

General Catalogue Issue
1979-80



General Catalogue Issue
September 1979

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

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The Institute has created and implemented and will continue to implement an affirmative action plan expressing its commitment to the principle of equal opportunity in education.

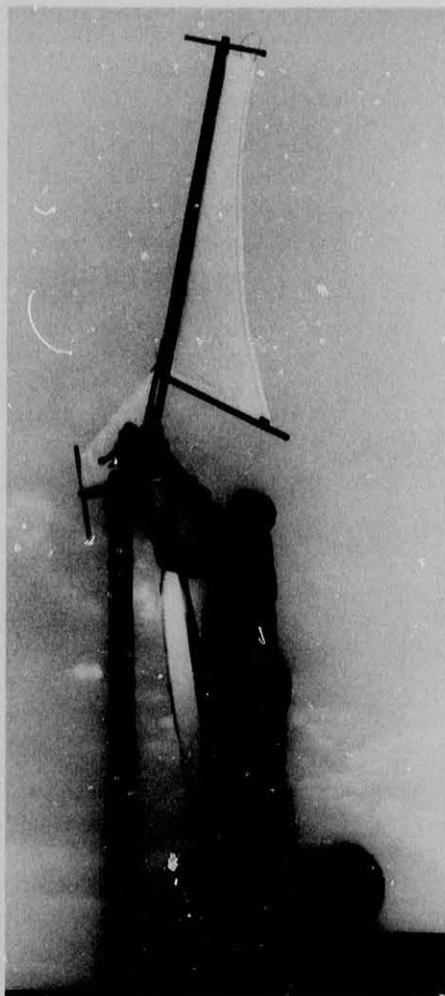
Contents

| | | | | | |
|-------------------------------------|----|----------------------------------|----|---------------------------------|-----|
| I | | III | | V | |
| This is M.I.T. | 3 | Undergraduate | | Interdepartmental Study | |
| | | Education at M.I.T. | 39 | and Research | 101 |
| History and Purpose | 4 | Academic Programs | 40 | Undergraduate Interdepartmental | |
| The Academic Program | 5 | General Institute | | Opportunities | 103 |
| The Academic Calendar | 6 | Requirements | 50 | Graduate Interdepartmental | |
| Educational Resources | 8 | Admissions | 61 | Opportunities | 108 |
| The Campus | 10 | Costs for Undergraduate | | Interdepartmental Organizations | |
| The Boston Environment | 12 | Students | 67 | and Research Facilities | 118 |
| Organization of the Institute | 15 | Financial Aids | 69 | Other Opportunities | 139 |
| Schools, Departments, | | | | | |
| Courses and Degrees | 16 | | | | |
| II | | IV | | | |
| Campus Life | 21 | Graduate | | | |
| | | Education at M.I.T. | 77 | | |
| Campus Activities | 22 | General Requirements for | | | |
| Housing | 28 | Graduate Degrees | 80 | | |
| Student Services | 32 | Admissions | 89 | | |
| Rules and Regulations | 34 | Costs for Graduate Students ... | 93 | | |
| | | Financial Aids | 95 | | |

| | | | | | |
|--|--|------------|---|----------------------------|----------|
| VI | School of Science | 275 | VII | M.I.T. Corporation, | |
| Departmental Programs | Biology | 277 | Academic Officers, | | |
| and Requirements | Chemistry | 281 | Administration, and | | |
| 141 | Earth and Planetary Sciences .. | 285 | Committees | 325 | |
| | Mathematics | 289 | | | |
| School of Architecture | Meteorology | 293 | The Corporation | 326 | |
| and Planning | Nutrition and Food Science | 297 | Principal Academic Officers, | | |
| 142 | Physics | 302 | Deans, and Heads | | |
| | Interdisciplinary Science | | of Departments | 328 | |
| Architecture | Program | 307 | Officers of the Faculty | 330 | |
| Urban Studies and Planning ... | Joint Program in Oceanography | | Institute Professors | 330 | |
| 153 | with the Woods Hole | | Directors and Principal Officers | | |
| | Oceanographic Institution | 308 | of Laboratories and Centers ... | 331 | |
| School of Engineering | Astronomy and Astrophysics .. | 310 | Administration | 333 | |
| 160 | | | Corporation Standing | | |
| | Whitaker College of Health | | Committees | 345 | |
| Aeronautics and Astronautics . | Sciences, Technology, and | | Corporation Auditing, Advisory, | | |
| 166 | Management and the | | and Visiting Committees | 346 | |
| Chemical Engineering | Harvard-M.I.T. Division of | | Standing Committees | | |
| 174 | Health Sciences and | | of the Faculty | 349 | |
| Civil Engineering | Technology | 311 | Councils | 350 | |
| 180 | | | Members of the Faculty | | |
| Electrical Engineering and | R.O.T.C. Programs | 318 | Ex-Officiis | 352 | |
| Computer Science | Air Force R.O.T.C. | 318 | | | |
| 188 | Army R.O.T.C. | 320 | Index | | v |
| Materials Science and | Naval R.O.T.C. | 322 | | | |
| Engineering | | | | | |
| 197 | | | | | |
| Mechanical Engineering | | | | | |
| 204 | | | | | |
| Nuclear Engineering | | | | | |
| 214 | | | | | |
| Ocean Engineering | | | | | |
| 220 | | | | | |
| Joint Program in Oceanographic | | | | | |
| Engineering with the Woods Hole | | | | | |
| Oceanographic Institution | | | | | |
| 227 | | | | | |
| Center for Advanced | | | | | |
| Engineering Study | | | | | |
| 229 | | | | | |
| | | | | | |
| School of Humanities and | | | | | |
| Social Science | | | | | |
| 231 | | | | | |
| | | | | | |
| Program in Science, | | | | | |
| Technology, and Society | | | | | |
| 234 | | | | | |
| Economics | | | | | |
| 238 | | | | | |
| Humanities | | | | | |
| 242 | | | | | |
| Linguistics and | | | | | |
| Philosophy | | | | | |
| 254 | | | | | |
| Political Science | | | | | |
| 257 | | | | | |
| Psychology | | | | | |
| 262 | | | | | |
| | | | | | |
| Sloan School | | | | | |
| of Management | | | | | |
| 265 | | | | | |



An M.I.T. Education for Our Times



Science and engineering have provided humanity with priceless gifts which have allowed us to move far from the frightened, superstitious, hungry state of a few centuries ago. These gifts include an understanding of the physical world in which we live and of the forces of nature with which we must contend to survive. They include the means to provide abundant livelihood for people everywhere. Research has provided us with deep insights into living organisms including ourselves; it has given us some understanding of the complex societies in which we live; and it has provided the basis of those tools with which we can compete more effectively with nature for the means of survival.

These great achievements of the human mind have been a source of optimism and pride, a source of the hope that increased understanding would bring a happier life. Yet at the moment many have become so aware of some of the unintended side effects of science and technology that they would, if they could, stop technological change and the scientific discoveries and technological developments on which the future depends.

To me it is evident that without new technology, to enhance our muscle and brain power, we could not continue the quest for a free and decent society for everyone. Without new energy technologies, for example, the nation and the world will face a declining standard of living. Technological opportunities abound and M.I.T. is committed to helping convert them into realities.

The contemporary crises we face are basically the consequence of an ever-increasing disparity between our growing mastery of the physical world on the one hand, and on the other hand, our limited understanding of the profound impact our actions have on ourselves and our social institutions. Modern crises are, as well, a consequence of the

lack of effective means, thus far, for guiding our self-induced social evolution. The effects of this incongruence between a growing ability to change the world and the inability to shape it to fit our hopes can be seen all around us.

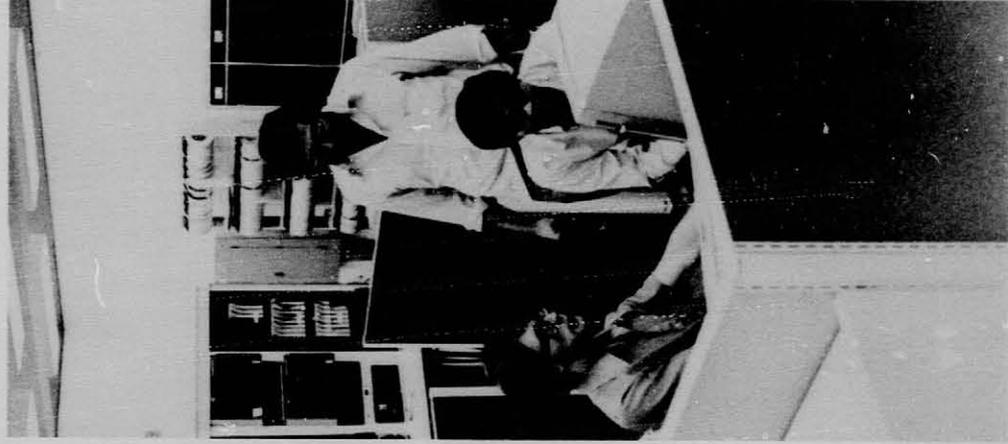
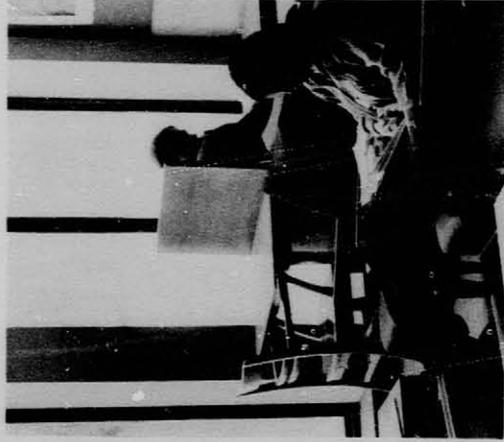
The bittersweet character of the modern world, the implicit contrast between the world that is and the world that could be, is what leads to the disenchantment we see on all sides. Yet the arts and the sciences are agencies of our hope. Both represent knowledge — about the world and about humankind — that is at once practical and useful, particularly when informed by technology, which is essential to each.

The first responsibility of universities must always be a dedication to rationality and scholarship in science and engineering, social science, the arts, and the professions. But at this moment universities must do more. We are called upon to become leaders in an effort to relate, through new educational, research, and action programs, our humanistic needs to the choices available in science, technology, and social planning. M.I.T.'s history is one of dedication to society's need, and we are committed to a major effort to help solve these pressing problems.

Jerome B. Wiesner
President



This is M.I.T.



This is M.I.T.

History and Purpose

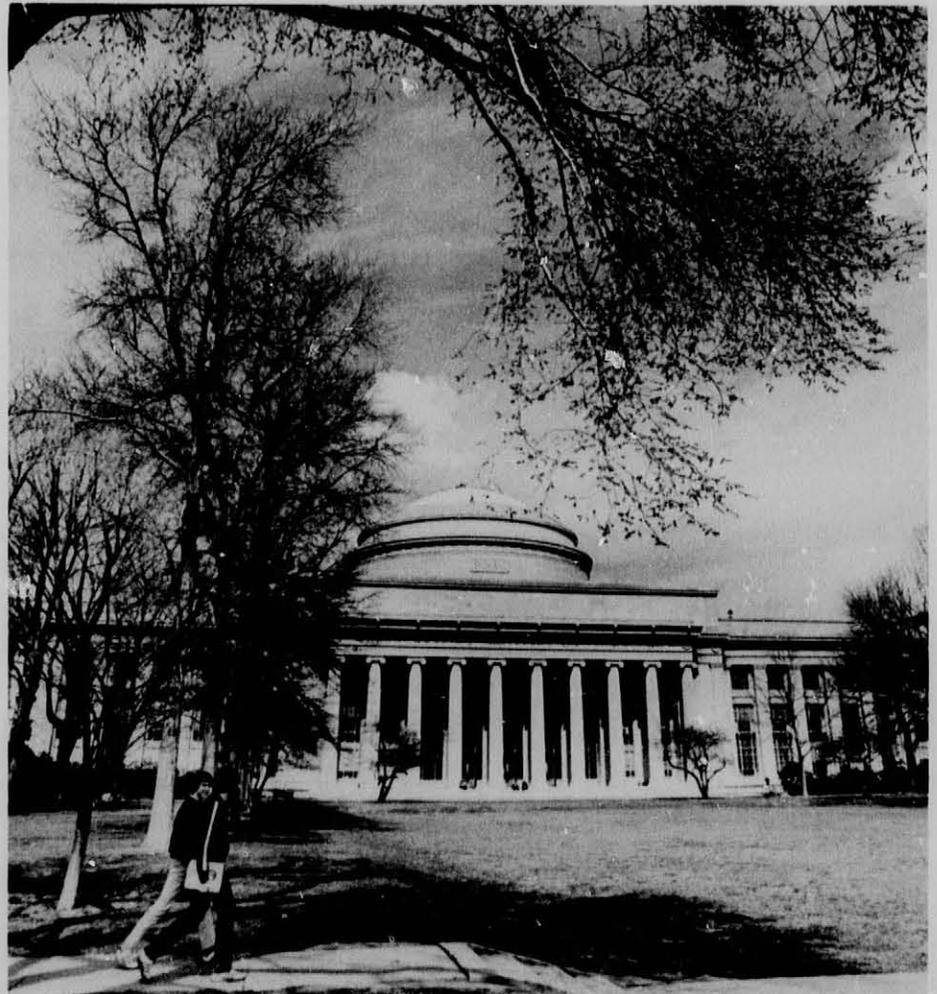
On February 20, 1865, four years after approval of its founding charter, the Massachusetts Institute of Technology opened its doors to admit the first class of 15 students. The event marked the culmination of an effort by William Barton Rogers, M.I.T.'s founder and first president, to create a new kind 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 M.I.T.'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. There are 23 academic departments within these Schools, as well as many interdepartmental laboratories, centers, and divisions which extend beyond the traditional boundaries of a single department.

M.I.T.'s total enrollment is approximately 8,800, almost evenly divided between undergraduate and graduate students. In 1978-79, M.I.T. students came from all 50 states and the District of Columbia, two territories, and 93 foreign countries. The proportion of international students at the Institute, about 17 percent, is one of the highest in an American university.

The M.I.T. faculty numbers approximately 940, with a total teaching staff of 1,730. Members of the faculty group themselves for teaching and research according to their interests. 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 M.I.T. 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 M.I.T., 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 central purpose of the academic program at M.I.T. 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 M.I.T. 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 theory and experiment for both students and faculty, and assures that classroom teaching is up to date. Teaching, at the same time, provides a setting in which the relevance, accomplishments, and vitality of research are continually clarified and assessed.

Each of the 23 academic departments offers one or more degree programs or Courses¹ of study. By and large, each student pursues 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 M.I.T. 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 of Science in Architecture Studies (S.M.Arch.S.), Master of Science in Visual Studies (S.M.Vis.S.), 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 students, undergraduate programs, including those which provide periods of on-the-job experience off-campus, require four years of full-time study for the Bachelor of Science.



1

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

2

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

Academic Calendar

In all universities, the academic calendar provides a framework for educational programs and cultural events, and generally influences the patterns of campus life. At M.I.T. the fall term starts in mid-September and ends before Christmas, and the spring term starts the second week in February and ends in late May.

The January Independent Activities Period (I.A.P.), provides a new dimension to educational activities. The time during I.A.P. may be devoted to research, study in a field of the student's interest, travel, relaxation, or investigation of new fields. During this time more than 500 special activities, including films, field trips, seminars and lectures, individual projects, intensive subjects and workshops, are offered on the campus. There are also numerous off-campus activities, including field trips and academic projects abroad. Among the options available this past January were: a subject called Physics of the Piano, an intensive course in the language of the Inca, a glass blowing lab, and a cartoonists' workshop.

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

1979

August 31
Freshman Orientation Week begins

September 4
Graduate Orientation Week begins

September 10
Registration Day

September 11
First day of classes

October 8, 9
Columbus Day, Vacation

November 12
Veterans Day (*Holiday*)

November 22, 23
Thanksgiving Vacation

December 12
Last day of classes for subjects with final exam

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

December 17-20
Final exam period

December 21-January 6
Christmas Vacation

1980

January 7
First day of Independent Activities Period

January 15
Martin Luther King Day (*Holiday*)

January 30
Last day of Independent Activities Period

January 31-February 3
Vacation

February 4
Registration Day

February 5
First day of classes

February 18-19
Washington's Birthday, Vacation

March 24-28
Spring Vacation

April 21, 22
Patriots' Day, Vacation

May 14
Last day of classes for subjects with final exam

May 16
Last day of classes for subjects with no final exam

May 19-22
Final exam period

May 26
Memorial Day (*Holiday*)

June 2
Commencement Exercises

June 9
First day of Summer Session



Educational Resources

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

For this work M.I.T. has unusual facilities, some of which are unique among educational institutions. There are more than 70 special laboratories on the campus in Cambridge. In general, the Institute's policy is to make these facilities available to students — with the result that nearly all of M.I.T.'s laboratories are shared by undergraduates, graduate students, and faculty members working together in close collaboration on ongoing projects.

Many of these research facilities are described in this catalogue by the departments which operate them. In addition to laboratories and facilities organized within departments, there is a large number of interdepartmental laboratories and centers, established to facilitate work in fields which cross the lines of traditional disciplines. Undergraduate opportunities in interdepartmental areas, graduate interdepartmental programs, 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 M.I.T. Libraries, with holdings of more than one and three-quarter million volumes. More than 18,000 current journals and periodicals and extensive back files provide comprehensive resources in all major fields. These are enriched by numerous special collections, including microfiche, slides, and maps. Through M.I.T.'s membership in the Boston Library Consortium, graduate students, faculty members, and research staff have access to extensive research collections outside the Institute.

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

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

Information Processing Services

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

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

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

M.I.T. Press

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

The Council for the Arts at M.I.T.

The Council for the Arts at M.I.T. was founded in the fall of 1971. A nationally based advice and support body with a membership of 100, the Council is composed of men and women who hold in common the view that relative progress in civilization rests in no small measure on a healthy balance between the arts and sciences. It is the Council's belief that the arts are a particularly significant element of a university based mainly on science and technology. This belief is reinforced at M.I.T. by an undergraduate body that increasingly wants more than specialization and professional competence in an education aimed at broad social and humane ends.

The Council is a grant-making body that uses its own funds to foster the arts at M.I.T. Its function is to act as a catalyst in a highly participatory, wide-ranging program that is firmly founded on the intellectual tripod of teaching, practice, and research in the arts. Visual and literary arts, dance, music, theatre, cinema, photography, and other art forms receive financial support from the Council. The Council's ultimate goal is to enhance the M.I.T. community as a whole and to help provide students with a collective experience in the arts that will match and complement the depth and insight of their experience in science and technology.

Lowell Institute School

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

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

Subjects offered by the School do not carry M.I.T. 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, M.I.T., Cambridge, Massachusetts 02139.

