraduate Teaching Seminar

Prereq.: —
U (1)
Arr.

SEM 312 Undergraduate Teaching Seminar

Prereq.: —
U (2)
Arr.

An opportunity to tutor students in ESG, an individualized academic program for freshmen. Supervision by faculty members in tutoring students, running study groups, and leading seminars in mathematics, physics, humanities and social science, chemistry, and computer science. Acceptance to the program by decision of the faculty member in charge of the particular area in ESG.
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.: —
U (S)
Arr.

A program intended to assist freshmen to develop their facility with those concepts, techniques, and skills required for success at MIT. Classes are held in five academic areas: calculus and review of pre-calculus topics; physics, introducing Newtonian mechanics; chemistry, placing emphasis on stereo-chemistry; computer programming; humanities, improving expository writing and study skills; and an in-depth examination of problem solving approaches. Credit arranged with an 18-unit maximum. Enrollment by invitation of the Office of the Provost and the Office of Minority Education.
W. D. McLaurin, A. Davison

SPS 11 ESG (Experimental Study Group)

Prereq.: —
U (1)
Arr.

SPS 12 ESG (Experimental Study Group)

Prereq.: —
U (2)
Arr.

An individualized educational program for freshmen in mathematics, humanities and social sciences, physics, and chemistry. Credit available for core subjects as well as special academic interests through tutorials, seminars, study groups, and independent study projects. Subjects may also be taken in the regular curriculum in conjunction with work done in ESG. Staff includes MIT faculty, instructors, graduate students, and undergraduate tutors who are interested in teaching in a small, interactive learning community.
R. L. Halfman

SPS 21 ESG (Experimental Study Group)

Prereq.: SPS 11 and/or SPS 12
U (1)
Arr.

SPS 22 ESG (Experimental Study Group)

Prereq.: SPS 11 and/or SPS 12
U (2)
Arr.

Continuation of ESG for sophomores.
R. L. Halfman

SPS 31 Concourse Program

Prereq.: —
U (1)
Arr.

SPS 32 Concourse Program

Prereq.: —
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

STS Science, Technology, and Society

General Subjects

STS UR Undergraduate Research

Prereq.: —
U (1, 2)
Arr.

Undergraduate research opportunities in the STS Program. For further information consult the Departmental Coordinator:
K. R. Manning

STS 100 Science, Technology, and Social Change

Prereq.: —
U (1, 2) HUM-D
3-0-9

An introductory subject designed to help engineering and science students think systematically about the intellectural, moral, and social issues raised by the rapid growth of science and technology in the 20th century. Case studies drawn from current and past experience are used to examine the ways in which cultural, economic, and technical elements in particular situations have shaped opportunities for social choice.
P. Buck, C. Kaysen

STS 110 Special Topics in Science, Technology, and Society

Prereq.: —
U (1)
Arr.

STS 111 Special Topics in Science, Technology, and Society

Prereq.: —
U (2)
Arr.

For students who wish to pursue special studies or projects with a member of the Program in Science, Technology, and Society.
K. R. Manning

STS 120 Advanced Topics in Science, Technology, and Society

Prereq.: —
G (1)
Arr.

STS 121 Advanced Topics in Science, Technology, and Society

Prereq.: —
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.
K. R. Manning

STS 130J Reading Seminar in Humanities, Science, and Technology I

(Same subject as 21.901J)
Prereq.: —
U (1)
2-0-7

STS 131J Reading Seminar in Humanities, Science, and Technology II

(Same subject as 21.902J)
Prereq.: —
U (2)
2-0-7

Term 1: Classic interpretation in the History of Ideas, focusing on the concept of the great chain of being as a precursor to evolutionary theory. Primary and secondary readings of historians, philosophers, and scientists. Term 2: Darwin and the Darwinian Revolution. Study of evolutionary theory before and after Darwin in its relation to social theory and to arguments about the meaning and purpose of life. Readings in a wide variety of texts from the 18th, 19th, and 20th centuries. Consideration of sociobiology and of the notion of God as Great Computer Programmer of the Biosphere.
Term 1: *M. Krieger*
Term 2: *A. C. Kibel*

STS 132J Project Seminar on the Context of Research

(Same subject as 21.903J)
Prereq.: —
U (1, 2)
3-0-6

Students draw upon their individual experience in a laboratory project, UROP project, or summer job to discuss broader aspects of scientific research or technical development (for example, how a new tool changes the way a phenomenon is analyzed, or how field experience with an engineering system motivates its improvement). A few issues are discussed by the whole group, and students apply the knowledge so acquired to interpret their experience.
L. Trilling