The Campus

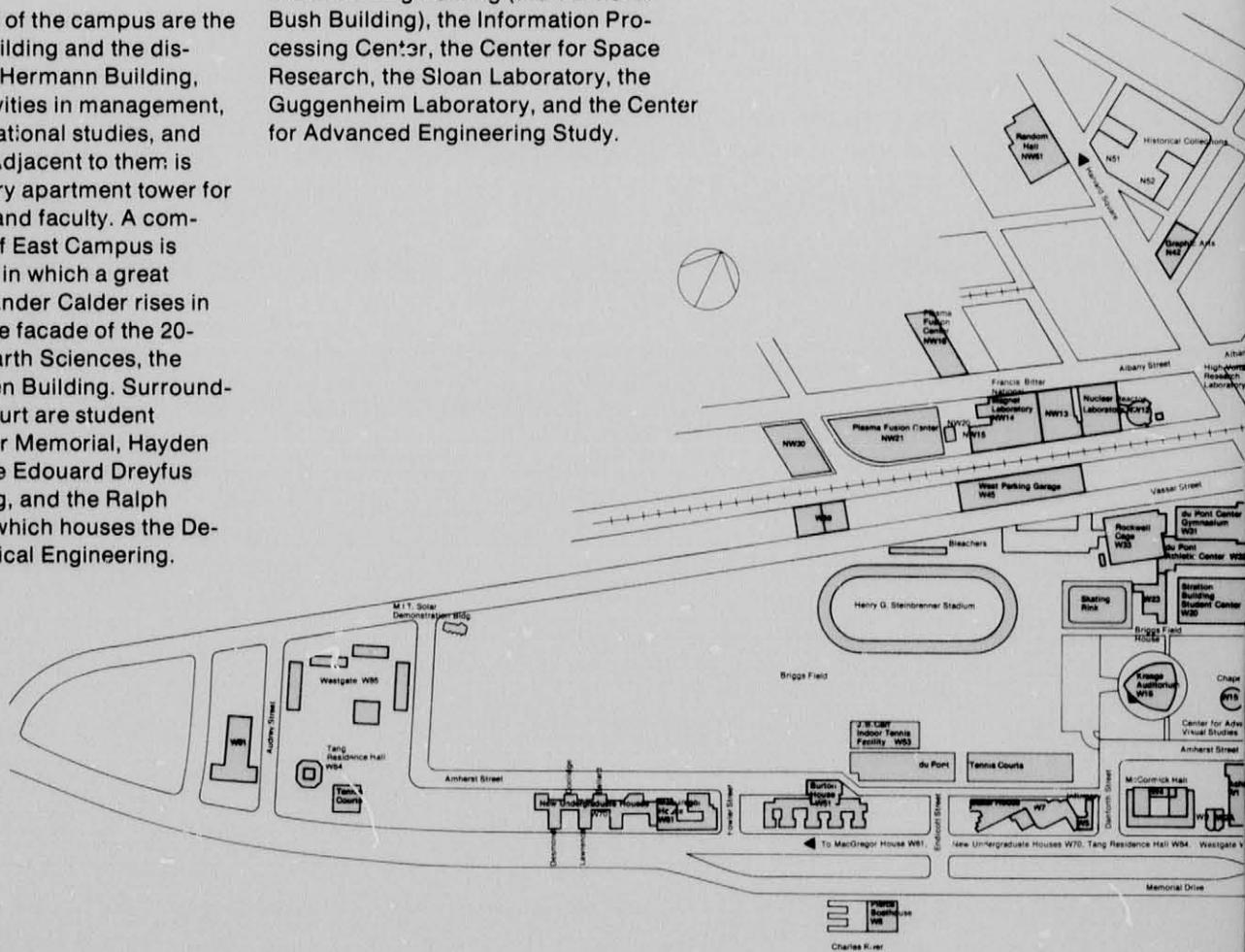
M.I.T.'s 125-acre campus extends for more than a mile along the Cambridge side of the broad Charles River Basin facing historic Beacon Hill and the central sections of Boston. Most academic activities are brought together in a group of interconnected buildings designed to permit maximum flexibility and easy communication among the departments and Schools. The extensive athletic plant and playing fields are on the campus, as are the recreational buildings, dormitories, and dining halls. This convenient arrangement contributes greatly to the sense of unity and interdepartmental involvement that characterize the Institute.

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

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

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

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



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

Located throughout the campus is an outstanding collection of contemporary environmental sculpture including works by Henry Moore, Louise Nevelson, Alex-

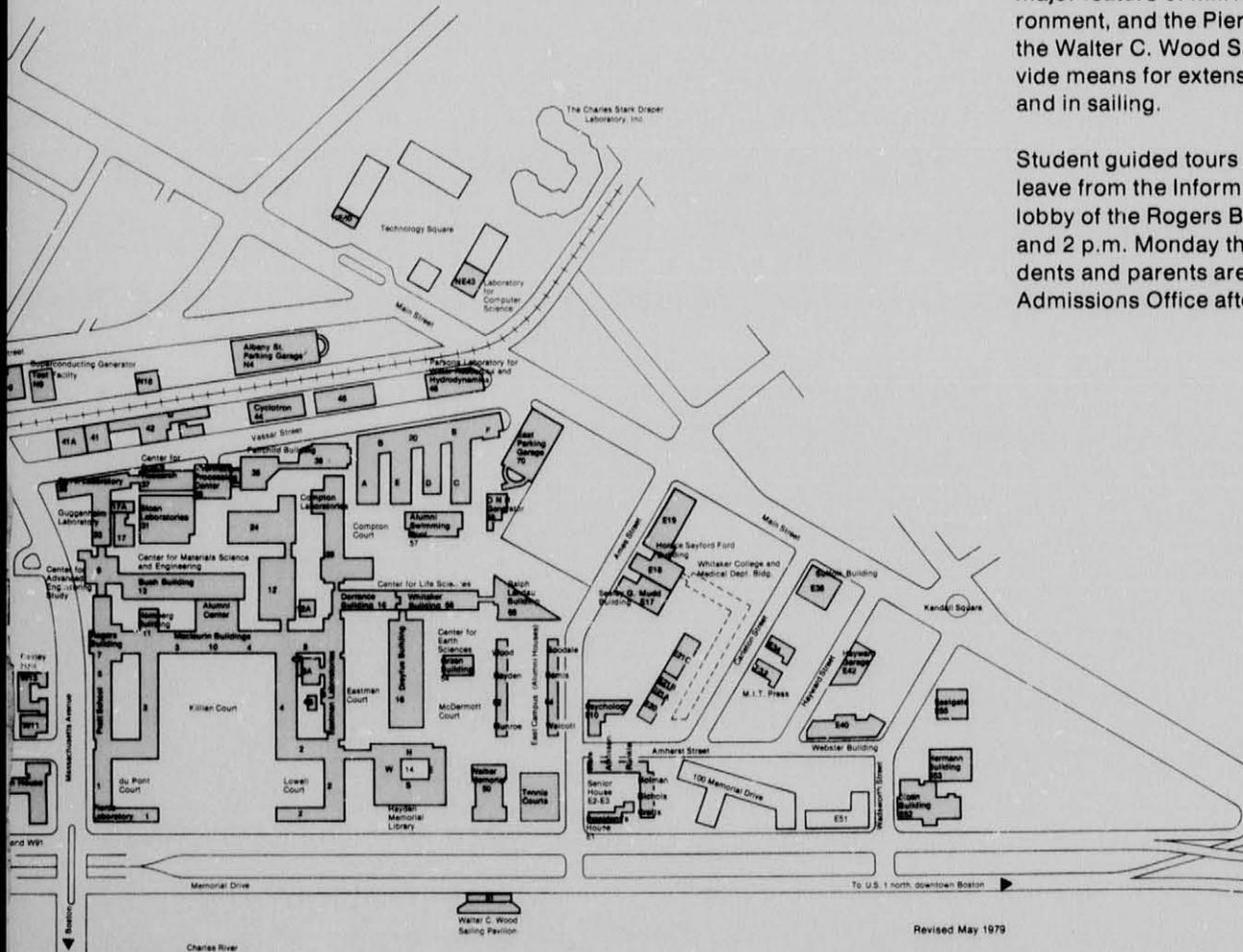
ander Calder, Pablo Picasso, and Tony Smith. This collection highlights the history, art, and architecture of the Institute for visitors walking around the campus.

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 Aivar 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 playing fields for soccer, lacrosse,

baseball, softball, touch football, rugby, cricket, track, and tennis. Here, too, are Rockwell Athletic cage, Briggs Field House, an outdoor skating rink, the J. B. Carr Tennis facility and the du Pont Athletic Center. M.I.T.'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 women's field hockey games.

The Charles River Basin, which is two miles long and a third of a mile wide, is a major feature of M.I.T.'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 a.m. and 2 p.m. Monday through Friday. Students and parents are welcome at the Admissions Office after the tour.



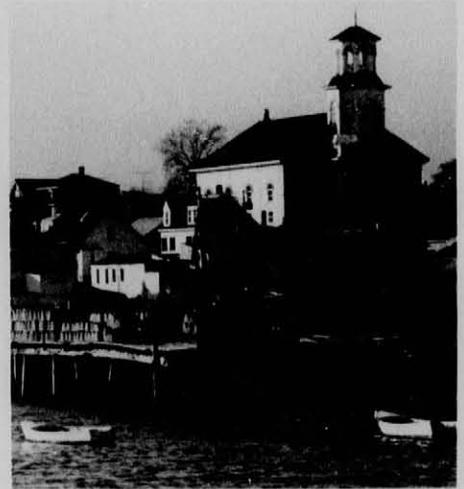
The Boston Environment

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

M.I.T. is one of more than 50 schools located within the Boston area. Others include Harvard University, Radcliffe College, Boston University, Northeastern University, 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 M.I.T. by car are the mountains of Vermont and New Hampshire, the ocean beaches of Cape Cod, the uncrowded 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, and camping.







Organization of the Institute

The governing body of the Institute is a board of trustees known as the Corporation, over which the Chairman presides. Its members include 90 distinguished leaders of science, engineering, industry, and education and (ex officio) the President, the Chancellor, 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. The Chancellor acts as deputy to the President on all matters. In addition, senior administrative officers of the Institute include the Provost, the Associate Provost, and seven Vice Presidents. The academic program is directed by the President, the Chancellor, the Provost, Associate Provost, and five Deans, each responsible for the undergraduate and graduate programs in one of the five academic Schools. The Institute's 23 academic departments are organized into five Schools, each presided over by a dean.

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

Officers concerned with the overall administration of the Institute meet regularly in the Academic Council. 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 M.I.T. faculty meets every month and conducts its business through a number of elected standing committees. The faculty committee on Educational Policy (C.E.P.), 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 C.E.P.

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 Office and the M.I.T. Associates Program are responsible for fulfilling the contractual obligations of the Institute to a group of leading American companies which make special grants in support of M.I.T.'s program in research and education.

The M.I.T. Alumni Association has a comprehensive program for keeping some 70,000 men and women, who have studied at M.I.T., 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 M.I.T. alumni. There are nearly 100 regional M.I.T. 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 M.I.T. Alumnae is an organization of former M.I.T. 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) Architecture Studies Visual Studies | M.Arch. S.M. S.M. Ph.D. |
| | Architecture (IV-B) | S.B. | | |
| Department of Urban Studies and Planning | Urban Studies (XI) | S.B. | Urban Studies and Planning (XI) | M.C.P. Ph.D. |
| School of Engineering¹ | | | | |
| 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) ² | S.M., E.E., Sc.D., Ph.D. |
| | Computer Science and Engineering (VI-3 ³) | S.B. | | |
| | Cooperative Course ² (VI-A) | S.B. | Electrical Engineering and Computer Science ² (VI-A) | S.M. |

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

| Schools and Departments | Undergraduate Courses (and Course Numbers) | Bachelor's Degrees | Graduate Courses (and Course Numbers) | Graduate Degrees |
|--|--|--|--|---------------------------------|
| School of Engineering (continued) | | | | |
| Department of Materials Science and Engineering | Materials Science and Engineering (III) | S.B. | Materials Science and Engineering (III) ³ | Met.E., Sc.D., Ph.D. |
| | Materials Science and Engineering (III-A) | S.B. | Ceramics Materials Engineering Materials Science Metallurgy | S.M. S.M. S.M. S.M. |
| | Cooperative Course (III-B) | S.B. | Polymeric | 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. | Shipping and Shipbuilding Management (XIII-B) ² | S.M. |
| | | Ocean Engineering ³ (XIII-W) | Ocean E., Ph.D. Sc.D. | |

| Schools and Departments | Undergraduate Courses (and Course Numbers) | Bachelor's Degrees | Graduate Courses (and Course Numbers) | Graduate Degrees |
|---|---|-----------------------|--|-----------------------|
| School of Humanities and Social Science | | | | |
| Department of Economics | Economics (XIV) | S.B. | Economics (XIV) | S.M., Ph.D. |
| Department of Humanities | Humanities and Engineering (XXI-A) | S.B. | | |
| | Humanities and Science (XXI-B) | S.B. | | |
| Department of Linguistics and Philosophy | | | Linguistics (XXIV) | Ph.D. |
| | Philosophy (XXIV) | S.B. | Philosophy (XXIV) | Ph.D. |
| Department of Political Science | Political Science (XVII) | S.B. | Political Science (XVII) | S.M., Ph.D. |
| | Political Science: Public Policy (XVII-A) | S.B. | | |
| Department of Psychology | | | Psychology (IX) | S.M., Ph.D. |
| Alfred P. Sloan School of Management⁴ | | | | |
| Department of Management | Management (XV) | S.B. | Management (XV) | S.M., Ph.D. |
| School of Science⁴ | | | | |
| Department of Biology | Life Sciences (VII) | S.B. | Biology (VII) | Ph.D. |
| | Biology (VII-A) | S.B. | | |
| | Life Sciences (VII-B) | S.B. | Biology ³ (VII-W) | Ph.D. |
| Department of Chemistry | Chemistry (V) | S.B. | Chemistry (V) | S.M., Ph.D., Sc.D. |
| Department of Earth and Planetary Sciences | Earth and Planetary Sciences (XII) | S.B. | Earth and Planetary Sciences (XII) | S.M., Ph.D. Sc.D. |
| | | | Oceanography | S.M. |
| | | | Oceanography ³ (XII-W) | Ph.D., Sc.D. |
| Department of Mathematics | Mathematics (XVIII) | S.B. | Mathematics (XVIII) | S.M., Ph.D., Sc.D. |
| Department of Meteorology | | | Meteorology (XIX) | S.M., Ph.D., Sc.D. |
| | | | Oceanography | S.M. |
| | | | Oceanography ³ (XIX-W) | Ph.D., Sc.D. |

| Schools and Departments | Undergraduate Courses (and Course Numbers) | Bachelor's Degrees | Graduate Courses (and Course Numbers) | Graduate Degrees |
|---|---|-----------------------|--|-----------------------|
| 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. |
| | | | Nutritional Biochemistry and Metabolism | S.M. |
| | | | Toxicology | S.M. |
| Department of Physics | Physics (VIII) | S.B. | Physics (VIII) | S.M., Ph.D., Sc.D. |
| School of Science | Interdisciplinary Science Program (XXV) | S.B. | Interdisciplinary Science Program (XXV) | S.M. |
| Harvard-M.I.T. Division of Health Sciences and Technology | | | Health Sciences and Technology (HST) | Ph.D., Sc.D. |

¹
In the Departments of the School of Engineering, the S.M. degree 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.

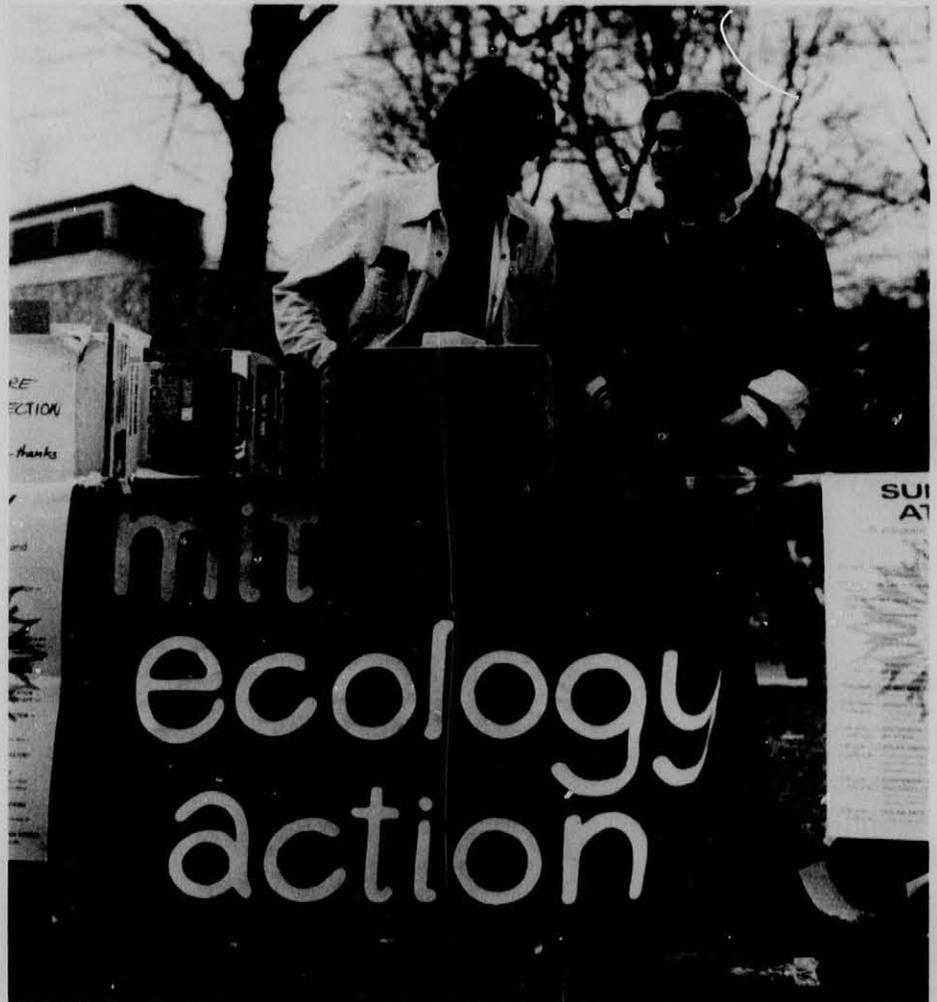
²
Five-year Course leading to Bachelor of Science and Master of Science degrees awarded simultaneously at the end of the graduate year.

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

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

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





Campus Activities

There is more to an M.I.T. 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 M.I.T. Undergraduate Association, to which all undergraduates belong, is the major undergraduate governmental body. A variety of committees is associated with the Undergraduate Association. The Finance Board coordinates budgets and allocates funds to student organizations; its budget hearings are open. The Student Center Committee helps manage the facility and also produces programs, including operation of a 24-hour coffeehouse. The Student Committee on Environment tries to improve classroom and building design and atmosphere and living conditions in the dorms, and implement coed housing in more living groups. 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 Coordinating Committee manages a variety of social and popular music events.

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

All living groups, both fraternities and Institute Houses, elect governing councils, responsible for the functioning of their houses. In addition to sponsoring social events, these house councils handle all judicial matters with the respective houses. To deal with the problems of common concern, the fraternities have joined in the Interfraternity Conference (I.F.C.), while the Institute Houses have formed the Dormitory Council. The I.F.C. 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 such common House activities as freshman orientation, major social events, and handles intra-House judicial problems.

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

Each class at M.I.T. elects a president and executive committee to handle various class affairs.

Graduate Student Government

All graduate students are included in the Graduate Student Organization. Its executive body is a Council of elected representatives of all Courses, Ashdown House, Tang Hall, Eastgate, Westgate, foreign students, and off-campus graduate residents. The Organization is concerned primarily with the general welfare of the graduate student body; encouraging social, athletic, cultural, and other extracurricular activities; promoting closer relations between graduate students and faculty outside formal academic exercises; and voicing ideas and suggestions of graduate students. The Graduate Student Council sends two students to represent the Organization on 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.

The intercollegiate program last year attracted approximately 960 men and women for competition in 32 sports, while 4,000 students seeking more informal activities joined intramural and club teams. The M.I.T. sailing program attracts another 1,500 students, faculty, and alumni, and extends sailing privileges to their families.

M.I.T. has varsity and freshman intercollegiate teams in outdoor and indoor track and field, cross-country, lightweight crew, heavyweight crew, baseball, skiing, gymnastics, hockey, basketball, fencing, golf, lacrosse, rifle, swimming, tennis, soccer, squash, pistol, sailing, water polo, and wrestling. In addition, there are women's varsity teams in crew, sailing, basketball, tennis, fencing, field hockey, swimming, gymnastics, softball, and volleyball. Competition includes traditional New England colleges and Ivy League schools.

The intramural athletic program is noteworthy; last year more than two-thirds of M.I.T. undergraduates participated in over 1,500 intramural contests. There were league competitions in touch football, cross-country, basketball, cycling, fencing, softball, volleyball, swimming, indoor and outdoor track, tennis, table tennis, sailing, badminton, hockey, squash, water polo, wrestling, riflery, bowling, chess, pool, soccer, and weight-lifting. Club sports, with intercollegiate competition but less formal organization than varsity teams, include tackle football, badminton, bicycling,

rugby, cricket, judo, white water, and weight-lifting. Undergraduate and graduate students participate in both intramural and club programs.

Excellent facilities for these sports are provided by: the du Pont Athletic Center, the du Pont Gymnasium, an outdoor skating rink with an ice-making system, the Alumni Swimming Pool, the Walter C. Wood Sailing Pavilion and the Pierce

Boathouse on the Charles River Basin, and the Briggs playing fields including the du Pont outdoor tennis courts. Rockwell Cage provides an indoor field house, and the J. B. Carr Tennis Center includes four indoor courts for use during the long and inclement New England winters. M.I.T.'s newly constructed Steinbrenner Stadium provides a 400 meter all-weather running track, the first of its kind in North America.



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. L.S.C. also has cosponsored, with M.I.T. departments or other campus groups, events of cultural, entertainment, or educational significance.

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

Music

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

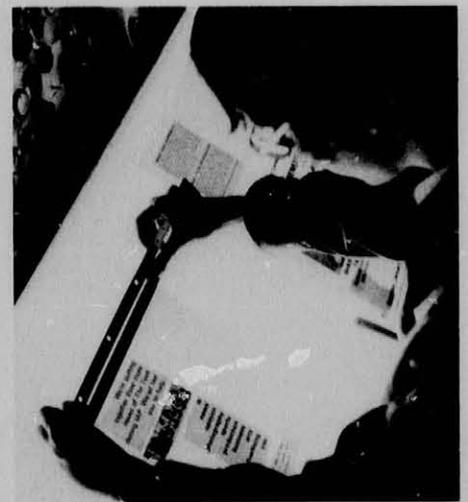
members from the entire M.I.T. community, performs both classical and contemporary choral works.

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 M.I.T. 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.

Student Publications

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



Theatre

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

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

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

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

The M.I.T. Shakespeare Ensemble produces a spring and fall performance each year.



Technology Community Association

Managed by undergraduates, T.C.A. conducts a diversified program of year-round services to the M.I.T. community, including a theatre ticket service, a book exchange, duplicating machines for student use, a print exchange, and annual blood donor and charity drives.

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. M.I.T. 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.

Special Interest Groups

There are more than 80 non-athletic activities and clubs at M.I.T., 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. The M.I.T. Urban Action Program sponsors many major projects in this area, such as the Urban Fellows program, in which students do major community service work for academic credit. Other groups, such as the Interfraternity Conference and Alpha Phi Omega, the national service fraternity, also sponsor active social service programs.

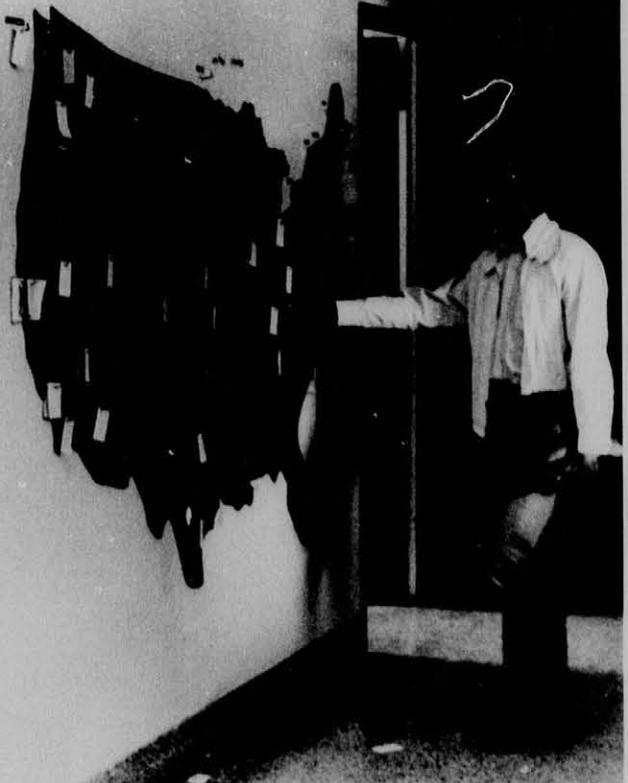
The M.I.T. Black Student Union (B.S.U.) runs a variety of programs in education, culture, and black students' issues. Numerous nationality clubs sponsor programs for foreign students including discussions and social events. The Technology Wives Organization (TWO) is composed of wives of M.I.T. students, both undergraduate and graduate. This social and service organization sponsors a variety of monthly programs.

Dancing of all kinds flourishes at M.I.T. 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. M.I.T. 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, model rocket, railroad clubs, and strategic games.



RIDE WALL
A SERVICE OF
ALPHA PHI OMEGA
ALPHA CHI CHAPTER



Visual Arts Activities

The Exhibitions Office of the Committee on the Visual Arts presents approximately eight major exhibitions a year in the Hayden Gallery, extending occasionally to the Hayden Courtyard and Plaza. Hayden Lobby has been renovated to accommodate monthly exhibitions of prints, drawings, and photographs. Scheduling is geared to a wide range of interests.

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

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

Exhibitions in the Margaret Hutchinson Compton Gallery illustrate the Institute's programs and fields of inquiry. Exhibitions this year included an overview of M.I.T.'s activities in computer development, a show examining publishing at the MIT Press, and an exhibition based on Professor Cyril Stanley Smith's research on the interplay of materials science and art.



Talbot House

Talbot House, an old New England farmhouse, is owned by M.I.T. and administered by the Office of the Dean for Student Affairs. It was a gift by Laurance Rockefeller to be used by the M.I.T. 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 M.I.T. 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 M.I.T. community, ranging in size from 15 to 27 people, may request the use of Talbot House. Many considerations, such as the make-up 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, M.I.T. is essentially a residential university. Of the total undergraduate student body of 4,500, about 2,350 single men and women live in the nine Institute Houses on the campus, and about 1,350 single men and women are in other residence groups including 31 fraternities, the cooperative M.I.T. Student House, and the Women's Independent Living Group.

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.

Student governing groups establish and administer House regulations and maintain acceptable standards of community behavior. Residential student governments also organize a wealth of social, athletic, and intellectual programs for House members. In the Institute House system a house tax determined by the residents of each House is collected by M.I.T. 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 M.I.T. Student House. Freshmen particularly gain from associations with upperclass students

and participation in residence programs. Therefore, all unmarried freshmen who cannot commute daily from their own homes or those of close relatives in the Greater Boston area are required to live "on campus." Exceptions to this "on-campus" living requirement may be made with the approval of the Dean for Student Affairs.



Institute Houses

- Everett Moore Baker House
- Bexley Hall
- Burton-Conner
- East Campus Houses — Munroe, Hayden, Wood, Goodale, Beemis, and Walcott
- French House
- German House
- Frank S. MacGregor House
- Stanley McCormick Hall
- New West Campus Houses — Ballard, Laurence, Coolidge, Desmond
- Random Hall
- Russian House
- Senior Houses — Ware, Atkinson, Runkle, Holman, Nichols, and Crafts
- Spanish House

Rooms in the Institute Houses are engaged for the full academic year. For the year 1979-80, the average rents for the houses range from \$518 to \$762 per term.

Commons Plans

The Commons Plans available for 1979-80 are as follows:

- 1
The 19-Meal Plan, with breakfast, lunch, and dinner Monday through Friday and brunch and dinner on Saturday and Sunday. All meals include unlimited seconds.
- 2
The 15-Meal Plan, which is the same as the 19-Meal Plan but with no Saturday or Sunday meals. All meals include unlimited seconds.
- 3
The Point Plan, designed as a "point system" that can be used to purchase any meals during the term. Point values are 1 for breakfast, 3 for lunch, and 4 for dinner. With the 300 point plan one can purchase all of the weekday dinners during the term.* All meals include unlimited seconds.

Commons contract prices for 1979-80 are listed below.

| | Fall Term | I.A.P. | Spring Term |
|---|-----------|--------|-------------|
| 19-Meal Plan | \$680 | \$136 | \$680 |
| 15-Meal Plan | 526 | 113 | 526 |
| Point Plan (300 points/term) | 329 | 79** | 329 |
| Point Plan (200 points/term) | 255 | 53*** | 255 |
| 4 Three plans which provide no seconds are available in the Student Center | | | |
| | Fall Term | I.A.P. | Spring Term |
| 15-Meal Plan | \$526 | \$113 | \$526 |
| Point Plan (300 points/term) | 329 | 79** | 329 |
| Point Plan (200 points/term) | 255 | 53*** | 255 |



*The 200 Point Plan will purchase 68 percent of the weekday dinners.
 **consists of 72 points.
 ***consists of 48 points.

Off Campus Housing Service

Fraternities

Recognized fraternities at M.I.T. include 29 chapters of national fraternities and two 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 M.I.T. 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 400 freshmen accept invitations to join fraternities. A few upperclassmen, including transfer students, also pledge fraternities at the beginning of each term.

Cooperative Living

The M.I.T. 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 about \$500 a year.

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 M.I.T. Student House are considered members of the Nonresident Student Association (N.R.S.A.). 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 N.R.S.A. The focus for N.R.S.A. 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.

The Women's Independent Living Group

The W.I.L.G. is a non-dormitory living experience 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.

Additional Information

Additional information on undergraduate housing and application procedures is contained in the publication *Undergraduate Residence at M.I.T.* 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 M.I.T. Others may request copies from the Office of the Dean for Student Affairs, Room 7-133, M.I.T., Cambridge, Massachusetts 02139. Information on fraternities also may be obtained by writing to Interfraternity Conference, Room W20-413, M.I.T., Cambridge, Massachusetts 02139. Information on the M.I.T. Student House may be obtained by writing to the President, M.I.T. Student House, 111 Bay State Road, Boston, Massachusetts 02215.

Students who do not live on campus will find help in locating accommodations in the Off Campus Housing Service, Room E18-301, M.I.T. 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, and to advise on many additional aspects of off-campus living. All correspondence should be addressed to Off Campus Housing Service, Box 42, M.I.T. Branch Post Office, Cambridge, Massachusetts 02139.



Graduate Single Student Housing

Approximately 40 percent of the single graduate students reside on the campus in Ashdown House and Tang Hall.

Avery Allen Ashdown House

Ashdown House, located on the corner of Massachusetts Avenue and Memorial Drive directly across from the main buildings of M.I.T., 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 or her 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 social and cultural facilities, is a center of graduate student activities.

Rooms in Ashdown House are rented for a full academic year; rents average \$1,180 per person for the academic year, depending on the type of room.

Ping Yuan Tang Residence Hall

Tang Hall, located on the far western end of the campus, houses 404 single graduate men and women in one-, three-, and four-bedroom apartments. The apartments, unfurnished except for wall-to-wall carpeting, drapes, and kitchen appliances, are rented on a 12-month license to each occupant, beginning September 1. Rents range from \$114 to \$156 per occupant per month and include all utilities except telephone. Community facilities are available in this building, two tennis courts are located next to it, and limited parking is available nearby at a nominal annual fee.

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

Married Student Housing

Residence in married student housing is limited to regular undergraduate and graduate married students registered and attending M.I.T. for at least two terms of each year. (The summer session is considered a term.) Assignments are made on a one-year license-agreement basis beginning September 1 of each year.

A nursery school, with one classroom in Westgate and two in Eastgate, is operated by Technology Nursery School, Inc., a nonprofit student-faculty organization. It is open to children of students residing off-campus, as well as those residing in Westgate and Eastgate. Regular classes are held from September to June; there is also a summer program each year.

Married student housing is managed by the M.I.T. Housing and Food Services Office, Room E18-301, M.I.T. 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 M.I.T. 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 M.I.T. campus is Eastgate, a 30-story apartment tower with 197 family units for married students.

The tower building contains 94 one-bedroom apartments, 84 large one-bedroom apartments, and 19 two-bedroom apartments.



Student Services

Advising and Counseling

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

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

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

The services provided by the Medical Department are described below. Many students consider the members of the psychiatric staff to be among the Institute's most skilled counselors. Most of those who visit them looking for help have found the experience useful.

Medical

The Institute's Medical Department provides a wide range of medical, nursing, and diagnostic services. The Department's principal location is in the Homberg Building (Building 11) off the main corridor where physicians, surgeons, and nurse practitioners see patients and where laboratory and X-ray facilities are located. In addition to specialists in internal medicine and surgery, the Department provides consultants in allergy, dermatology, gynecology, neurology, ophthalmology, orthopedics, otolaryngology, pediatrics, psychiatry, and urology. The Psychiatry Service and the Social Work Service are located in Building 12. An Off-hours Clinic, a Pediatric Service, a Dental Service, and a 28-bed in-patient facility are in the M.I.T. Infirmary, a building situated between McCormick Hall and Baker House. Facilities of the Boston and Cambridge hospitals are used in cases involving major surgery and critical illness. The M.I.T. Infirmary is used for non-critical illness and convalescence when appropriate.

The Student Health Program at M.I.T. consists of medical services on campus and insurance to cover the cost of hospital care off campus. Beginning in the 1979-80 academic year, the cost of on-campus health services will be included in the tuition payment.

All regular and special registered students are entitled to comprehensive health care services at the M.I.T. Medical Department, including consultation with a wide range of specialists, diagnostic studies, and hospitalization in the M.I.T. Infirmary. Charges are made for routine eye examinations, contact lens services, ear piercing, dental care services, obstetrical care, missed appointments, and those surgical procedures and outside diagnostic tests that are generally covered by the student's hospital and accident insurance policy.

Student spouses may use the M.I.T. Medical Department either on a fee-for-service basis or, by paying a comprehensive health fee, receive the same benefits as a student. In 1979-80 this health fee will be \$200 for 12 months' coverage.

The M.I.T. Student Insurance covers hospitalization (other than in the M.I.T. Infirmary) due to accidents or illness at an annual cost of \$130. This portion of the program 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 with an \$850 maternity benefit is \$300. Hospitalization insurance for one or more children may be purchased for \$120.

Annual Rates

| | M.I.T. Medical Department | Insurance for Outside Hospitaliza- tion | Both |
|-----------------------------|---------------------------------|--|-------|
| Student | — | \$130 | — |
| Student Spouse | \$200 | \$300 | \$500 |
| Children, one or more | Fee for service | \$120 | — |

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.

Career Planning and Placement

The Dental Service offers dental treatment for students and their spouses and is available on a fee-for-service basis. The Pediatric Clinic is also available on a fee-for-service basis.

Prior to matriculation, every student, undergraduate or graduate, is required to submit an M.I.T. entrance medical form completed by the student and his or her personal physician, which is mailed to the Assistant Medical Director. This form consists of historical information, immunization record, physical examination, and specified laboratory studies. In addition, freedom from active tuberculosis as evidenced by an intradermal skin test or chest X ray is mandated by public health requirements and cannot be waived.

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

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

More than 300 companies, government agencies, and graduate schools make recruiting visits to the Career Planning and Placement Office each year. These visits are publicized in descriptive notices which are posted throughout the Institute. All bona fide employers (employment agencies are excluded) are given access to the facilities of the Office on equal terms. Their presence gives students a valuable opportunity to discuss employment prospects with different firms.

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 is pleased to assist alumni interested in a change of job or of career.

Preprofessional Advising

The Office of Preprofessional Advising and Education serves students who are interested in preparing for careers in medicine, education, law, and related fields in public administration. The director of the Office serves as the Executive Officer of the Committee on Preprofessional Advising and Education, and acts as liaison between the student and members of the Premedical Advisory Council and the Prelaw Advisory Council. More detailed information concerning these areas may be found in Chapter III of this catalogue.

Rules and Regulations

Conduct and Discipline

M.I.T. 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. Cheating, plagiarism, and other forms of intellectual dishonesty are considered serious offenses against the academic community. Attempts by students to present, as their own, work which they have not performed or to pass any examination by improper means are unacceptable.

Violations by students of M.I.T. regulations such as those governing living groups, parking, and the improper use of M.I.T.'s name, keys, telephones, and so forth, render the offender subject to institutional penalties. The position paper by the Committee on Discipline, "Infractions of the M.I.T. Code and Violations of Law," is available from the Office of the Dean for Student Affairs.

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, M.I.T. 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 M.I.T. 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 pro-

cesses 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.

M.I.T. 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 (C.O.D.) for a hearing.

The C.O.D. 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 M.I.T. 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 M.I.T. 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, suspension, and expulsion are noted on the student's transcript for a specified period. Such notation may be removed upon written application to the Committee under conditions given in the statement referred to above.

Privacy of Student Records

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

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

Review of Records and Challenges to Record Content

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

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

Under the Family Educational Rights and Privacy Act of 1974, an M.I.T. student who has applied for admission, but has not yet attended, another component unit of M.I.T. (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.

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 M.I.T. 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. The *Student Directory*, although it contains certain information listed above, is intended for authorized Institute use only. Mailing lists of members of the Institute student body may not be provided to persons outside of M.I.T. 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 M.I.T. or written by a member of the M.I.T. faculty or staff in connection with admission to educational institutions, employment, or consideration for an honor or recognition. Such a waiver must be in writing and must include adequate identification of the concerned individual, the author of the letter, and the purpose for which the letter is intended. Such waivers must not be required as a condition for admission to, receipt of financial aid from, or receipt of any other services or benefits from any agency or institution. Faculty and staff should take care not to encourage waivers unnecessarily.

Personal Files

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

Statement of Institute Policy

Questions concerning the policy may be directed to the Dean for Student Affairs; Chairman of the Committee on Privacy; or the Vice President for Administration and Personnel, 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 Health, Education and Welfare, Washington, DC 20201.