The Social and Historical Study of Science and Technology

STS 200 The Scientific Revolution

Prereq.: —
U (1) HUM-D
3-0-9

The Scientific Revolution and its later consequences during the Enlightenment. Origins of scientific thought in the West. Emergence of science as a new intellectual and social force in the late 16th and 17th centuries. Focuses on major scientists such as Copernicus, Kepler, Harvey, Galileo, and Newton, and philosophers such as Bacon, Descartes, and Leibniz.
K. R. Manning

STS 201 History of 19th- and 20th-Century Science

Prereq.: —
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 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.
I. Kaplan

STS 202 Seminar in the History of Science and Technology

Prereq.: —
G (1)
3-0-9

Intensive reading and analysis of key works in the history and historiography of science and technology. Aims at exploring similarities and differences between the two fields and at introducing students to basic interpretive issues, bibliographic sources, and professional standards. Topics change from year to year.
P. Buck, L. R. Graham

STS 205J Nature of Scientific Knowledge

(Same subject as 24.05J)
Prereq.: —
U (2) HUM-D
3-0-6

See description under subject 24.05J.
T. S. Kuhn

STS 206 Social and Political Implications of Science

Prereq.: —
U (2) **Next offered 1984-85**
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. Emphasis on how scientists have viewed the relationship of their scientific work to moral and ethical issues.
L. R. Graham, P. Buck

STS 207J Scientific Knowledge, Social Values, and Politics (A)

(Same subject as 17.336J)
Prereq.: Permission of Instructor
G (2) **Next offered 1984-85**
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: 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.
L. R. Graham, P. Buck

STS 210 American Science Since the 1930s

Prereq.: —
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 US during the period.
C. Weiner

STS 211 Russian Science and Society

Prereq.: —
U (2)
3-0-6

An introduction to the history of Russian and Soviet science. 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. Required readings in English; supplementary readings in Russian also available.
L. R. Graham

STS 220 History of Modern Mathematics

Prereq.: 18.02
U (2)
3-0-9

Development of algebra in the 16th century and of the calculus of Newton and Leibniz. Traces applications of calculus in the work of 18th-century mathematicians such as Euler, Lagrange, and Laplace. The 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.
K. R. Manning

STS 223J Ancient Cosmology

(Same subject as 21.930J)
Prereq.: —
U (1) HUM-D
3-0-6

See description under subject 21.930J.
H. A. T. O. Reiche

STS 224J Rise of Scientific Cosmology: Aristotle to Newton

(Same subject as 24.272J)
Prereq.: —
Year.: U (2) **Next offered 1984-85**
3-0-9

See description under subject 24.272J.
T. S. Kuhn

STS 231 Cross-Cultural Studies of Scientific and Technological Institutions

Prereq.: —
U (1)
3-0-6

Analyzes several studies of laboratories and research groups around the world to investigate how culture impinges upon scientific activity. Evaluates key terms in the study of science and technology for their cultural assumptions by using those terms to explicate these laboratory studies. Discusses the design of ethnographic studies of scientific and technological laboratories.
S. Traweek

STS 300 History of Technology in America I: 1787-1876

Prereq.: —
U (1) HUM-D **Next offered 1984-85**
3-0-6

A study of America's rural, agrarian, and artisanal society from 1787 to the Centennial Exhibition of 1876. Examines the emergence of industrial capitalism within this setting: the rise of the factory system, machinofacture, and new forms of power, transport, and communication. Views technology as part of the larger culture and reveals innovation as a process consisting of a range of possibilities which are chosen or rejected according to social criteria of the time.
M. R. Smith

STS 301 History of Technology in America II: 1876-the Present

Prereq.: —
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.
D. F. Noble

STS 310J Industrialization and Cultural Change in 19th-Century America

(Same subject as 21.433J)
Prereq.: —
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. Students submit thematic essays addressing various aspects of industrialization and culture change.
M. R. Smith

STS 315J The Industrial Revolution: A Social and Cultural History (1750-1850)

(Same subject as 21.371J)
Prereq.: —
U (2) **Next offered 1984-85**
3-0-6

See description under subject 21.371J.
B. Mazlish

STS 320 Arms, Power, and the Engineer

Prereq.: —
U (1)
3-0-6

Examines cultural, social, and technical factors which underlie exercise of political power. Describes how consequences of technical progress and the resulting new outlook 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.
L. Trilling