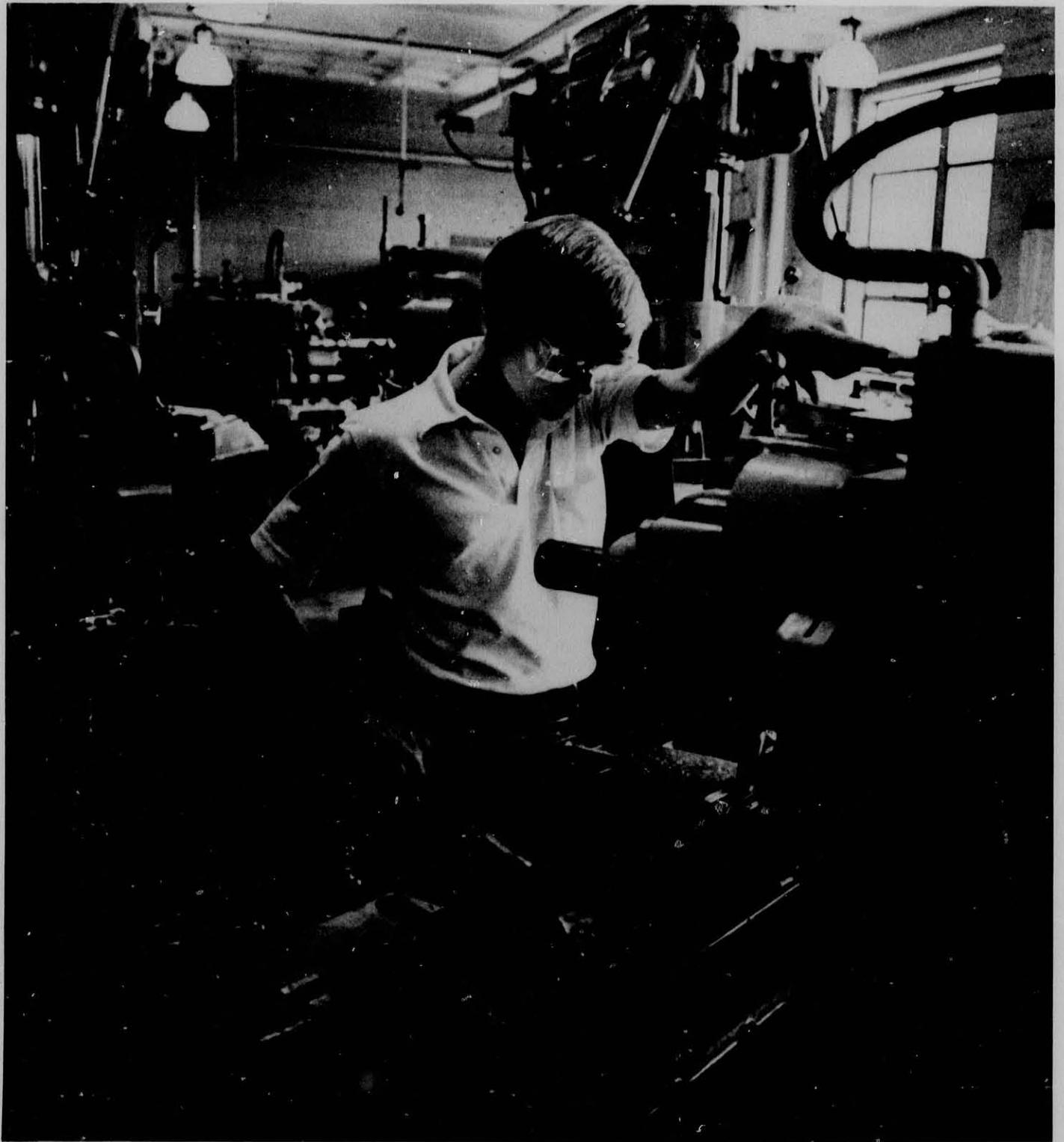
Motor Vehicles

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

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

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







Academic Programs

The undergraduate programs at M.I.T. are designed to help students develop the understanding, maturity, and capabilities needed to meet the challenges of modern society. An M.I.T. education has its roots in science and engineering and its vision in 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 of 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 M.I.T. 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.

M.I.T. 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 and planning, or in the humanities and social sciences. In the first year, most students concentrate on a program centered around 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 routes through 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 their departmental programs.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 always considerable time for students to take elective subjects each year. These elective opportunities allow students to follow special interests or to deepen and broaden their educational background. Alternatively, a student may use elective time to prepare for advanced study in a professional field such as medicine or law; for graduate study in an area in which M.I.T. gives no undergraduate degree, such as meteorology or psychology; or for advanced study in an interdepartmental field.

For most students, the program for the Bachelor of Science degree 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.

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.



The Freshman Year

During the first year at M.I.T., most students take a program which includes among its subjects mathematics, physics, chemistry or biology, and humanities. There are 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 (E.S.G.). M.I.T. provides these different modes to allow students to study in a manner best suited to their interests, learning styles, and preparation.

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

For students entering with only the preparation implied by the entrance requirements, a typical program for the first year would include two terms of physics, two terms of calculus, two terms of humanities, one term of chemistry or biology, plus one or more elective subjects perhaps including an undergraduate seminar. Some freshmen also elect to become involved in the Undergraduate Research Opportunities Program (described later in this section). 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.



Concourse Program

A student who chooses the Concourse Program becomes a member of a group of 35 to 50 freshmen working with a team of five to seven faculty members in an integrative program of study which emphasizes interactions of ideas and methods from engineering, science, and humanities. Concourse has operated as an alternative program for freshmen since 1971-72, and has been made a regular part of the M.I.T. curriculum. The Program's central focus is an exploration of the unity and conflict of humanistic and technical viewpoints and ideas. The general theme is "Man, Machine, and Meaning," a study designed to treat the mutual relevance of freshman calculus, physics, chemistry, biology, and humanities in the context of topics such as information theory, computation, physiological psychology, perception, the structure of history, the uses and construction of models, and the mind-body problem.

The Concourse faculty members, representing different professional disciplines, collaborate closely in the planning and teaching of the curriculum, which embraces 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 of the Institute departments.

Concourse operates under the aegis of the Department of Electrical Engineering and Computer Science. The program supervisors for 1979-80 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, M.I.T., Cambridge, Massachusetts 02139.

Experimental Study Group (E.S.G.)

The Experimental Study Group is a self-paced academic program for freshmen and sophomores at M.I.T. The E.S.G. community consists of approximately 40 freshmen, 20 sophomores, 10 staff members, and a number of upperclass students formerly enrolled in E.S.G., who believe it is important for students to have the opportunity to take responsibility for their own education. E.S.G. allows freshmen and sophomores to work toward this goal within a supportive and informal environment.

The day-to-day life of E.S.G. students is in some ways similar to that of students in the regular curriculum: for example, many E.S.G. students organize their programs to include much, if not all, of

the subject material of the General Institute Requirements which most students in the regular curriculum usually cover in their first year. However, instead of attending lectures and recitation sections, E.S.G. students participate in small seminars, work individually with staff or upperclass tutors, or work independently at their own pace on subjects of their choice. Students have the opportunity to approach their studies in a way that is largely free of the constraints on time, learning methods, and subject material that the regular curriculum imposes.

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

Staff at E.S.G. are drawn from interested members of the Departments of Physics, Mathematics, Humanities, and Chemistry at M.I.T., and range in background from graduate students to full professors. They are supplemented by approximately 15 upperclass tutors who have been freshmen in E.S.G.

E.S.G. is more than just an academic program — it is also a community where students and staff use the E.S.G. facilities (including a computer terminal,

kitchen, and library) to socialize and share information. E.S.G. does not draw sharp lines between academic and non-academic work, or between upper-classmen, freshmen, and staff. In such an atmosphere, students are able to regard staff as colleagues and friends rather than simply as teachers.

More information may be found in the *Freshman Handbook* or by writing to the Experimental Study Group, Room 24-612, M.I.T., 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 M.I.T., 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. Distributed also to the freshman advisors, the *Handbook* is a primary reference document for the first year.

Freshman Grading

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

For most freshmen a normal subject load consists of four or five subjects totaling 45-54 units of credit (nominally equivalent to that many hours spent per week in class and study time). Freshmen are limited, however, to 60 units of credit in the fall and 63 in the spring. Credit earned for passing an Advanced Standing Examination will be counted toward this credit limit unless such an exam is taken promptly during the first examination period of the term of entrance. An Advanced Standing Examination taken by a freshman at any other time will be counted toward the credit limit for the term in which it is taken. R.O.T.C. subjects totaling more than four units will also be counted toward the credit limit.

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. Experience shows that a substantial percentage of those who do enter with a decided preference 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 students this consideration of available possibilities will reinforce existing convictions, while for others it will open up new avenues of interest.

Faculty members recognize that the most effective educational ally they can have is the creative interest of students in the material they are studying. The faculty believes, therefore, that the primary aim of students in choosing a Course of study should be to find that area which holds maximum challenge and rewarding satisfaction for them.

Each of the undergraduate Courses combines the study of basic principles with the study of their application in particular situations. From the interest aroused by this combination of principles and applications studied in depth in a particular Course comes the motivation for the continuing learning which leads to professional competence.

Students usually choose a Course at the end of the first year though they need not do so until the end of their second year. There is sufficient overlap and flexibility so that a change in Course can be made with relative ease in the second year. Thus, even though a student has doubts about which of two Courses to choose, it is usually wise to enroll in one of them for a year to get the true flavor of being an undergraduate in that department.

Each student entering M.I.T. 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 which are relevant to the Courses under consideration. It is important that these subjects be selected with care because each department has different recommendations for Science Distribution Subjects.

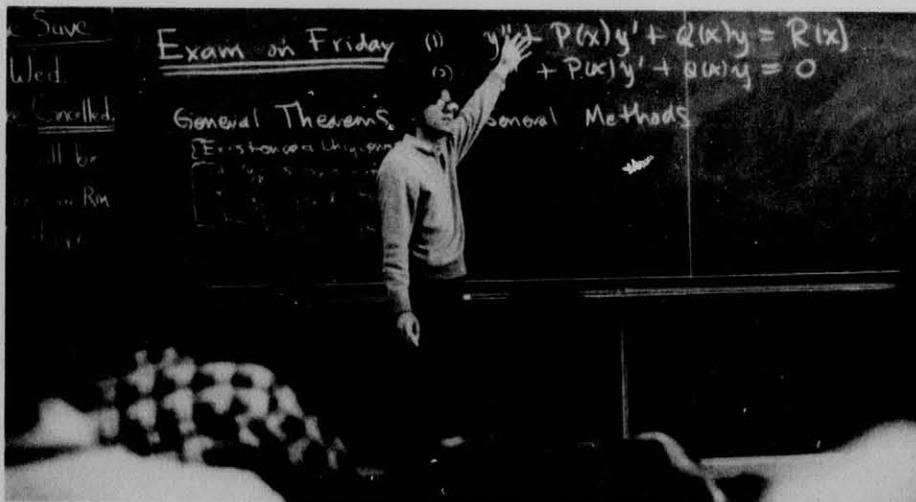
Electives

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

Electives can be used for several different purposes. For example, many students who are undecided about their eventual program of study will use part or all of their elective time to get more information about the various departments or fields they are considering. Other students who are more certain of their professional goals will use elective time to explore areas of secondary interest. Still others will choose to begin work on departmental or Institute requirements, deferring subjects of a more supplemental nature until a later year. The study of a language may be started or continued; most of the R.O.T.C. programs are normally begun as electives in the first year. Before deciding which electives to take, most freshmen will find it helpful to ask themselves which of these uses of electives best suit their individual needs.

Departmental Programs

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



Undergraduate Research Opportunities Program (UROP)

UROP invites undergraduates to participate with M.I.T. faculty and staff members in a wide range of research and project activities both on and off campus.

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; trying a hand at initiating a project; and establishing a focus for educational experiences. These are some of the returns to expect. 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* published in the fall. 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 will be required in order to achieve a satisfying collaboration. Such a collaboration takes mutual negotiation by all parties. Once a commitment to an undertaking is made, students are expected to conduct themselves responsibly in the enterprise. The UROP experience will be unlike any other; its benefits and rewards are great, but expectations and standards are commensurately demanding. Call or visit the UROP office at any time, Room 20B-141, (617) 253-5049; advice, consolation, or congratulations await.

Undergraduate Seminars

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

Most seminars carry six units of pass/fail credit and the class size is generally restricted to a small group. Titles of seminars and their descriptions are printed in the *Freshman Handbook* for fall term subjects and in the *Undergraduate Seminar Booklet* for spring term subjects. These publications are available from the Undergraduate Seminar Office, Room 7-105.



Preprofessional Advising and Education

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

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

Premedical Education

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

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

Education Studies

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

Prelaw Education

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

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

Full-time Study at Other Universities

Junior Year Abroad

Many opportunities are open for study in foreign countries through participation in one of the excellent programs administered by nonprofit educational organizations or through an individually arranged program. Plans for study abroad should be worked out by each student with his or her Faculty Advisor and the Dean for Student Affairs Office. Although almost any field can be studied abroad, it is generally advisable to take most professional subjects at M.I.T. 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 this 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 M.I.T. tuition, official M.I.T. registration as an "undergraduate on foreign study," and thereby student aid status and dormitory priority. Total costs including travel have often proven 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 M.I.T. degree, upon successful completion of their studies and subsequent return to M.I.T.

Domestic Year Away

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

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

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

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

Those students interested in these programs should consult the Dean for Student Affairs Office.

Wellesley College

The Wellesley-M.I.T. cross-registration program for undergraduates was initiated in the fall of 1968. The purpose of the program is to extend and diversify the educational programs now available to students of both institutions. Under this program, M.I.T. students may substitute subjects taken at Wellesley for M.I.T. subjects. Details on the exchange, including the rules governing the substitution of required subjects, are provided in a publication entitled *Wellesley-M.I.T. Exchange: Guide for M.I.T. Students*, and in Chapter I of the *Courses and Degree Programs* issue of the M.I.T. Bulletin.

New issues of the *Guide* are available to all students each term: in April for the fall term, and in December for the spring term. Copies of the most recent *Guide* are available in the Information Center, Room 7-121, (617) 253-4795, and the Wellesley-M.I.T. Exchange Office, Room 7-108, (617) 253-1668. Bus transportation between Wellesley and M.I.T. for academic purposes is provided to cross-registered students without cost.

Harvard University

A limited number of M.I.T. undergraduates are permitted to take one or two subjects at Harvard University (Faculty of Arts and Sciences) for degree credit and at no extra charge, provided the subjects are not offered regularly at M.I.T. Except in rare instances, applicants must be third- or fourth-year students with excellent academic records. Arrangements are made through the Office of the Dean of the School of Humanities and Social Science.

General Academic Information

Registration

Each student is required to fill in registration forms and present them to the Registrar on a date before the opening of each term specified in registration instructions. First-term registration material for continuing students should be picked up in May. Second-term registration material should be picked up in December. An individual who has not completed the registration procedures by the start of the sixth week of a term will be considered withdrawn.

It is not usually necessary to restrict the number of students admitted to a subject. If an unexpectedly large number apply for an elective subject, however, it may be necessary to limit enrollment for the term to a number commensurate with the available staff and educational facilities.

A subject may not be added to a student's registration after the fifth week of a term.

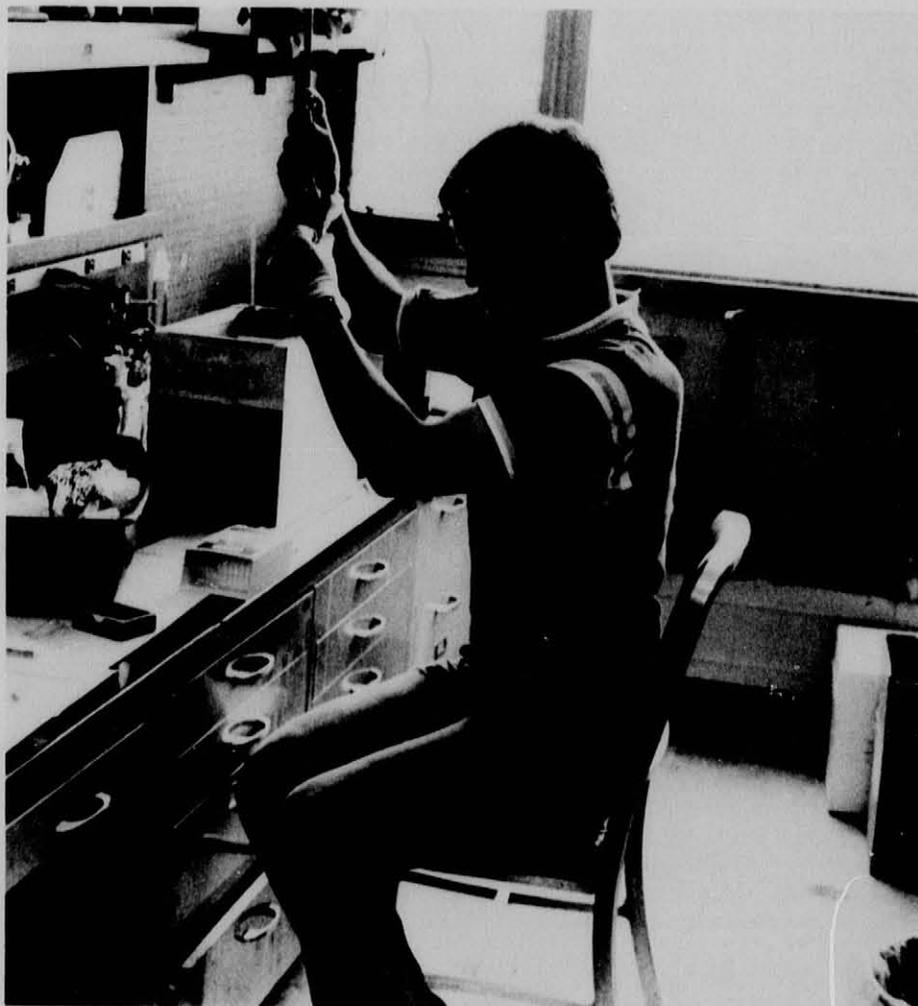
In the last three weeks of a regular term, registration in any subject may not be canceled by a student without the additional approval of the appropriate faculty committee. The final date for canceling subjects without this approval will be posted outside the Information Center, Room 7-121.

An undergraduate may designate a total of two elective subjects to be graded on a pass/fail basis during the student's third and fourth years. These subjects cannot be used to fulfill either an Institute or a departmental requirement; they must be designated and the Registrar notified before the end of the fifth week of the term.

Every student is assigned to a member of the faculty who serves as his or her academic advisor. Each student's program must be approved by this faculty member, and changes may be made only with his or her approval. Freshmen are assigned to advisors by the Office of Freshman Advising. Sophomores who have not selected a department are assigned to undesignated sophomore advisors. Other undergraduates enrolled in a department have a faculty counselor from that department.

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 field-work; 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 51 units per term. However, if approved by his or her faculty counselor, a student may follow a program leading to an S.B. degree in either more or less than eight terms.

Final Examinations

Final examinations are held at the end of each term; the schedule is issued about a month before the examination period. Each student is held responsible for obtaining an examination schedule at the Information Center, Room 7-121, for reporting any conflicts in examinations 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.

Examinations for Advanced Standing

Undergraduates may take examinations for advanced standing during the scheduled examination periods, provided that they have never been registered for or attended class in the subject concerned. Notice of intention must be filed with the Registrar and must be submitted at least three weeks before the day of the first scheduled examination of the examination period. An Advanced Standing Examination is given only after the faculty member in charge of the subject has given approval. The faculty member may require evidence of competence in addition to the Examination if the subject normally involves measures of student performance which are qualitatively different from the Examination. A passing grade entitles a student to full credit for the subject. A failing grade will appear on the permanent record except for a freshman, for whom a failing grade will appear only on the internal record.

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, at a cost of \$2 per copy.

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 counselors 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 counselors should take responsibility for examining the entire program in the same way as they would for a candidate for a single S.B. degree.

Simultaneous Award of Bachelor's and Master's Degrees

Any department of the Institute may admit to the Graduate School, as a candidate for the Master's degree, an undergraduate student of the Institute who is also regularly enrolled as a candidate for the Bachelor's degree. Students must register as graduate students for at least one regular (not summer) term to be recommended for the simultaneous award of the Bachelor's and Master's degrees. The thesis submitted for the Master's degree may also be accepted by the department in fulfillment of the undergraduate thesis requirement, if any. A student wishing to pursue this type of academic program must apply for graduate admission in the usual way, as well as present a petition approved by the student's undergraduate Faculty Counselor and the Graduate Registration Officer.

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 the 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 counselor. The Departmental Program and the total number of units required are shown for each Course in Chapter VI.

The 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 Bachelor of Science, students must have satisfactorily completed the following units:

| General Institute Requirements | Total Units |
|--|------------------------|
| Science Requirement | 60 |
| Chemistry/Biology (3.091 or 5.40 or 5.41 or 5.60 or 7.01) | 12 |
| Physics (8.01 or 8.011 or 8.012 or 8.013J and 8.02 or 8.021 or 8.022 or 8.023J) | 24 |
| Calculus (18.001 or 18.01 or 18.012 and 18.002 or 18.02 or 18.022) | 24 |
| Humanities, Arts, and Social Sciences Requirement | 72 |
| Eight subjects totaling at least | |
| Science Distribution and Laboratory Requirements | |
| Science Distribution Subjects | 36 ¹ |
| Laboratory Subjects | 12 ² |
| Departmental Program | |
| As specified for each Course, a minimum of | 180 ^{3,4} |
| Total units required for the S.B. Degree, at least | 360⁴ |

Science Requirement

M.I.T. 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 M.I.T. 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.