STS 321 Military Enterprise and Technological Change: Historical Perspectives on the American Experience

Prereq.: —
U (1) HUM-D **Next offered 1984-85**
3-0-6

A history of the role of the military in promoting and developing new technology (from medieval times to the present). Examines the design, deployment, and diffusion of new technologies; the behavioral/social problems that arose with their introduction; and their influence on industrialization, colonialism, and warfare in the modern world.
M. R. Smith

STS 400J The Archaeology of Technology (New)

(Same subject as 21.541J)
Prereq.: —
U (1)
3-0-6

See description under subject 21.541J.
H. N. Lechtman

STS 401J Rationality, Risk, and Choice in Industrial Society

(Same subject as 17.305J)
Prereq.: —
U (2) HUM-D
3-0-9

Survey of the environmental consequences of 20th-century science and technology, viewed from legal, scientific, historical, and ethical perspectives. Air and water quality; nuclear and fossil power; occupational exposure to industrial chemicals; gene transfer and control. Scope and limitations of cost-benefit analysis and of models for decision making under uncertainty. The problem of justice between generations, as embodied in environmental decisions.
J. Yellin

STS 405 The Sociology of Science

Prereq.: —
U (2)
3-0-6

An introduction and overview of the sociology of science, with special emphasis on the range of theoretical and methodological perspectives in the field, on the sociology of sciences of mind, and on the social controversies around sciences that are experienced as "subversive" of widely shared, "everyday" ways of looking at the world, including artificial intelligence, psychoanalysis, and sociobiology.
S. R. Turkle

STS 408 Biotechnology and Society (New)

Prereq.: Permission of Instructor
U (1)
2-0-7

STS 409 Biotechnology and Society (New)

Prereq.: Permission of Instructor
G (1)
2-0-7

Rapid growth of biotechnology focuses on relation of academic scientists and universities to industrial and medical applications of research. Connects historical background with contemporary issues to view biotechnology in context of university education and research, funding of science, academic-industrial links, roles and responsibilities of scientists, and public expectations and perceptions. Evaluates professional, institutional and public policy alternatives. Graduate students focus on topics in their own fields.
C.Weiner, M. Gefter

STS 410 Ethical Issues in Science and Engineering

Prereq.: —
U (1)
3-0-6

Seminar on ethical problems of scientists and engineers as employees, consultants, and advisors. Case studies of on-the-job ethical dilemmas and responses of technical professionals in such fields as weapons technology, nuclear energy, genetic engineering, chemical engineering, computer science, and biomedicine. Issues include social responsibility, conflicts of interest, whistleblowing, the role of institutions and professional societies. Student projects in fields of their interest.
C. Weiner

STS 411J Legal and Scientific Issues in Environmental Controversies

(Same subject as 17.307J)
Prereq.: Permission of Instructor
U (1)
3-0-9

Seminar on major environmental decisions. Course materials are mainly recent federal court opinions dealing with air and water quality, nuclear power, occupational exposure to industrial chemicals.
J. Yellin

STS 412J Ethics and Technocrats

(Same subject as 1.16J)
Prereq.: —
U (2)
4-0-8

See description under subject 1.16J.
M. L. Manheim

STS 413J Public Controversies on the Control of Technology

(Same subject as 8.206J)
Prereq.: —
U (2)
2-0-7

Role of scientists and engineers in anticipating and controlling negative effects of technology. Presentations by individuals who have played major roles in such issues. Historical and current cases studied through readings, discussions, lectures, and student reports. Topics: dangers of the nuclear arms race; environmental and health hazards; opportunities for involvement and alternative career possibilities. 8.206J also may count toward Humanities Requirement.
C. Weiner, B. T. Feld

STS 430 Engineering Design in Social Context

Prereq.: —
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.
L. L. Bucciarelli

STS 440J Applied Social Research, Public Policy, and the Social Sciences (New)

(Same subject as 17.818J)
Prereq.: —
G (1)
3-0-9

See description under subject 17.818J.
P. Buck

Technology and the Organization of Industrial Societies

STS 500J Anthropology of Industrial Society (New)

(Same subject as 21.589J)
Prereq.: —
U (2) **Next offered 1984-85**
3-0-6

See description under subject 21.589J.
S. Traweek

STS 501 The Automobile: Mass Production and Mass Consumption

Prereq.: —
U (1) HUM-D **Next offered 1984-85**
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.
C. F. Sabel

STS 502 The Profession of Engineering

Prereq.: —
U (2) HUM-D
3-0-6

Practice, evolution, and dilemmas of engineering as a profession. Analyzes the role of engineers in the conception, design, manufacture, and marketing of a sophisticated consumer product. Studies automobile industry history in 20th-century US. Examines judgments having political, economic, social, and ethical considerations. May be taken as full 9-unit subject with HUM-D credit (attend lectures, recitations, and write three full term papers) or as undergraduate seminar (attend lectures and write three short papers).
K. Keniston, L. Trilling

STS 510J The Rise of the Modern State (A)

(Same subject as 17.154J)
Prereq.: Permission of Instructor
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

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

STS 512J Comparative Systems of Industrial Relations and Human Resource Development (A)

(Same subject as 14.674J, 15.674J)
Prereq.: 14.64 or 15.663
G (1)
3-0-6

See description under subject 15.674J.
M. J. Piore

STS 520 Technology as a Social Process

Prereq.: —
U (1)
3-0-6

Explores content and historical origins of both the idea of technological determinism and the recent critique of that idea in capitalist society. Major part of the subject is spent examining technology as a social process in itself. Aims to shed light on the cultural, ideological, political, sociological, economic, and psychological determinants of technological development.
D. F. Noble

STS 521 Technology and Labor in Industrial America: Another Look at Progress

Prereq.: —
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.
D. F. Noble

STS 540J The Political Economy of Food

(Same subject as 20.414J)
Prereq.: Permission of Instructor
G (2)
3-0-6

See description under subject 20.414J.
E. G. Rothschild, L. J. Taylor

STS 550 A Practicum in the Role of Education in Society (New)

Prereq.: Permission of Instructor
U (2)
3-5-4

Studies relationship among education, social values, and social change. Examines in depth ways of forming supportive learning relationships. Students spend five laboratory hours per week tutoring for the MIT-Wellesley Upward Bound Program at its Cambridge Rindge and Latin High School site. Discussions focus on resolution of problems such as social class conflicts, racial and sexual bias, and skills deficiencies.
J. Terry

STS 555 Education in Society (New)

Prereq.: Permission of Instructor
U (1) HUM-D
3-0-9

Examines the interrelation between family, status, jobs, and income in modern industrial societies. Particular attention to higher education as a channel of social mobility. Explores and discusses basic assumptions about human nature, inequality, and social class differences.
C. Kaysen, J. Terry

STS 557 The Social Psychology of Schools (A) (New)

Prereq.: Permission of Instructor
G (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. Examines macrostructures such as social class, tracking, and labeling as well as microstructures such as teacher classroom behavior. Attempts 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

STS 560 Arms Races in Industrial Society

Prereq.: —
U (1)
2-2-5

Studies the influence of technology in arms races and the consequences for dynamics of industrial society. Examines the interplay between political and technical processes. Emphasis on the relationship of scientists, the military, and government since WWII, and on the employment of engineers and scientists in military industries. Considers 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

STS 575J Problems of Advanced Industrial Societies (A) (New)

(Same subject as 17.532J)
Prereq.: 17.156J
G (2)
3-0-9

See description under subject 17.532J.
S. Berger, M. J. Piore

Cultural Dimensions of Science and Technology

STS 600 Technological Society and Its Critics

Prereq.: —
U (2) HUM-D
3-0-6

The emergence of industrial-technological society has provoked strong critical reactions that affirm the value of a more "natural," simple, emotionally direct and reverential relationship to the environment. These alternative visions are examined in two periods in America: 1) the mid-19th century, and 2) the 1960s. Focuses on the usefulness of these visions as criticism of (or possible alternatives to) the complexity of advanced industrial society.
K. Keniston, L. Marx

STS 601J Literature, Ideology, and National Experience in the US

(Same subject as 21.103J)
Prereq.: —
U (1) HUM-D
3-0-6

Study of the interplay among imaginative literature, the prevailing ideologies, and collective experience in the US, emphasizing critical reading within an historical context. Readings chiefly drawn from classic American writers of the 19th century, but works from earlier and later periods included: F. Scott Fitzgerald, Franklin, Jefferson, Emerson, Tocqueville, Thoreau, Whitman, Hawthorne, Melville, Max Weber, and D. H. Lawrence.
L. Marx