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 R.O.T.C. subjects, if elected.

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-M.I.T. 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 Calculus (two versions); and 18.01-18.02 Calculus (four versions with variations). Both 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 — 18.01-18.02 has been using *Calculus and Analytic Geometry* by Professor Thomas); 3) structure (both subjects are lecture-recitation; 18.001 and 18.002 have three one-hour exams, while 18.01 and 18.02 have a flexible examination structure including "self-paced" repeatable exams); and 4) 18.001-18.002 is taught by the faculty in the Applied Mathematics group while 18.01-18.02 is taught by the rest of the mathematics faculty.

In addition, there is a third 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.

Humanities, Arts, and Social Sciences Requirement

M.I.T. 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 the potentials, 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. The Humanities, Arts, and Social Sciences subject listing contains a mixture of nine- and 12-unit subjects. It is possible for students to satisfy the Requirement with eight nine-unit subjects in all fields except foreign languages.

2

Distribution At least three of the eight subjects must be chosen from a specially designated list of humanistic subjects. The three subjects are to be selected from three separate Fields from the list given below and may be taken at any stage appropriate to the rest of the student's program.

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, depending on the Field. 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:

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

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

Provisional programs for Concentration also are available in:

American Studies
Russian Studies

For information about these programs and procedures for registration, see the descriptions elsewhere in this catalogue under the Department of Humanities.

Distribution Subjects

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

All of these subjects, with the exception of the foreign language subjects and the following music subjects (21.613, 21.651, 21.660, 21.661, 21.680, 21.683) 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, so as to begin satisfying the Institute Requirement and so as to sample the offerings in fields that might later be selected for more intensive study.

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

The following is the final list of **Humanities Distribution Subjects**. It supersedes all other HUM-D information.

American Studies

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

STS 302 Culture and Technology in America: The 19th Century

Anthropology and Archaeology

21.50 An Introduction to Anthropology

21.501 Understanding Other Cultures

21.502 Issues and Ideas in Anthropology

21.503 Approaches to Archaeology

Creative Writing

21.728 Writing: Meaning and Expression

21.737 Writing and Reading Short Stories

21.738 Writing and Reading the Essay

Foreign Languages

21.213 French III

21.214 French IV

21.243 German III

21.244 German IV

21.272 Classical Greek II

21.283 Russian III

21.284 & 21.285 Russian IIIA and IIIB (1 HUM-D for both)

21.286 Russian IV

21.297 Spanish III

21.298 Spanish IV

Wellesley Italian 202 Intermediate Italian

History

21.350 The Ancient World I: Ancient Near East and Greece

21.351 The Ancient World II: Rome

21.352 The Middle Ages I

21.353 The Middle Ages II

21.356 Modern World History I

21.357 Modern World History II

21.367 Ideas of Progress

21.368 Darwinism and Culture

21.376 Imperial and Revolutionary Russia: Culture and Politics

21.383 Revolution in the 20th Century

21.390 American History to 1865

21.391 American History since 1865

21.410 American Intellectual History: The Classical Age

21.411 American Intellectual History: The Modern Age

21.418 The American South: Portrait in Black and White I

21.450 The History of Africa

21.451J Nationalism and Nation Building in 20th Century Africa [17.54J]

Wellesley History 320 Social History of American Law: The Formative Era

History of Art and Architecture

4.601 Topical Studies in the History and Theory of Art

4.602 Introduction to the History and Theory of Architecture

4.636 Introduction to Renaissance Architecture

4.651 Modern Art from Cubism to the Present

Wellesley Art 215 European Art to the Renaissance

Wellesley Art 216 European Art from the Renaissance through the Nineteenth Century

Linguistics

24.900J The Study of Language [21.140J]

Literature

A. Subjects Taught in English

21.001 Literature I

21.003 Introduction to Fiction

21.004 Major Poets, English and American

21.005 Introduction to Drama

21.006 Introduction to American Literature

21.007 Forms of Western Narrative

21.009 Shakespeare

21.021 Comedy

21.022 Tragedy

21.031 The Film Experience

21.071 Major English Novels

21.079 Modern Russian Literature and Its Historical Structure

21.101 The American Novel

21.102 American Poetry

21.107 Black American Literature

21.325 Introduction to European Fictional Modes

21.327 French Literature in Translation: The Search for Identity in an Alien World

21.329 German Literature in Translation

21.331 Civilization and Literature of Slavic Nations

21.332 Russian Novel of the 19th Century

Wellesley English 227 Milton

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

^{1, 2} **B. Subjects Taught in a Foreign Language**

| | |
|-------------------|---|
| 21.218 | French Civilization I |
| 21.219 | French Civilization II |
| 21.220 | Introduction to French Literature |
| 21.221 | Introduction to French Poetry |
| 21.229 | The Adolescent in French Literature |
| 21.231 | French Romanticism |
| 21.248 | German Cultural and Social History I |
| 21.249 | German Cultural and Social History II |
| 21.251 | Introduction to Literary Forms in German |
| 21.252 | Introduction to German Poetry |
| 21.259 | Modern German Drama (1750 to the Present) |
| 21.288 | Russian Culture and Civilization |
| 21.304 | Contemporary Hispanic Literature |
| 21.305 | The Novel in Spain |
| 21.306 | Literature and Social Conflict: Perspectives on Spain, 1820-present |
| Music | |
| 21.60 | Introduction to Music |
| 21.613 | The Symphony |
| 21.651 | Haydn, Mozart, and Beethoven |
| 21.660 | Music in the Romantic Period |
| 21.661 | Beethoven |
| 21.680 | The Opera |
| 21.683 | Musical Traditions in America |
| Philosophy | |
| 24.01 | Contemporary Moral Issues |
| 24.02 | Philosophy of Art: Classic and Contemporary |
| 24.03 | Logic, Language and Values |
| 24.04 | Problems of Philosophy |
| 24.05 | Science and Philosophy |
| 24.07 | Classics in the History of Philosophy |
| 24.09 | Freedom and Authority |

Political Science

| | |
|--------|---|
| 17.03J | Value, Choice and Risk in Modern Technology [STS 401J] |
| 17.05 | The Quest for Equality and Development in Third World Countries |
| 17.07 | Aggression, War and Civilization |
| 17.08 | American Politics and Social Change |
| 17.09J | Politics and Public Policy [11.007J] |
| 17.13 | Socialism |
| 17.14 | Revolution and the Theory of Politics |
| 17.18 | Introduction to Political Theory: Individual and Community |
| 17.19 | Modern Political Theory: Democracy and Freedom |
| 17.21 | Introduction to the American Political Process |
| 17.53 | Political and Economic Development of Tropical Africa |
| 17.57 | American Foreign Policy in a Changing World |

Religious Studies

| | |
|---|--|
| Wellesley Religion 107 Crises of Belief in Modern Religion | |
| Wellesley Religion 108 Introduction to Asian Religions | |

Science, Technology, and Society

| | |
|---------|--|
| STS 200 | Science from the Renaissance through the Enlightenment |
| STS 201 | History of 19th- and 20th-Century Science |
| STS 210 | American Science since the 1930s |
| STS 240 | The Work of the Scientist, and Its Sources |
| STS 300 | History of Technology in America I: 1787-1876 |
| STS 301 | History of Technology in America II: 1876-the present |

| | |
|--|--|
| STS 400 | Science, Technology, and Society: Problems of Innovation |
| STS 500 | Professions |
| STS 600 | Technological Society and the Recovery of "The Natural" |
| Urban Studies | |
| 11.005 | Urban Social Structure and Process |
| 11.006J | Politics, Planning and Urban Policy [17.32J] |
| 11.013J | American Urban History [21.432J] |
| 11.018 | The Writer and the City |
| 11.165 | Law and Public Policy |
| Visual Arts and Design | |
| 4.802 | Visual Form and Expression |
| 4.901 | Creative Seeing |
| The Western Tradition: Issues and Texts | |
| 21.710 | The Bible and Western Tradition |
| 21.711 | The Greeks |
| 21.713 | Major Medieval Texts |
| 21.714 | The Renaissance in the North and the Reformation |
| 21.715 | The Enlightenment: The Isolated Individual |
| 21.716 | Romanticism |
| 21.717 | The Modern Period: 1900-1970 |
| Interdisciplinary Subjects | |
| SEM 212 | A Reading Course in the Role of Education in Society |
| Wellesley Extradepartmental 211 Dante in English | |
| Wellesley Extradepartmental 247 Arthurian Legends | |

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.

Elective Subjects

The remainder of the eight-subject Requirement, above and beyond Distribution and Concentration, may be fulfilled by the necessary number of 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. Appropriate subjects taken by cross-registration at Harvard University or Wellesley College may also be counted toward the Requirement; however, a petition must be submitted.

Graduate Subjects (designated "Year: G") may be used to satisfy the Requirement only by petition, which must include the instructor's signature.

Undergraduate Research and Reading Seminars and other similar subjects whose content is not specified in the catalogue description of the subject may be used to satisfy the Requirement only by petition, which must include the instructor's signature and a description of the subject 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 | 1Brain Science and Behavior |
| 9.04 | Sensory Neurophysiology |
| 9.35 | 1Perception: Mechanisms and Models |

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

Economics

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

Political Science

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|-------|------------------------------|
| 17.01 | Political Science 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 in fulfillment of the Institute Requirement:

Architecture

All undergraduate subjects of at least 9 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 4.681
- B) 4.742J Shaping the Urban Environment [11.132J]
- C) 4.801 through 4.875
- D) 4.901 through 4.992

Urban Studies and Planning

The following subjects are eligible toward the Requirement:

| | |
|---------|--|
| 11.005 | Urban Social Structure and Process |
| 11.006J | Politics, Planning and Urban Policy [17.32J] |
| 11.007J | Politics and Public Policy [17.09J] |
| 11.008J | Urban Economics [14.51J] |
| 11.009 | Technology and the City |
| 11.010 | Community Sociology |
| 11.013J | American Urban History [21.412J] |

| | |
|---------|--|
| 11.014J | American Urban History [21.413J] |
| 11.018 | The Writer and the City |
| 11.019J | Modern Social Movements and Mass Phenomena in Historical Perspective [21.438J] |
| 11.121 | Introduction to Environmental Issues |
| 11.122 | Environmental Policy and Regulation |
| 11.131 | The Urban Neighborhood |
| 11.132J | Shaping the Urban Environment [4.742J] |
| 11.141 | Urban and Regional Planning in Developing Countries |
| 11.142 | Introduction to Community Development |
| 11.146 | The Political Economy of Urban Poverty |
| 11.163 | Institutions and Communities |
| 11.166 | Legal Institutions and Social Change |
| 11.167 | Seminar on Legal Institutions |
| 11.197J | State and Local Government Internships [17.26J] |
| 1.01J | Ethics and Technocrats [STS 412J] |
| 1.014J | Engineering Aspects of Economic Analysis [14.014J] |

3

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

| | |
|----------|--|
| 3.17J | Understanding the Discovery Process — An Historical Approach [STS 231J] |
| 3.80J | Comparative Ancient Technologies [21.543J] |
| 3.81J | Art, Materials and Culture [21.541J] |
| 8.206J | Seminar in Public Interest Science [STS 413J] |
| 20.024J | Nutrition, National Development and Planning [17.48J] |
| 22.003J | In Pursuit of Arms Control: Analysis of the Past and Choices for the Future [17.45J] |
| SRE 104J | Developmental Psychology [9.89J] |

Science Distribution Requirement

The Science Distribution Requirement of 36 units is met by taking subjects especially designed for this purpose. Available subjects are listed below. To fulfill the requirement, students must study subjects totaling 36 units of which no more than 12 units may be taken in subjects offered by a student's own department. Subjects designated "J" which are cooperatively taught by faculty members in the student's own department also fall under the 12-unit departmental limitation. If 5.41 or 5.60 or 7.01 is used to satisfy the General Institute Requirement in Chemistry/Biology, then it cannot be used for the Science Distribution Requirement. The combination of subjects chosen must be approved by the student's Faculty Counselor. 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 | Information Systems (3-0-9) | 2.901J | Introduction to Polymer Science and Engineering (3-0-9) |
| 1.02J | Materials of Construction (3-0-9) | 3.00 | Thermodynamics of Materials (4-0-8) |
| 1.07 | Analysis of Uncertainty (3-1-8) | 3.05 | Computer Models of Physical and Engineering Systems I (3-3-6) |
| 1.08 | Introduction to Engineering Geology (3-3-6) | 3.061J | Introduction to Polymer Science and Engineering (3-0-9) |
| 1.11J | Introduction to Systems Analysis (3-0-9) | 3.07 | Introduction to Ceramics (4-0-8) |
| 1.13 | Behavior of Physical Systems (5-0-7) | 3.091 | Introduction to Solid-State Chemistry (5-0-7) |
| 1.16 | Computer Models of Physical and Engineering Systems I (3-3-6) | 3.093 | Magnetics (3-0-9) |
| 1.86 | Element Cycles in the Environment (2-0-4) | 3.10 | Chemical Physics of Materials (3-0-5) |
| 2.01 | Mechanics of Solids (4-0-8) | 3.11 | Mechanics of Materials I (4-0-8) |
| 2.02 | Introduction to System Dynamics (4-0-8) | 3.141 | Engineering Materials (3-3-6) |
| 2.101 | Computer Models of Physical and Engineering Systems I (3-3-6) | 3.143J | Materials of Construction (3-0-9) |
| 2.131J | Environmental Ecology I (2-1-6) | 3.145J | Introduction to Systems Analysis (3-0-9) |
| 2.132J | Environmental Ecology II (3-0-6) | 4.30 | Basic Structural Theory (3-3-6) |
| 2.19J | Introduction to Systems Analysis (3-0-9) | 4.43 | Environmental Control — Acoustics (4-0-4) |
| 2.20 | Fluid Mechanics (4-0-8) | 5.121J | Planetary Physics and Chemistry I (3-0-9) |
| 2.40 | Thermodynamics (4-0-8) | 5.122J | Planetary Physics and Chemistry II (3-0-9) |
| | | 5.40 | General Chemistry (4-0-8) |
| | | 5.41 | Introduction to Structure, Bonding and Mechanism (5-0-7) |
| | | 5.60 | Chemical Thermodynamics (4-0-8) |
| | | 5.61 | Physical Chemistry (4-0-8) |

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

| | | | | | |
|--------|---|---------|---|---------|---|
| 6.002 | Circuits and Electronics (4-2-9) | 11.004 | Models and the Metropolis (3-0-9) | 18.03 | Differential Equations (4-0-8) |
| 6.018 | Statistical Mechanics and Thermodynamics (4-0-8) | 11.123 | Environmental Quality Assessment (3-2-7) | 18.031 | Introduction to Linear Algebra and Differential Equations (4-0-8) |
| 6.030 | Introduction to Computation (4-3-5) | 12.00 | Evolution of the Earth (2-0-4) | 18.05 | Introduction to Probability and Statistics (3-0-9) |
| 6.034 | Artificial Intelligence (4-0-8) | 12.002 | The Earth and the Planets (2-0-4) | 18.055J | Biostatistics I (3-0-9) |
| 6.041 | Probabilistic Systems Analysis (4-0-8) | 12.003J | Environmental Ecology I (2-1-6) | 18.057 | Introduction to Applied Statistics (3-2-7) |
| 6.071 | Introduction to Electronics (4-2-6) | 12.004J | Environmental Ecology II (3-0-6) | 18.061 | Introduction to Algebraic Systems (4-0-8) |
| 6.524J | General Physiology (3-0-9) | 12.01 | Geological Processes, Features and History (3-4-5) | 18.313 | Probability (3-0-9) |
| 7.01 | General Biology (4-0-8) | 12.02 | Physics and Chemistry of Minerals and Rocks (3-4-5) | 18.440 | Probability and Random Variables (4-0-8) |
| 7.05 | General Biochemistry (5-0-7) | 12.111 | Survey of Astronomy I (2-0-4) | 18.700 | Linear Algebra (3-0-9) |
| 7.51J | General Physiology (3-0-9) | 12.112 | Survey of Astronomy II (2-0-4) | 18.703 | Modern Algebra (3-0-9) |
| 8.03 | Physics III (5-0-7) | 12.113 | Astronomy I (3-0-9) | 18.710 | Abstract Linear Algebra (3-0-9) |
| 8.04 | Statistical and Quantum Physics I (5-0-7) | 12.114 | Astronomy II (3-0-9) | 19.02 | Descriptive Meteorology (2-2-5) |
| 8.20 | Introduction to Special Relativity (2-0-7) | 12.115J | Dynamical Astronomy (3-0-9) | 19.83 | Physical Oceanography (3-0-9) |
| 8.201J | Statistical and Biological Physics (5-0-7) | 12.131J | Planetary Physics and Chemistry I (3-0-9) | 20.021 | Physiological and Nutritional Biochemistry (4-0-8) |
| 8.211 | Introduction to Quantum Physics (5-0-7) | 12.132J | Planetary Physics and Chemistry II (3-0-9) | 20.113J | Biostatistics I (3-0-9) |
| 8.244 | Modern Optics (3-0-9) | 12.21 | Physics of the Ocean (3-0-9) | 22.006 | Computer Models of Physical and Engineering Systems I (3-3-6) |
| 8.263 | Physics of Fluids (3-0-9) | 13.001 | Introduction to Marine Applied Mechanics (4-0-8) | 22.02 | Introduction to Applied Nuclear Physics (3-0-9) |
| 8.282 | Introduction to Astrophysics and Astronomy (3-0-9) | 13.013J | Water, Air and Interface Vehicles (3-0-9) | 22.03 | Engineering Design of Nuclear Power Systems (3-0-9) |
| 8.291J | Planetary Physics and Chemistry I (3-0-9) | 13.014 | The Oceans (3-0-9) | 22.04 | Radiation Effects and Uses (2-1-9) |
| 8.292J | Planetary Physics and Chemistry II (3-0-9) | 13.51 | Computer Models of Physical and Engineering Systems I (3-3-6) | HST | Statistical and Biological Physics (5-0-7) |
| 8.293J | Dynamical Astronomy (3-0-9) | 14.30 | Introduction to Statistical Method in Economics (4-0-8) | NS51J | Water, Air and Interface Vehicles (3-0-9) |
| 10.10 | Process Synthesis (3-0-6) | 15.053 | Introduction to Management Science (4-0-8) | | |
| 10.11 | Computer Models of Physical and Engineering Systems I (3-3-6) | 15.852 | Principles of Dynamic Systems I (3-0-9) | | |
| 10.13 | Mass and Energy Processing (4-0-8) | 16.001 | Unified Engineering I (4-3-5) | | |
| 10.17 | Air Pollution Fundamentals (2-0-4) | 16.008 | Computer Models of Physical and Engineering Systems I (3-3-6) | | |
| | | 16.811J | Introduction to Systems Analysis (3-0-9) | | |

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

Laboratory Requirement

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

A typical Laboratory Subject offers the student an opportunity to set up and carry out experiments dealing with phenomena of the natural world. Under faculty supervision the student plays a substantial role in planning

- a) the design of the experiment
- b) the selection of the measurement technique
- 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 M.I.T., 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 Systems Laboratory Projects (0-3-3) | 6.163 | Strobe Project Laboratory (2-8-2) |
| 1.103 | Geotechnical Engineering Laboratory (0-3-3) | 6.164 | Electron Optical Design (2-8-2) |
| 1.104 | Materials of Construction Laboratory (0-3-3) | 6.182 | Psychoacoustics Project Laboratory (3-4-5) |
| 1.105J | Structural Engineering Laboratory (0-3-3) | 7.011 | Introduction to Experimental Biology (2-8-4) |
| 1.106 | Laboratory Projects of Aquatic Systems: Physical Aspects (0-3-3) | 7.021 | Experimental Immunology (2-16-6) |
| 1.107 | Laboratory Projects in Aquatic Systems: Chemical and Biological Aspects (2-6-4) | 7.031 | Experimental Microbial Genetics (2-16-6) |
| 2.671 | ¹ Measurement and Instrumentation (2-3-4) | 7.041 | Experimental Cell Biology (2-16-6) |
| 2.672 | Project Laboratory (1-3-2) | 7.051 | Experimental Biochemistry (2-16-6) |
| 2.86 | ¹ Manufacturing Processes Laboratory (3-3-3) | 8.11 | Physics Project Laboratory I (1-6-5) |
| 3.081 | Materials Laboratory I (1-6-5) | 8.12 | Physics Project Laboratory II (1-6-5) |
| 3.083J | Semiconductor Devices Project Laboratory (2-8-2) | 9.50 | Research in Psychology (2-8-2) |
| 4.071J | Design with Microclimate (3-6-3) | 11.011 | Laboratory in Research Methods (2-5-5) |
| 4.315J | Structural Engineering Laboratory (0-3-3) | 11.185J | Design with Microclimate (3-6-3) |
| 5.310 | Laboratory Chemistry (2-8-2) | 13.901 | Ocean Engineering Laboratory I (1-5-0) |
| 5.311 | Introductory Chemical Experimentation (2-8-2) | 13.902 | Ocean Engineering Laboratory II (1-5-0) |
| 6.101 | Introductory Electronics Laboratory (3-8-1) | 14.31 | Econometrics (3-4-5) |
| 6.111 | Introductory Digital Systems Laboratory (3-7-2) | 15.301 | Managerial Psychology Laboratory (2-6-4) |
| 6.112 | Digital Systems Project Laboratory (2-8-2) | 15.307 | Behavioral Science Research Practicum (2-8-8) |
| 6.121 | Bioelectronics Project Laboratory (2-8-2) | 16.62 | Experimental Projects (2-6-4) |
| 6.141 | Power Systems Project Laboratory (2-8-2) | 17.01 | Political Science Laboratory (2-6-4) |
| 6.151J | Semiconductor Devices Project Laboratory (2-8-2) | 20.001 | Applied Microbiology Laboratory (2-6-4) |
| 6.161 | Modern Optics Project Laboratory (2-8-2) | 20.002 | Laboratory in Applied Biology (2-8-4) |
| 6.162 | Image Transmission Systems Project Laboratory (0-12-0) | 22.069 | Undergraduate Plasma Laboratory (1-8-3) |
| | | 22.09 | Introductory Nuclear Measurements Laboratory (2-6-4) |

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

Physical Education Requirement

The Institute expects each student to gain experience in recreational athletics during his or her first two years at M.I.T. By the end of this period each student must have compiled at least 8 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 19 subjects in which advanced credit examinations are given. Please consult the Director of Physical Education if interested in advanced credit examinations.