STS 602 Perspectives on Technology

Prereq.: —
U (2) HUM-D **Next offered 1984-85**
3-0-6

A discussion of the centrality of the machine as fact and metaphor, emphasizing its place in theories of technology and society. Reveals how technological power is central to modern thought and policy. Readings include the work of Adam Smith, Thomas Carlyle, Karl Marx, Charles Dickens, Frank Norris, Lewis Mumford, and Jacques Ellul.
L. Marx, M. R. Smith

STS 603 Introduction to Cultural Criticism (New)

Prereq.: Permission of Instructor
U (2)
2-0-7

STS 604 Introduction to Cultural Criticism (New)

Prereq.: Permission of Instructor
G (2)
2-0-7

Examines modern concept of culture as it emerged during the Industrial Revolution, and considers some of the theories and methods of analysis that have been developed around that concept. Among the basic theories considered are those associated with Marx, Emerson, Arnold, and Freud. Second half examines more recent elaborations of the culture concept in the work of such theorists as Panofsky, Burke, Benjamin, Marcuse, Foucault. Graduate students pursue topics in greater depth.
L. Marx

STS 620J Big Decisions (New)

(Same subject as 11.511J)
Prereq.: —
G (2)
2-0-7

See description under subject 11.511J.
M. H. Krieger

STS 625J American Television: A Cultural History

(Same subject as 21.032J)
Prereq.: One subject in Literature or Science, Technology, and Society
U (1)
3-0-6

See description under subject 21.032J.
D. Thorburn

STS 626J Camera and Culture

(Same subject as 21.594J)
Prereq.: —
U (2) **Next offered 1984-85**
3-0-6

How photographs come to be read as evidence in science, law, history, anthropology, and families; how this labeling of certain photographs as realistic representations of something no longer present corresponds to developments in camera technology and production; and how photographs and photographic technology shape and are shaped by the cultures in which they are used.
S. Traweek

STS 630 Technology and the Individual

Prereq.: —
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 noninstrumental or unintended human effects and uses of technologies through four case studies: 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 631 Computers and People

Prereq.: —
U (1)
3-3-6

Aspects of the computer presence in our society in the context of larger issues in the sociology of science. Three perspectives on computer impacts examined: 1) Computer impact on large social processes; 2) Computer impact on the individual; 3) Computer impact on sciences of mind and images of humanity. Projects include fieldwork studies at MIT and elsewhere to document and analyze different computer "subcultures."
S. R. Turkle

STS 632 Computer Cultures, Computation, and the Individual (A)

Prereq.: Permission of Instructor
G (1)
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. Emphasizes ethnographic and individual case study approaches. Conducted as a research seminar requiring a supervised research project.
S. R. Turkle

STS 633J Perspectives on Computers and Society (A)

(Same subject as 6.880J)
Prereq.: Permission of Instructor
G (1)
3-0-9

See description under subject 6.880J.
J. Weizenbaum

SWE

Engineering School-Wide Electives

Undergraduate Subjects

Computer Models of Engineering Systems

Offered under: 1.12, 2.101, 3.05, 10.11, 13.51, 16.008, 22.006
Prereq.: 18.02, 8.01
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 programming. Manipulation of the models using algorithms on digital computers. Examples drawn from fields primarily of interest to engineers. Extensive "hands-on" computing experience. Working knowledge of FORTRAN expected.
B. Schumacker

Introduction to Technology and Law

Offered under: 1.165, 2.998, 10.803, 13.97, 16.792, 22.085
Prereq.: —
U (1)
3-0-9

Basic principles and functions of law, using cases and materials arising from scientific and technical issues. The legal process — private, judicial, legislative, and administrative law making — and its impacts on engineers and scientists. How federal and state governance grows as technology grows. How regulation controls and supports technology. Curbs on that power. How scientific and engineering conflicts are resolved inside a legal framework. Role of values in that process.
J. D. Nyhart

Inventions and Patents

Offered under: 3.172, 6.901, 16.673, 22.084
Prereq.: 14.02
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 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.
R. H. Rines

Management in Engineering

Offered under: 2.96, 6.930, 10.806, 13.52, 16.993, 22.002
Prereq.: —
U (1)
3-0-9

Introduction of engineering management in variety of settings. 1) Role of engineering and relationship to other functions, 2) managerial tools and concepts used in engineering organizations, 3) practice in handling short- and long-term problems, 4) career strategy and development. Topics: financial principles, management of innovation, engineering project planning and control, human factors, career planning, patents, and technical strategy. Case method of instruction emphasizes participation in class discussion. Juniors, seniors, or graduate students.
R. T. Lund, D. P. Hoult, H. S. Marcus

Graduate Subjects

Engineering Risk-Benefit Analysis (A)

Offered under: 1.155, 2.943, 3.577, 6.938, 10.816, 13.621, 16.794, 22.82
Prereq.: 18.02
G (2)
3-0-6

Risk assessment, decision and cost-benefit analysis, and fault-tree methods for describing and making decisions about societal risks (nuclear reactors, dams, carcinogens, transport and disposal of hazardous materials) associated with large engineering projects. Balancing risks and benefits in situations involving human safety, environmental risks, and financial uncertainties. Presentations of major risk assessments and the public decision processes associated with them.
A. W. Drake, A. R. Odoni

Engineering Systems Analysis (A)

Offered under: 1.146, 2.192, 3.56, 13.62, 16.784, 22.821, TPP21
Prereq.: Permission of Instructor
G (1)
3-0-6

Synthesis of analytic procedures for identification and selection of optimal systems. Review of economic framework for analysis. Systematic application of mathematical optimization to engineering problems. Evaluation procedures for single and multi-attributed problems covering decision analysis in addition to standard procedures. Application of this material to real problems.
R. de Neufville, J. P. Clark

Entrepreneurship

Offered under: 2.942, 6.936, 10.801, 13.78, 16.672, 22.86
Prereq.: —
G (2)
4-0-5

Introduction to various issues faced by technical innovators/entrepreneurs. Topics include concept evaluation, patents and licensing, financing, marketing, business planning, accounting, and team building. Case studies are used. Term project required in which student ideas are developed into business plans. Open to undergraduates by permission of instructor.
D. G. Jansson

TPP Technology and Policy

TPP 11J Project Proseminar in Technology and Policy I (A)

(Same subject as 2.981J)
Prereq.: Permission of Instructor
G (1)
4-0-8

TPP 12J Project Proseminar in Technology and Policy II (A)

(Same subject as 2.982J)
Prereq.: TPP 11J
G (2)
4-0-8

Designed to develop the students' ability to analyze problems involving the interaction of technology with economic and social considerations. Case studies and group projects drawn from diverse fields. Integral historical and value-oriented critique of both issues and process. 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
G (1, 2)
2-0-1

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

TPP 21 Engineering Systems Analysis (A)

Prereq.: Permission of Instructor
G (1)
3-0-6

School-Wide Elective Subject. Description given at end of this chapter on SWE page.
R. de Neufville, J. P. Clark

TPP 22J The Policy-Making Process (A)

(Same subject as 17.220J)
Prereq.: Permission of Instructor
G (2)
3-0-9

See description under subject 17.220J.
D. A. Stone

TPP 32J Law, Technology, and Public Policy

(Same subject as 3.576J)
Prereq.: Permission of Instructor
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; 2) technological change in response to legal action; 3) changes in legal theory and practice resulting from new technical developments; 4) responses of the political system to proliferating technology; and 5) equity/market changes brought about by the law-technology interaction.
N. A. Ashford, G. R. Heaton, Jr., J. P. Clark

TPP 33J Environmental Law: Pollution Control (A)

(Same subject as 1.811J)
Prereq.: Permission of Instructor
G (1)
3-0-6

See description under subject 1.811J.
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
G (2)
3-0-6

See description under subject 1.812J.
N. A. Ashford, D. B. Hattis, G. R. Heaton, Jr.

TPP 35J Technology, Law and the Working Environment

(Same subject as 10.805J)
Prereq.: Permission of Instructor
G (1)
3-0-6

See description under subject 10.805J.
N. A. Ashford, L. B. Evans

TPP 42J Implementation (A)

(Same subject as 11.503J)
Prereq.: TPP 11J, TPP 12J or 11.200, 11.230
G (2)
2-0-7

See description under subject 11.503J.
S. T. Buckle, L. G. Buckle

TPP 43J Logistical and Transportation Planning Methods (A)

(Same subject as 1.203J, 6.281J, 11.526J, 13.665J, 15.078J, 16.76J)
Prereq.: 6.431, 15.075
G (1)
3-0-9

See description under subject 1.203J.
A. I. Barnett, R. C. Larson, A. R. Odoni, H. N. Psaraftis