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, beginning and intermediate ballet, partner dance, tap dance, development, field hockey, touch football, football officiating, ultimate frisbee, golf, karate, lacrosse, pistol, precision air rifle, rock climbing, rugby, sailing, scuba, sculling, self-designed fitness, soccer officiating, beginning swimming, T'ai Chi, beginning and intermediate tennis.

Second Quarter:

Badminton, basketball fundamentals, basketball officiating, beginning and intermediate ballet, partner dance, tap dance, development, diving, fencing, gymnastics, hockey, judo, pistol, precision air rifle, Red Cross Advanced Life Saving, self-designed fitness, beginning skating, squash, beginning and intermediate swimming, volleyball officiating, yoga.

I.A.P.:

Archery, badminton, ballet (beginning), basketball, basketball officiating, diving, fencing, first aid, hockey, hockey officiating, karate, box lacrosse, modern dance (beginning), partner dance, pistol, precision air rifle, self-designed fitness, skating, figure skating, squash, advanced squash, tap dance, trampoline, water polo, yoga.

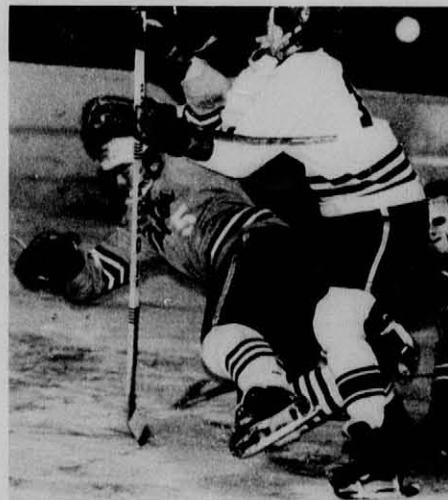
Third Quarter:

Ballet, development, diving, fencing, first aid, folk dance, gymnastics (women's), judo, modern dance, partner dance, rifle, Red Cross Water Safety Instructor's Course (part 1), self-designed fitness, skating, figure skating, self defense, squash, swimming (beginning and advanced techniques), trampoline, volleyball.

Fourth Quarter:

Archery, ballet, bicycling, development, golf (beginning and intermediate), modern dance, partner dance, precision air rifle, Red Cross Water Safety Instructor's Course (part 2), rock climbing, sailing, scuba, sculling, self-designed fitness, softball, swimming, tap dance, tennis (beginning and intermediate).

Upon entering M.I.T. 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, the athletic requirements may be modified.



Wellesley-M.I.T. Exchange Program

M.I.T. students may fulfill part of their academic program by taking courses at Wellesley College. This opportunity for cross-registration is made possible by a program initiated by Wellesley College and M.I.T. in 1968.

Wellesley courses may be substituted for required M.I.T. subjects according to the following rules:

Departmental Requirements may be substituted with the permission of the student's own Faculty Counselor.

The Committee on the Institute Requirement in the Humanities, Arts, and Social Sciences has approved 12 Wellesley subjects for the Distribution Requirement and has assigned each to one of the specific Fields into which M.I.T. is organized. (Further information about the Fields may be found in the section on the Requirement in this chapter.) Students intending to count these subjects toward completion of this Requirement should keep in mind that each of the three required Distribution subjects should be in a different Field of study (e.g., students taking a term of Italian 202 for Distribution credit will not be permitted to count a second subject in the Field of Foreign Language).

One or more Wellesley subjects may be accepted toward a student's Field of Concentration in the Humanities, Arts, and Social Sciences at the discretion of the designated advisor in the Field of Concentration. Relevant Wellesley subjects will be routinely accepted for substitution for one or more of the unrestricted electives under the terms of the Humanities, Arts, and Social Sciences Requirement. Petitions must be completed for all substitutions of the Humanities, Arts, and Social Sciences Requirement and submitted to the Office of the Dean of the School of Humanities and Social Science, Room 20D-203.

Mathematics 203 may be taken to satisfy the Science Distribution Requirement. Students may petition the Committee on Curricula to take other subjects to fulfill this requirement. The requirement that students must study in at least three different departments continues to apply with the understanding that a Wellesley subject in essentially the same field as an M.I.T. department will not be counted as different. Generally, substitutions for Science Core subjects are not permitted. This is also true of the Laboratory Requirement.

Through the Wellesley-M.I.T. Exchange Program, M.I.T. students may extend and diversify their educational experience in two ways: environment and curriculum. Wellesley College is a small, liberal arts college for women and is located on a 500-acre campus which borders Lake Waban in Wellesley, Massachusetts. M.I.T. students may pursue areas of study not available at M.I.T., as well as find individual courses which complement or supplement the offerings of M.I.T. departments. The following is a list of the Wellesley departments:

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

In addition, Wellesley College has established interdepartmental programs which include Classical Civilization, Classical and Near Eastern Archaeology, East Asian Studies, Medieval/Renaissance Studies, Molecular Biology, American Studies, Italian Culture, Language Studies, Urban Studies, and Women's Studies.

A few Wellesley courses are taught on the M.I.T. campus and are listed with M.I.T. subjects in this catalogue. For detailed descriptions of these and other Wellesley courses, students may consult a publication entitled *Wellesley-M.I.T. Exchange: Guide for M.I.T. Students*, which is issued in May for fall term and in December for spring term. This guide and other information on the Exchange Program are available in the Wellesley-M.I.T. Exchange Office, Room 7-108. Bus transportation between Wellesley College and M.I.T. for academic purposes is provided to cross-registered students without cost.

Admissions

Freshman Admissions

The majority of undergraduate men and women enter M.I.T. 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 will provide suitable preparation for the student who takes full advantage of the opportunities which such schools afford. 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)
Algebra (2)
Plane Geometry (1)
Physics (1)
Chemistry (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. M.I.T. does not offer a summer program; 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.

M.I.T. 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.

Minority Group Programs

The Institute desires to make its facilities available to all, regardless of financial condition, cultural background, or quality of schooling, to the extent that the student appears ready to pursue an M.I.T. program. To this end special efforts are made to acquaint members of educationally deprived minority groups of the opportunities at M.I.T. For those who are admitted but seem to need more exposure in specific academic areas, a special prefreshman summer

session, Project Interphase, is available by invitation at no expense to the student. Interested members of minority groups who want more information relative to admissions procedures, financial aid, and life at M.I.T., should write to the Director of Admissions, Room 3-108, M.I.T., Cambridge, Massachusetts 02139.

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. There is a \$25 application fee. Notices concerning the admission decision will be mailed in 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 M.I.T. Educational Council near the applicant's home. Council members are alumni who have been selected for their ability to represent M.I.T. and for their interest in and liking for 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 prior to January 1 of the year of entrance. If an applicant sees a counselor before the spring of the junior year, another conference should be arranged after May 1 of that year.

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

Entrance Examinations

All candidates are required to take the following tests given by the College Entrance Examination Board: the Scholastic Aptitude Tests and three one-hour achievement tests in 1) Level I Mathematics or Level II Mathematics, 2) Physics or Chemistry or Biology, 3) English Composition or one of the History tests.

The 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 Entrance Examination Board, Box 592, Princeton, New Jersey 08540. Residents of western North America, Mexico, Australia, Pacific Islands, Japan, and Taiwan should apply to the College Entrance Examination Board, Box 1025, Berkeley, California 94701.

Candidates for admission for September 1980 must have completed the SATs and the three achievement tests by the January 1980 testing date. Either the SAT or up to three achievements may be taken on any scheduled test date, but not both. 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 M.I.T. 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

M.I.T. 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 M.I.T., is not required to reply to the Institute before the candidates' reply date in early May. This is therefore not an "early decision" plan in the usual sense.

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 transfers rather than matriculate as deferred freshmen.



Advanced Placement

M.I.T. has always encouraged students to move ahead academically according to their capabilities. It offers three procedures by which students entering from secondary schools may go directly into a subject at an advanced level:

- 1) the College Entrance Examination Board Advanced Placement Program;
- 2) college transcript; and
- 3) Advanced Standing Examination at M.I.T.

Students who take college-level subjects offered in their schools in cooperation with the College Entrance Examination 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 M.I.T. Degree credit for M.I.T. 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 before registration of the credit offered so that they may discuss with their Faculty Advisor an optimum schedule.

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 M.I.T. credit under the regular college transfer procedures.

M.I.T. does not give credit for high school or other precollege study of foreign languages but students whose advanced study does not follow either of these patterns and who are interested in being considered for M.I.T. degree credit at entrance should write to the Director of Advanced Placement at M.I.T. about their studies.



International Undergraduate Admissions

The M.I.T. undergraduate student body includes citizens of other countries.

These students normally join the freshman class after completing secondary school at the highest level. Students are encouraged to plan to complete the Higher School Certificate, the General Certificate of Education at the Advanced Level, the Baccalaureate, the Maturite, or the Gymnasium, even though decisions on admission to M.I.T. 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 a year before they plan to enter M.I.T. for information about application procedures. Included in the response will be the leaflet, "Information for Prospective Foreign Students" and a Request for Application form which should be returned promptly. Final Application materials will be forwarded to those whose Request for Application form is approved. All documents must be completed in English or accompanied by attested translations of the original into English. In order to receive consideration, the Final Application must be completed and returned by January 1, and the required College Entrance Examination Board tests (including, if appropriate, the Test of English as a Foreign Language) must be taken by then. All students are urged to register for the tests at least six to eight weeks in advance of the testing date.

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

Personal Conferences

Applicants may be asked to arrange a personal conference with a local M.I.T. 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 M.I.T. are conducted in English. All applicants must present evidence of their ability to carry on their studies in English.

Entrance Examinations for Foreign Applicants

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

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



College Transfer Admissions

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

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

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

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

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

Application Procedures

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



The applicant must assure that the following documents are submitted:

- 1 A completed Application for Admission with Advanced Standing, indicating all subjects that will have been completed at the time of transfer, and a nonreturnable fee of \$25.
- 2 A certified transcript of the college record to date, including a statement of good standing. A certified statement covering subjects subsequently taken should be sent as soon as it is available. Students in their first year in college may wait until the end of the year before sending the first transcript of record.
- 3 Catalogue pages describing all subjects which will have been completed.
- 4 Three evaluation reports, including two from faculty instructors and one from the Dean of Students or the applicant's chief faculty advisor. These forms should be sent directly to the Director of Admissions by the endorsers.
- 5 A report from the secondary school attended. The report should be made on the form provided with the Final Application and should be sent directly from the secondary school to the Director of Admissions.
- 6 College Entrance Examination 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.

Special Student Admissions

College Transfer Admissions (continued)

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. The aid application material is provided only after a decision to offer admission has been made.

Advanced Credit

Students admitted by transfer may expect to receive credit for subjects of study completed elsewhere which 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 M.I.T. 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 M.I.T.

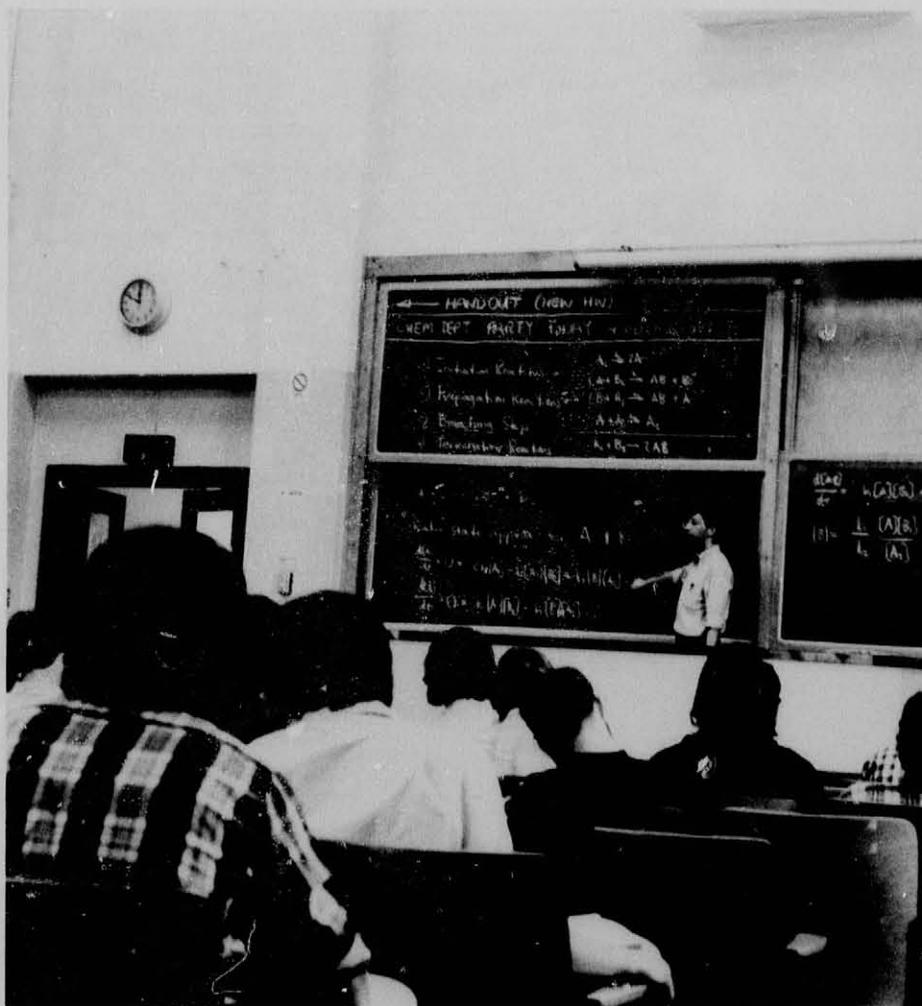
Applicants admitted with advanced standing in architecture will be placed in the design sequence in accordance with their performance on their first problem.

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 M.I.T. 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 M.I.T. Special Student status is granted for *one term only*, and a new application for this status is required for any successive terms. Admission as a special student does not carry any implication for applications filed at a later date. Applicants must present academic

credentials of high quality or evidence of professional experience relevant to the proposed program. Admission is subject to available places in the classroom, laboratory, or studio.

The Director of Admissions will supply application forms upon request. There is an application fee of \$25 for the first application; it is not required for renewal applications within a two-year period. Completed applications should be submitted at least six weeks prior to the beginning of the term.



Costs for Undergraduates

Undergraduate student costs for the academic year 1979-80 at M.I.T. will be about \$8,900. This includes tuition, comprehensive health care services at the M.I.T. 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 costs of books and supplies, clothes, laundry, recreation, and other personal necessities vary widely depending upon interests, tastes, and needs, but typically total about \$915. There are many kinds of dining and housing arrangements at M.I.T. and the range of student expenses for room and board is broad (but is generally between \$2,000 and \$3,000 for the academic year). Total costs for most undergraduates during the 1979-80 academic year will be in the range of \$8,200 to \$9,200 (excluding cost of travel), depending upon specific choices.

The following are the basic **tuition and fees** at M.I.T. for the academic year 1979-80 (which are reviewed and likely to increase each year):

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|---|---------|
| Tuition | \$5,300 |
| Hospital and Accident Insurance Policy ² | 130 |

The tuition for all regular undergraduates in the first and second terms is \$2,650 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 \$85 per unit with the approval of the Faculty Counselor and, if not a degree candidate, the additional approval of the Dean for Student Affairs. In such cases, there is a minimum fee of \$510 for subjects and a minimum of \$220 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 \$85 per unit taken either for credit or not for credit. This unit fee applies up to a maximum of \$2,650 per term and is subject to the following minimum fees:

| | |
|--|-------|
| Members of the M.I.T. Community ³ | \$510 |
| Other Special Students | \$765 |

Cooperative programs offered by M.I.T. 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), \$5,300

Chemical Engineering Practice, Course X-A
 September-January or February-June, \$2,650

Electrical Science and Engineering or Computer Science and Engineering, Course VI-A
 Materials Science and Engineering, Course III-B
 July 1 to June 30, \$5,300

In each case, the first \$2,650 is due on the date when the first-term tuition is normally due, and the additional \$2,650 is due on the date when the second-term tuition is normally due. Upon recommendation of the Department, a special tuition rate for any cooperative program may be set by the Dean in an unusual case.

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 Counselor 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.

Miscellaneous Fees

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|-------------------------------|------|
| Application Fee for Admission | \$25 |
| Late Registration Fee | 5 |
| Fee for Late Payments | 20 |

¹ Payment of the tuition fee entitles all regular and special registered students to comprehensive health care services at the M.I.T. Medical Department, including consultation with a wide range of specialists, diagnostic studies, and hospitalization in the M.I.T. Infirmary. Charges are made for routine eye examinations, contact lens services, ear piercing, dental care services, obstetrical care, 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 M.I.T. Student Insurance covers hospitalization (other than in the M.I.T. 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 with an \$850 maternity benefit is \$300. Hospitalization insurance for one or more children may be purchased for \$120.

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

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.

Payments

All payments are to be made to M.I.T., Cambridge, Massachusetts 02139, by the time specified in the financial registration instructions issued prior to the opening of each term. A late charge of \$20 is assessed for each payment that is not received when due. Registered student status can be withdrawn at any time for non-payment of fees. A student who expects to be a candidate for a degree must make satisfactory financial arrangements for any indebtedness prior to requesting entry of his or her name on the degree list.

To assist students in meeting each term's expenses, various financial aids are available for which the student may be eligible (described in the next section). Also, students and their families might consider the installment plans that are offered. The M.I.T. Parent Loan Plan, for example, was recently developed to help parents pay for four years of college costs over a period of about six and one-half years. M.I.T. provides the basic funds for this monthly installment plan, which offers loans at moderate interest rates to parents whose annual family income is between \$15,000 and \$60,000. 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, M.I.T. Parent Loan Plan Office, Box 160, Boston, Massachusetts 02101, (617) 253-3342.

M.I.T. also offers a deferred payment plan to undergraduates on a limited basis. This plan allows for each term's tuition and other payments to be spread over the term in three installments. (An administrative fee of \$20 per term will be charged for this service.) The deferred payment program for undergraduates, however, is planned primarily to assist students (and their families) with short-term emergency situations or other special family circumstances. This plan may be modified (or discontinued) over the next several years, as various alternatives, such as the Parent Loan Plan, are developed. Financial registration instructions and billings for tuition and fees will be sent to admitted and continuing undergraduate students prior to the beginning of each term.

Institute House Rentals and Meals

All term rentals for all houses and all fees for Commons meals are to be paid to the Cashier's Office, Room 10-180, prior to the beginning of each term.

Financial Aids

Grants, Loans, and Employment

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

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

The Student Financial Aid Office provides grants and loans based on the financial need of the individual student, as determined by analysis of the Financial Aid Form, a statement of family finances. This form is submitted through the College Scholarship Service of the College Entrance Examination Board as part of the initial application procedure. A copy of the most recent parental Federal tax return is required in support of aid applications.

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

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 M.I.T. student loans are granted only on the basis of demonstrated financial need. Undergraduate loans are provided from several sources, including the National Direct Student Loan (NDSL) Program and the Institute's own Technology Loan Fund, which is closely linked with the Guaranteed Student Loan Program. Eligible students are provided loans under the Guaranteed Loan Program only when they cannot obtain a Guaranteed Loan at a hometown bank. Most Institute loans to US undergraduates are covered by the NDSL and GSL programs; those that are not will require a co-signer.

Students are expected to work and/or borrow as the first incremental portion of their aid. 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 and return the Financial Aid Application which is included with the Application for Admission. In addition, a Financial Aid Form (F.A.F.) must be submitted to the College Scholarship Service, designating M.I.T. as a recipient. The F.A.F. may be obtained from a secondary school or from the College Scholarship Service, P.O. Box 176, Princeton, New Jersey 08540, or P.O. Box 1051, Berkeley, California 94701. The M.I.T. application form must be submitted prior to January 1. An application for admission is not prejudiced by an application for aid. The two decisions are entirely separate — need criteria have no bearing on admissions, and admissions criteria have no part in determining qualifications for aid. There is no reason to be deterred from applying concurrently to M.I.T. for admission and aid.

Foreign Students

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

Scholarships for Undergraduates

Transfer Students

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

Upperclass Students

M.I.T. awards are made on an annual basis, and recipients are required to reapply in January each year for continued assistance in the following year. Upperclass students who have not received prior assistance may also make application at this time. Upperclass financial aid application forms are available from the Student Financial Aid Office in mid-December; 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 Basic Grant. Eligibility for M.I.T. undergraduate grant funds will end when the student is eligible to receive an initial degree, or after eight terms, whichever occurs first.

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

- Frank W. and Carl S. Adams Memorial Fund (1955)
- Alcoa Scholarships (1965 and 1968)
- Max I. Alimansky ('28) Memorial Student Scholarship Fund (1973)
- Caroline Hadley Allen Fund
- Elbert G. Allen ('00) Fund (1969)
- Nils Anderson Scholarship (1961)
- William P. Anderson, Jr. Fund (1965)
- Anonymous (1979)
- Louie G. Applebee Fund (1942)
- Rufus Applegarth, Jr. Scholarship (1963)
- W. Cornell Appleton Scholarship Fund (1971)
- Association of Iron and Steel Engineers — Madsen Scholarship Fund (1966)
- Athan Scholarship (1962)
- Elisha Atkins Fund (1894)
- Hattie G. Atkins Fund (1962)
- Julian M. Avery ('18) Fund (1957)
- Jason S. Bailey Fund (1952)
- Thomas Wendell Bailey Fund (1914)
- Charles Tidd Baker Fund (1922)
- Constance and Arthur H. Ballard Memorial Scholarship Fund (1969)
- Ethel Amweg Barber Fund (1979)
- Colonel Daniel Moore Bates ('96) Scholarship Fund (1973)
- Lester I. Beals Memorial Scholarship Fund (1976)
- Louis D. Beazumont Foundation Scholarships (1973)
- John Rice Bell Memorial Scholarship (1961)
- Harry Howe Bentley Fund (1979)
- Alf K. Berle Memorial Scholarship Fund (1960)
- Billings Student Aid Fund (1900)
- Ernst Henri Birnbaum Memorial Fund (1964)
- Huse Templeton Blanchard ('01) Fund (1946)
- Levi Boles Fund (1915)
- Jonathan Bourne Fund (1915)
- Albert G. Boyden Fund (1931)
- Bertram Brewer Scholarships (1952)
- Hubert D. Broderic (1965)
- A. Raymond Brooks ('17) Scholarship Fund (1973)
- A. Lawrence Brown Fund (1979)
- Harriet L. Brown Fund (1932)
- Walter Stanley Brown Scholarship Fund (1968)
- Bryant Chucking Grinder (1979)
- Willard B. Buck Scholarship Fund (1971)
- The John S. Buhler ('27) Memorial Scholarship Fund (1973)
- Denison K. Bullens Scholarship Fund (1960)
- Vannevar Bush Scholarship Fund (1960)
- Cabot Corporation Scholarships (1955)
- Godfrey L. Cabot Fund (1950)
- Thomas D. Cabot Scholarship Fund (1960)
- William Putnam Cabot Scholarship Fund (1977)
- Joel W. Campbell Scholarship Fund (1967)
- William H. Carlisle, Jr. Scholarship Fund (1968)
- Mrs. Richard Carson, Sr. Fund (1979)
- Mabel Blake Case Fund (1920)
- Harry Hardin Catching ('12) Memorial Scholarship Fund (1975)
- Nino Teshler Cattlin Fund (1926)
- Francis Ward Chandler Memorial Fund (1969)
- Edward S. Chapin ('98) Scholarship Fund (1967)
- James M. Chovak ('57) Memorial Scholarship Fund (1976)
- Clapp and Pollak Scholarships (1966)
- Lucius Clapp Fund (1905)
- Clark Foundation Scholarships (1953)

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| Edna McConnell Clark Scholarship (1973) | Ernest J. Cronenbold ('03) Scholarship Fund (1974) | Francis Edwin Faxon Scholarship Fund (1967) |
| J. Russell ('29) and Dorothy V. Clark Fund (1972) | Eunice McLellan Cruft Fund (1949) | Joshua B. Feldman ('40) Memorial Scholarship Fund (1976) |
| Thomas L. Clark Memorial Scholarship (1956) | Allan R. Cullimore Fund (1979) | Harold W. Fisher Fund (1979) |
| A. V. Clarke Fund (1950) | Ralph E. Curtis Scholarship (1960) | Charles Lewis Flint Fund (1889) |
| Class of 1887 Scholarship Fund (1967) | The Dalafield Memorial Fund (1960) | Sarah S. Forbes Fund (1913) |
| Class of 1895 Memorial Scholarship Fund (1945) | Louis R. Damiano Memorial Scholarship Fund | Clara and F. Joseph Ford Scholarship (1951) |
| Class of 1906 Scholarship Fund (1967) | Isaac W. Danforth Fund (1903) | Foundry Educational Foundation Scholarships (1947) |
| Class of 1909 Memorial Fund (1957) | D'Autremont Scholarship Fund (1979) | Arthur E. Fowle Fund (1956) |
| Class of 1910 Scholarship Fund (1967) | Tenney L. Davis Scholarship Fund (1967) | Benjamin Franklin Fund (1956) |
| Class of 1917 Edwin E. Aldrin, Jr. Scholarship Fund (1972) | Robert Taylor Dawes ('26) Scholarship Fund (1969) | Evert W. Freeman Scholarship Fund (1956) |
| Class of 1918 Memorial Scholarship Fund (1971) | Orville B. Denison Memorial Fund (1960) | Philip Jacob Friedlander Fund (1945) |
| Class of 1925 Scholarship Fund (1974) | Marie G. Dennet Scholarship Fund (1963) | William W. Garth ('36) Memorial Scholarship Fund (1975) |
| Class of 1926 Charles Stark Draper Fund (1974) | Carl Pullen Dennet Memorial Scholarship Funds (1956 and 1959) | Jurgis J. Geguzis Fund (1957) |
| Class of 1931 Compton Memorial Freshman Scholarship Fund (1956) | Edward Depoyan ('30) Memorial Fund (1976) | Norman H. George Fund (1919) |
| Class of 1932 Fund (1951) | Thomas C. Desmond Scholarship Fund (1960) | Arthur B. Gilmore Fund (1941) |
| Class of 1933 Fund (1958) | John H. Dessauer Scholarship Fund (1973) | James R. Glazebrook Fund (1959) |
| Class of 1933 Robert M. Kimball ('33) Memorial Scholarship (1964) | Development Fund Scholarships (1950) | Ethel A. Gleason Memorial Scholarship (1963) |
| Class of 1934 Compton Fund (1959) | Ann White Dickinson Fund (1968) | Samuel A. Goldblith ('40) Scholarship Fund (1976) |
| Class of 1935 Memorial Scholarship Fund (1971) | Frederick N. Dillon, Jr. Scholarship Fund (1968) | Lewis Goldstein Memorial Scholarship Fund (1973) |
| Class of 1936 Scholarship Fund (1971) | Fred C. Dobbs Fund (1960) | Barnett D. Gordon ('16) Fund (1942) |
| Class of 1937 Scholarship Fund (1971) | Dormitory Fund (1903) | Haskell ('38) and Ina Gordon Scholarship Fund (1974) |
| Class of 1938 Scholarship Fund (1938) | Philip B. Downing Trust | John William Grant Fund (1979) |
| Class of 1950 Scholarship Fund (1974) | Henry C. Dresser Fund (1965) | John H. Gregory Fund (1963) |
| Fred L. and Florence L. Coburn Fund (1932) | Thomas Messinger Drown Scholarships (1928) | John A. Grimmons Fund (1952) |
| Coffin Memorial Fund (1929) | Edouard N. Dube, Class of 1921 (1979) | Robert G. Gross — Lockheed Aircraft Corporation Scholarships (1963) |
| Arthur L. Collier Memorial Fund (1977) | Charles Dyer Scholarship Fund (1968) | Rita Welch Gruber Memorial Scholarship (1961) |
| W. A. Conant Scholarship Fund (1943) | The Ederic Foundation (1979) | Gulf and South America Steamship Company Fund (1953) |
| Albert Conro Scholarship Fund (1943) | Daniel W. Edgerly Fund (1964) | William T. Haebler ('22) Memorial Scholarship (1960) |
| The George R. Cooke ('08) Fund (1939) | Robert B. Zsabel Ehrman Memorial Scholarship Fund (1970) | Humphrey M. Haley Scholarship Fund (1958) |
| Charles D. Coryell Memorial Scholarship Fund (1971) | Calvin P. Eldred Memorial Scholarship Fund (1970) | Lucia G. Hail Scholarships (1945) |
| Paul F. Cotter ('57) Fund (1974) | Electrical Regulator Scholarship Fund | Hall-Mercer Scholarship Fund (1940) |
| John G. Crane Scholarships (1951) | Leola M. Farnham Scholarship Fund (1966) | Russell Hamilton ('19) Scholarship Fund (1976) |
| Allen S. Crocker Memorial Fund (1961) | Farnsworth Fund (1889) | Claire Morton Prince Hanks Fund (1966) |
| Lucretia Crocker Fund (1916) | Alton J. Farrel, Jr. Scholarship Fund (1967) | |
| | Robert S. Faurot ('44) Scholarship Fund (1976) | |

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| Katherine Hansen ('53) Memorial Scholarship Fund (1975) | Richard and Eric T. Keller Memorial Scholarship Fund (1973) | Madsen Scholarship Fund (1966) |
| Harrington Scholarship Fund (1961) | Henry Donald Kemp Fund (1964) | Estus H. Magoon ('14) Student Aid Fund (1975) |
| James H. Haste Fund (1930) | Bo Kwang Kim Scholarship Fund (1957) | Eugene H. Mahoney Fund (1975) |
| Charles Hayden Memorial Scholarships (1939) | Warren J. King ('48) Scholarship Fund (1976) | Georgia Lamar Malone Scholarship (1961) |
| Delos G. Haynes Scholarship Fund (1970) | Malcolm G. Kispert ('44) Memorial Scholarship Fund (1975) | Theodore A. Mangelsdorf Fund (1961) |
| Herrick Foundation Scholarship Fund (1976) | Amelia S. Kniesner Scholarship Fund (1944) | Francisco Marcucella Fund (1953) |
| Joseph Hewett ('96) Fund (1965) | Kurrelmeyer Fund (1947) | Rupert Anderson Marden Fund (1933) |
| Bancroft Hill Memorial Fund (1957) | Forrest Fay Lange Class of 1923 Scholarship Fund (1973) | Martin-Marietta Foundation Scholarship Fund (1954) |
| Clifford E. Hoar Scholarship Fund (1972) | John Lawrence ('32) Scholarship Fund (1974) | Waldo A. Martin Scholarship Fund (1950) |
| Eric Hodgins ('22) Memorial Scholarship Fund (1972) | Constance D. Lazear Fund (1979) | Margaret A. Matthews Fund (1947) |
| George Hollingsworth Scholarship (1916) | William Houston Lazear ('23) Memorial Fund (1976) | Thomas Mayor Fund (1963) |
| Loren C. Holm Scholarship Fund (1950) | George J. Leness Scholarship Fund (1969) | George J. Mead Scholarships (1951) |
| James T. ('14) and Esther Roen Holmes Scholarship Fund (1974) | Teh Ching Li ('37) Memorial Scholarship Fund (1971) | Charles E. Merrill Scholarship Fund (1955) |
| Theodore V. Houser Scholarship Fund (1956) | Y. T. Li Fund (1959) | Samuel Mildram Memorial Fund (1970) |
| Elias Howe, Jr. Scholarships (1949) | Jacob and Jennie Lichter Fund (1949) | Arthur Merkel Miller Fund (1960) |
| Dr. and Mrs. Chiao-Yue (nee Yeuh-Gin Gung) Hu Scholarship (1970) | Gustaf Robert Lindberg Fund (1957) | Robert W. Milne Fund (1943) |
| Hunt Scholarship Fund (1971) | Paul Weeks Litchfield Scholarship (1954) | Joseph R. Minevitch Memorial Scholarship Fund (1957) |
| Samuel P. Hunt Fund (1945) | William Litchfield Scholarship (1910) | Li Ming Scholarship Fund (1969) |
| T. Sterry Hunt Scholarship (1894) | Ellis Litmann Fund (1979) | James H. Mirrlees Fund (1886) |
| William F. Huntington Fund (1892) | Littman Foundation Scholarship (1960) | M.I.T. Alumni Fund National Scholarships (1957) |
| Cuthbert Hurd Scholarship Fund (1968) | Charles E. Locke Memorial Fund (1923) | M.I.T. Boston Stein Club — New England and National Scholarship Funds (1955) |
| Rudolph Hurwich Fund (1979) | Richard W. Lodge Fund (1955) | M.I.T. Boston Stein Club — Jerome B. Wiesner Freshman Scholarship Fund (1976) |
| Charles L. Ireson Scholarship Fund (1959) | Sheridan A. Logan Fund (1964) | M.I.T. Club of Atlanta (1979) |
| David L. Jewell Fund (1928) | Elisha T. Loring Fund (1890) | M.I.T. Club of Chicago Scholarship Fund (1944) |
| Edward A. Jones Scholarship Fund (1947) | George J. Loveley Scholarship Fund (1960) | M.I.T. Club of Rochester Scholarship Fund (1968) |
| Ralph T. Jope Fund (1979) | Percival Lowell Scholarships (1955) | M.I.T. Women's League (1979) |
| Joy Scholarship (1886) | Samuel E. Lunden Leadership Fund (1967) | Morningstar Scholarship (1953) |
| Henri P. Junod ('21) Memorial Scholarship Fund (1974) | George P. Lunt ('10) Memorial Scholarship Fund (1974) | Fred W. Morrill Scholarship Fund (1941) |
| Sarah Maude Kaemmerling Fund (1952) | John A. Lyons Scholarship Fund (1966) | Wm. T. Morris Foundation, Inc. (1979) |
| William R. Kales Scholarship Fund (1953) | Eugene and Margaret McDermott Scholarship Fund (1960) | Maude Phipps Morrissey Fund (1972) |
| Kalker Scholarship Fund (1969) | Frederick F. Mackentepe ('14) Scholarship Fund (1970) | Frederick Taft Moses ('07) Scholarship Fund (1959) |
| Walter R. and Nellie J. Kattelle Scholarship Fund (1972) | Alice Macclaurin Scholarship (1951) | Floyd A. Naramore Memorial Scholarship Fund (1972) |
| Mitchell B. Kaufman ('15) Memorial Scholarship Fund (1975) | | Gertrude B. Newman Scholarship (1952) |
| | | Niarchos Scholarship (1956) |

| | | |
|---|--|--|
| Nichols Scholarship (1895) | George Scher Fund (1949) | Wentworth Stevens Fund (1957) |
| Charles C. Nichols Scholarship (1904) | Anna and David C. Schilling Scholarship Fund (1970) | Julia Stewart Scholarship (1974) |
| Hart and Arthur Nichols Scholarship Fund (1966) | William E. Schrafft Charitable Fund | Phillip Stockton Fund (1961) |
| William E. Nickerson Scholarship Fund (1949) | Science Scholarships (1956) | Albert F. Sulzer Scholarship (1955) |
| Samuel Niedelman ('24) Fund (1976) | Second Century Scholarship | Sydney Family Scholarship Fund (1976) |
| Mrs. Samuel Niedelman Fund (1979) | Paul D. Seghers, Jr. Scholarship (1948) | Tau Beta Pi Memorial Scholarship Fund (1947) |
| Howard A. Noble ('97) Scholarships (1956) | Robert J. Seid Award (1971) | Howard F. Taylor Memorial Scholarship Fund (1962) |
| John Felt Osgood Scholarship (1909) | Louise E. and Theresa Seley Student Aid Fund (1961) | Technology Club of New York Scholarship Fund (1976) |
| Louise Parks Knight and Charles F. Parks Memorial Fund (1952) | Irving Shaknov Scholarship (1954) | Lawrence E. Teich '40 Memorial Scholarship Fund (1966) |
| George L. Parmelee Fund (1921) | Friends of Jay Tsun Shaw ('46) Scholarship Fund (1974) | Mary Thacher Scholarship (1956) |
| Frank E. ('05) and Seba B. Payne Foundation Scholarship Fund (1962) | Frederick J. Shepard, Jr. Fund (1959) | Richard H. Tingey Memorial Fund (1962) |
| Langdon Pearse Memorial Scholarship (1958) | James and Donald H. Sheridan Scholarships Fund (1961) | Samuel E. Tinkham Fund (1924) |
| Frank Stetson Pecker Fund (1947) | Frank Arnold Sherman Scholarship Fund (1947) | Franklin Towle Fund (1979) |
| Richard Perkins Fund (1887) | Thomas Sherwin Scholarship (1871) | Arthur L. Townsend Fund (1960) |
| Malcolm Oliver Petri Memorial Fund | Albert and Harry Smith Fund (1979) | W. H. Triplett ('12) Scholarship Fund (1961) |
| St. Elmo Tower Piza Memorial Fund (1962) | Chester W. Smith ('29) Scholarship Fund (1976) | Y. T. Tsai Memorial Scholarship (1955) |
| Abraham Pletman Scholarship Fund (1975) | Frank Langdon Smith Scholarship Fund (1968) | James E. Turner ('33) Scholarship Fund (1976) |
| Charles H. and Helen Bartlett Pray Fund (1950) | G. H. Miller Smith Fund (1945) | John L. Turner ('31) Fund (1960) |
| Florence E. Prince Fund (1943) | H. Hilliard Smith Fund (1950) | John Deloss Underwood Memorial Scholarship (1977) |
| William W. Quarles Memorial Scholarship (1971) | Horace T. Smith Fund (1931) | Estate of Maud Underwood (1979) |
| Walter R. Ramsaur Scholarship Fund | Society of Naval Architecture and Marine Engineering Scholarships (1957) | Susan Upham Fund (1892) |
| George H. Rand Scholarship (1958) | Sons and Daughters of New England Puritan Colony Scholarship (1931) | Samson R. Urbino Fund (1927) |
| Thomas Adelbert Read Scholarship (1934) | Walter W. and Edna J. Soroka Memorial Student Aid Fund (1971) | Vermont Scholarship (1924) |
| Willis Ward Reeves, Jr. Fund (1945) | Anna Spooner Fund (1939) | F. P. von Olker Fund (1962) |
| Arthur Reid Memorial Scholarship (1966) | Louis E. Stahl ('36) Scholarship Fund (1976) | Ann White Vose Fund (1896) |
| Charles A. Richards Fund (1939) | Standard Oil Company of California Scholarships (1955) | Arthur M. Waitt Fund (1925) |
| Frederick L. Richards Memorial Fund (1960) | Philip B. Stanley ('06) Memorial Scholarship Fund (1971) | Grant Walker Fund (1943) |
| I. D. Richheimer Memorial Scholarship (1961) | Mrs. Avery Stanton Fund (1979) | Muriel Alvord Ward Fund (1960) |
| John Roach Scholarship Fund (1937) | Creighton B. Stanwood Scholarship Fund (1974) | Warren Benevolent Fund (1961) |
| Karl Robbins Scholarship (1951) | | Henry Arthur Waterman Scholarship Fund (1969) |
| Willard F. Rockwell Scholarship Fund (1961) | | John J. Watson Memorial Fund (1963) |
| Gilbert M. Roddy ('31) Scholarship Fund (1974) | | James Wait Scholarship (1942) |
| William Barton Rogers Scholarships (1947) | | Edwin S. Webster ('88) Foundation (1974) |
| William P. Ryan Memorial Fund (1935) | | Louis Weissbein Fund (1915) |
| John P. Schenkl Fund (1922) | | |