AS Aerospace Studies[1]

AS 11 The Air Force Today

Prereq.: —
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 forces. Emphasis is on development of written communicative skills.
J. S. Hetland

AS 111 Leadership Laboratory

Prereq.: —
U (1)
0-1-0

Introduction to the customs, traditions, and courtesies of the Air Force through seminars, guest speakers, and appropriate field trip.
Staff

AS 12 The Air Force Today

Prereq.: —
U (2)
1-0-1

Continues study of the contemporary Air Force by examining national security objectives and the uses of national power to achieve objectives. Compares US and Soviet military power.
J. S. Hetland

AS 121 Leadership Laboratory

Prereq.: AS 111
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.: —
U (1)
1-0-1

History of the development of air power from balloon experiments up through World War II. Emphasis is on the interaction among technology, doctrine, and historical events. Students required to research and present a short speech.
J. P. Bisognano, Jr.

AS 211 Leadership Laboratory

Prereq.: AS 121
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.: —
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.
J. P. Bisognano, Jr.

AS 221 Leadership Laboratory

Prereq.: AS 211
U (2)
0-1-0

Continues AS 211. Adds a special program in preparation for Field Training.
Staff

AS 31 Management and Leadership

Prereq.: —
U (1)
3-0-3

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.
S. K. Sudderth

AS 311 Leadership Laboratory

Prereq.: AS 221
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
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.
S. K. Sudderth

AS 321 Leadership Laboratory

Prereq.: AS 311
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.

MS
Military Science[1]

AS 41 The Military in American Society

Prereq.: —
U (1)
3-0-3

Study of the military's role as an institution in a democratic society. Topics: civil-military interaction, weapons acquisition, and the military as a profession. Emphasis on developing communicative skills through student presentations.
S. L. Wallace

AS 411 Leadership Laboratory

Prereq.: AS 321
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
U (2)
3-0-3

Study of the role of the military in maintaining the security of the US. Examines the international environment, the background of defense policy, strategy and forms of conflict. Addresses specific issues including arms control, nuclear deterrence, the national military decision-making process, and military law.
S. L. Wallace

AS 421 Leadership Laboratory

Prereq.: AS 411
U (2)
0-1-0

Continues AS 411. Includes preparation for professional duties.
Staff

MS 111 Introduction to ROTC and the Army (Revised Unit)

Prereq.: —
U (1)
1-1-1

Investigates the generalized employment of the US Army, starting with the formulation of US foreign policy and the uses of military power in diplomacy. Covers the development of Army combat power in terms of personnel and organization. Emphasizes knowledge of current military events and their impact on the nation, and written and verbal communication skills.
G. S. Smith, Jr.

MS 121 The Army Today (Revised Unit)

Prereq.: MS 111
U (2)
1-1-1

Discusses interface between Active Army, National Guard, Reserves, and civilian work force; interservice and intra-alliance support. Examines organization and role of company-sized units; small unit tactics and combined arms concepts. Specialities of soldiers are related to operational unit missions. Introduces principles of war and relates them to actual historical events.
Staff

MS 21 Leadership

Prereq.: —
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 interpersonal communications, motivation and counseling, discussed. Case studies are used to enhance classroom effort.
W. B. Miller

MS 211 Instructional Methodology (Revised Unit)

Prereq.: —
U (1)
1-1-1

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 three oral presentations. The student is critiqued and evaluated by the instructor and other members of the seminar. For the third presentation, students required to develop an acceptable lesson plan as part of that presentation.
G. A. Ross

MS 221 Branches of the Army (Revised Unit)

Prereq.: MS 111, MS 121
U (2)
1-1-1

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. The Army's Officer Personnel Management System is introduced and addressed from the point of view of the individual officer's management of his or her own career.
W. P. Roe

MS 31 Small Unit Tactics (Revised Content)

(MS 321, MS 322)
Prereq.: MS 221
U (1, 2)
2-0-1

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.
Staff

[1]Military Science subjects are not for MIT credit.

MS 311 Military Management (Revised Content and Unit)

(MS 31)
Prereq.: MS 21
U (1)
1-1-1

Concerned with the integrated management of Army units and activities. 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.
Staff

MS 321 Land Navigation (Revised Unit)

(MS 312)
Prereq.: —
U (2)
1-1-1

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.
Staff

MS 41 Military History

Prereq.: —
U (1, 2)
2-0-1

Examines, the development of the US Army. Emphasizes giving the student a better understanding and perspective regarding the history of the US Army, the roles military professionals have played in shaping the US, and where the military profession fits into the society it serves. Equips the student with the tools necessary to analyze military operations at all levels using historical methodology and stimulates an interest in the study of military history which leads the potential Army Officer to a mature, informed conception of his role as a leader in the US Army.
W. B. Miller

MS 411 Military Law and Administration (Revised Unit)

Prereq.: MS 31
U (1)
1-1-1

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.
W. P. Roe

MS 421 Military Ethics and Professionalism (Revised Unit)

Prereq.: MS 31
U (2)
1-1-1

Brings together material on two major topics: the military as a profession, and morality and war. Stresses ethical dimensions of the military profession and juxtaposes positions of well known scholars. Themes examined include the inextricable association of human values with the military profession and the resolution required when crucial military values are at odds with the parent society.
G. S. Smith, Jr.

NS Naval Science[1]

NS 11 Introduction to Naval Science

Prereq.: —
U (1)
2-0-1

General introduction to seapower and the naval service, covering an overview of the organization and historical development 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.
P. F. Farrell

NS 12 Naval Ships Systems I[2]

Prereq.: —
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.
P. F. Farrell

NS 21 Naval Ships Systems II[2]

Prereq.: 18.02, 8.01
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.
D. E. Guza

NS 22 Seapower and Maritime Affairs

Prereq.: —
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.
D. E. Guza

NS 31 Navigation and Naval Operations I

Prereq.: —
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.
D. S. Foreman

NS 32 Navigation and Naval Operations II[2]

Prereq.: —
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.
D. S. Foreman

NS 33 Modern Warfare

Prereq.: —
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 factors on strategic thought. Great leaders and military organizations of history examined to discover the ingredients of their successes.
G. Durand

NS 34 Marine Corps Doctrine and Tactics

Prereq.: —
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.
G. Durand

NS 41 Leadership and Management I

Prereq.: —
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.
R. J. McClure

NS 42 Leadership and Management II

Prereq.: —
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.
R. J. McClure

NS 43 Amphibious Warfare

Prereq.: —
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.
G. Durand

[1]Naval Science subjects are not for MIT credit.

[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.

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1
Address correspondence to the Massachusetts Institute of Technology, Cambridge, Massachusetts 02139.

2
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3
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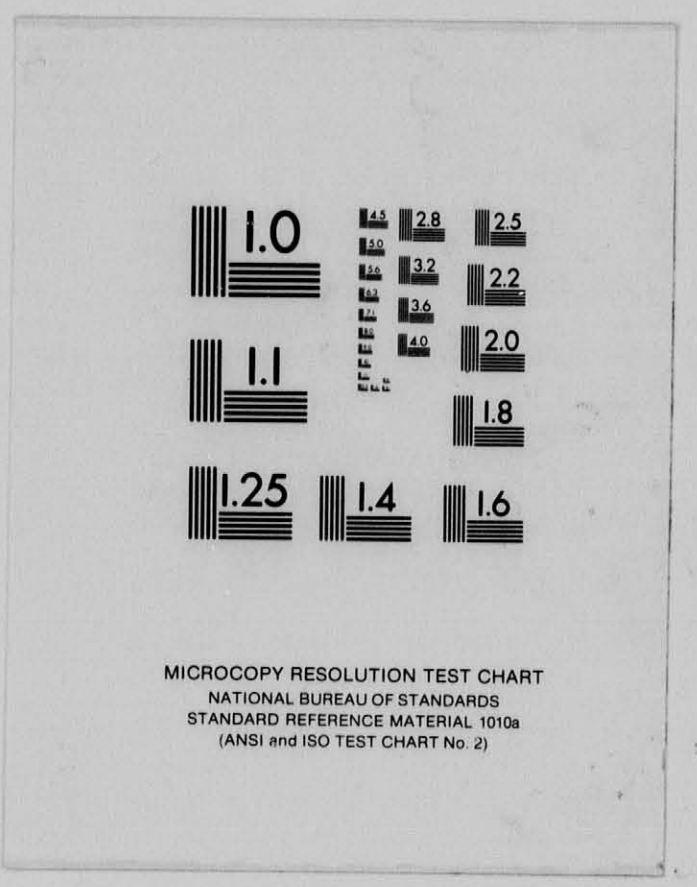
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