Special Loan Funds

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

Frances Erving Weston Fund (1912)

Samuel Martin Weston Fund (1912)

Archer E. Wheeler Scholarship Fund (1957)

Ray Hill White Memorial Fund (1956)

Amasa J. Whiting Fund (1927)

Granger Whitney Fund (1957)

Harold O. Whitney Scholarship Fund (1968)

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

Elizabeth Babcock Wilmann Fund (1935)

Wilson Scholarship (1953)

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

Howard I. Wood Scholarship Fund (1969)

Augusta Wolff Scholarship Fund (1975)

Morrill Wyman ('15) Fund (1923)

Conrad Henry Young Scholarships (1957)

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

Walter Phelps Bliss Memorial Fund

Boston Stein Club Freshman Loan Fund (1953)

Boston Stein Club Freshman Loan Fund (1968)

Anna J. and Francesco Casaretta Loan Fund (1966)

Francis W. Chandler Loan Fund (1927)

Ruth Hornblower Churchill Memorial Loan Fund (1958)

Class of 1917 Loan Fund (1937)

Class of 1963 Loan Fund (1963)

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

Daunis Family Fund (1971)

Carl P. Dennett Loan Fund (1956)

George Freydborg Fund (1972)

Ethel I. Fryer Scholarship Loan Fund (1951)

Nathan R. George Loan Fund (1943)

John A. Grimmons Loan Fund (1963)

Gerald L. Hartstein Memorial Loan Fund (1963)

John A. Herlihy Loan Fund (1962)

Jerome Hunsaker Loan Fund (1970)

Roscoe Hupper Loan Fund (1955)

Rebecca R. Joslin Loan Fund (1924-36)

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

Lamson-Virgin Loan Fund (1946)

Dr. Max Levine Loan Fund

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

M.I.T. Incentive Loan Fund (1971)

Anthony P. Mathesius Loan Fund (1970)

George H. May Loan Fund (1914)

Helen and Leo Mayer Loan Fund (1967)

George J. Mead Loan Fund (1951)

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

Pemrose Loan Fund

Michael Joseph Pollock Loan Fund (1962)

Ellen H. Richards Loan Fund (1964)

M. H. Rogers Loan Fund (1945)

Lillie C. Smith Fund (1965)

Gertrude W. Swartz Memorial Student Loan Fund (1971)

Technology Matrons Loan Fund (1960)

Robert Kelley Thulman Loan Fund (1963)

Timbie Memorial Fund (1954)

F. B. Tough Fund (1924)

Frank P. Wakefield Loan Fund (1955)

Prizes and Awards

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

Alpha Chi Sigma Prizes (1965)

American Institute of Chemists Awards (1957)

Association of M.I.T. Alumnae Award (1958)

Avery Allen Ashdown Award

Baton Society Awards (1960)

Robert A. Boit Prizes (1921)

Karl Taylor Compton Prizes (1951)

The Frederick Gardner Fassett, Jr. Award

The Goodwin Medal

Ellen King Prize (1950)

Military Prizes

Outstanding Freshman Award

Phi Lambda Upsilon Award in Freshman Chemistry

Phi Lambda Upsilon Sophomore Award

Scott Paper Foundation Leadership Award

William L. Stewart, Jr. Awards (1964)

Stratton Prizes (1930)

Aeronautics and Astronautics

Luis de Florez Awards (1960)

James Means Memorial Prize (1925)

Henry Webb Salisbury Memorial Award (1941)

Architecture and Planning

Alpha Rho Chi Medal (1932)

Athletics

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

Class of 1948 Award

Admiral Edward L. Cochrane Award

Eastern College Athletic Conference Merit Medal

Chemical Engineering

Robert T. Haslam Cup (1959)

Hunneman Prize (1927)

Civil Engineering

A.S.C.E. Student Chapter Scholarship

Tucker-Voss Award (1953)

Richard Lee Russel Prize (1967)

Electrical Engineering and Computer Science

Morris J. Levin Award

Supervised Investors' Services, Inc. Awards (1957)

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

David T. Schultz Award (1969)

Management

The Brooks Prize in Management

Editorship of the Sloan Management Review

Sloan School of Management Senior Prize

Materials Science and Engineering

Metallurgy and Materials Prize (1963)

American Metal Climax Foundation Prize (1969)

Mechanical Engineering

American Society of Mechanical Engineers Student Paper Awards

Luis de Florez Awards (1957)

Silent Hoist and Crane Company Materials Handling Award (1950)

El Wellech — Corning Glass Works Award

Engineering Projects Laboratory — Showcase Awards

Meteorology

The Carl-Gustav Rossby Award in Meteorology

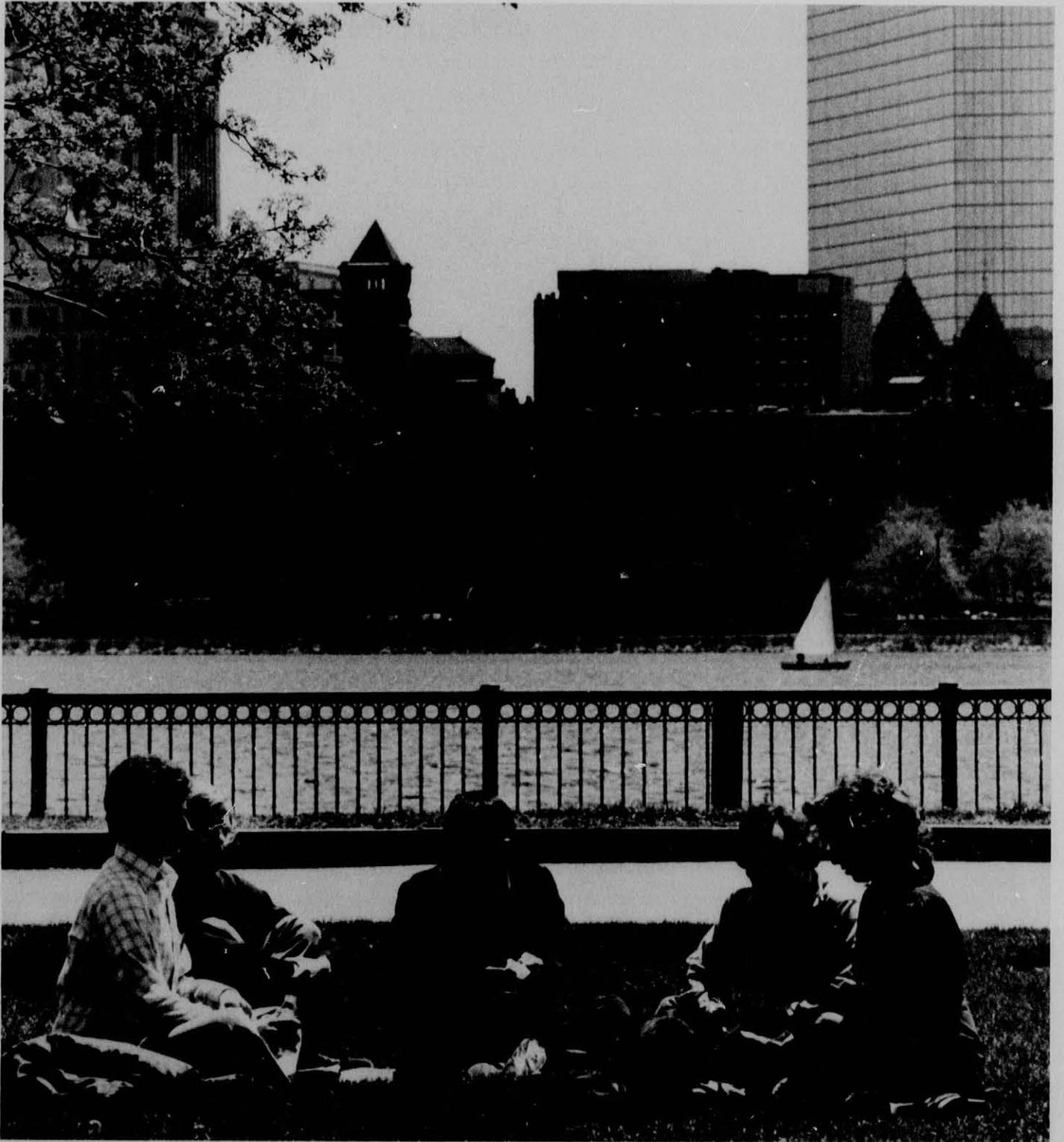
Ocean Engineering

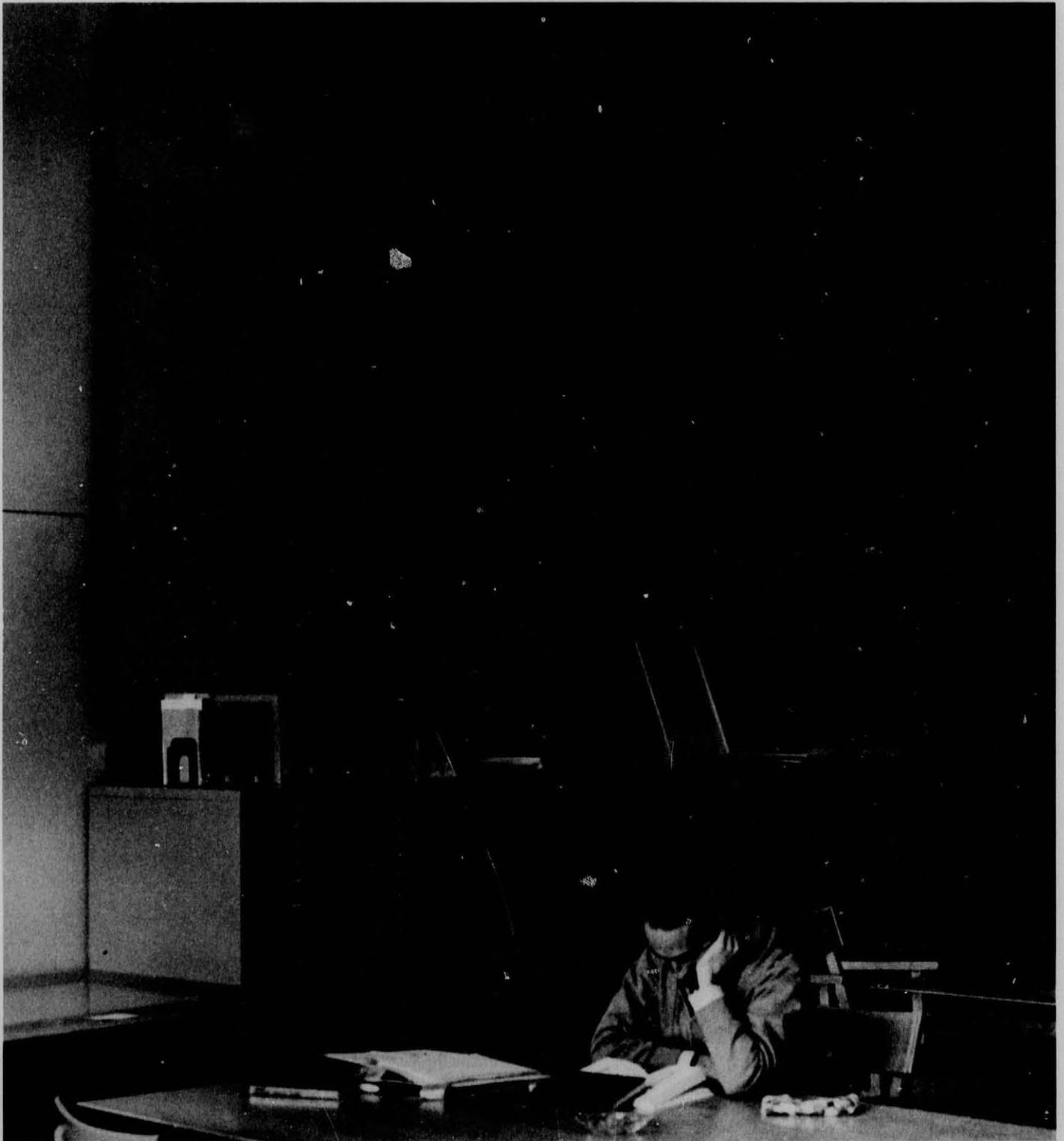
American Bureau of Shipping Prize, Naval Architecture and Marine Engineering (1924)

American Bureau of Shipping Prize, Ocean Engineering (1973)

Brand Award (1957)

Naval Ship Systems Command Award (1970)





Graduate Education at M.I.T.

For almost a century the M.I.T. Graduate School has provided an ideal environment for advanced study with 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 developed national prominence. In addition, graduate programs in economics and social sciences, architecture, urban studies, and management have become an integral part of the broadening spectrum of graduate education.

The most important factors in the effectiveness of the graduate programs at M.I.T. are the quality and productivity of the faculty. Faculty strength over a wide range of fields responds to student interests. M.I.T. is proud of its nationally and internationally recognized faculty of scholars and academic leaders who are also effective teachers and research collaborators.

Also of importance in the Graduate School is an atmosphere of intellectual independence and individual creativity combined with a strong sense of group unity and cooperation. The Graduate School aims to develop in each student the realization that one's intellectual growth and subsequent success are directly related to the depth of his or her command of basic principles. Although graduate study is often popularly associated only with a high degree of specialization, M.I.T. believes that such specialization should be coupled with extending intellectual horizons, producing new orientations, and developing depth of understanding.

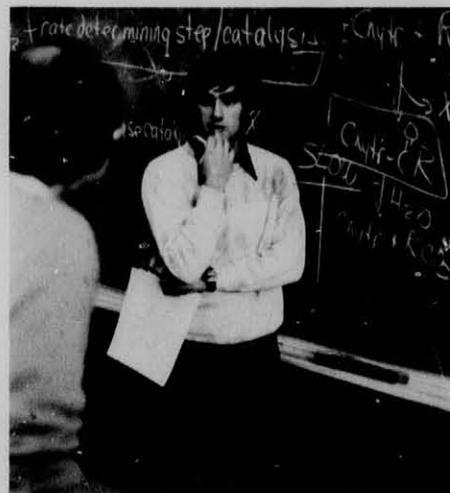
Successful graduate study is also closely associated with the ability to organize important ideas in clear and simple terms. Thus graduate students find assignments as teaching assistants rewarding and stimulating as an integral

part of their graduate education. These as well as positions as research assistants offer the student professional experiences. At M.I.T., graduate students are in a very real sense partners of the faculty in all aspects of study, teaching, and pioneering research.

Graduate education at M.I.T. places special emphasis on the relevance of science and technology to the complex problems of society. In order to attack such problems, it is often necessary to utilize an interdisciplinary approach which may involve expertise in several different departments. Although on an individual basis such programs can be developed for many students, there are other options which have become so well developed that special curricula are available. This is the case in interdisciplinary areas such as instrumentation, operations research, biomedical engineering, economics and urban studies, technology and policy, and environmental engineering.

The broad scope and high quality of its graduate education have made M.I.T. a leader in the international field. About a third of its graduate students come from foreign nations. In recent years it also

has become a place where minority students can participate profitably in academic work at all levels. Although it has always welcomed women graduate students, it is only in the last decade that an increasing number of women have found M.I.T. to be an ideal place in which to pursue study toward a graduate degree. Such broad representations of students from widely different backgrounds have contributed greatly to the enrichment of student life on the campus and to the excellence of the Graduate School.



Resources for Graduate Study

Extensive resources for graduate study have developed naturally at M.I.T. from a long tradition of emphasis on contributions to new knowledge. The wealth and diversity of teaching and research resources, described in this catalogue in the departmental sections and in the section on interdepartmental study and research, are a direct result of the pioneering interests of its faculty — interests that have generated both demand and support for research. Graduate students participate in all of the Institute's wide-ranging research activities; collaboration in research is vital to the educational experience of students and faculty and to the success of the research itself.

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 M.I.T.'s laboratories. In general, each graduate student's program can be designed to fulfill his or her own particular interests, subject to the general requirement that the field thus defined has a scope and depth appropriate for an advanced degree regardless of whether or not its boundaries happen to fall within the scope of a single department. Most important, the faculty tends to regard departmental organization more as an administrative convenience than a limitation of scholarly interests. The scope of many interdisciplinary programs and facilities is described in Chapter V, *Interdepartmental Study and Research*.

The M.I.T. Libraries provide a major resource for graduate study. Comprehensive collections are available in those fields in which M.I.T. concentrates its teaching and research efforts. Materials in subject areas beyond the scope of the M.I.T. Libraries are available at academic and research libraries in the Boston area which participate in the Boston Library Consortium. Through this cooperative program, graduate students, faculty members, and research staff have quick access to extensive research collections outside the Institute.

Another significant resource for graduate study is the cross-registration program with Harvard University (including the Medical School), Wellesley College, and the Woods Hole Oceanographic Institution. These programs and more specialized study opportunities available at Brandeis University, Tufts University, and Boston University are described in detail later in this chapter.

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

Graduate students are encouraged to use M.I.T.'s extensive athletic facilities. A number of teams composed of both undergraduates and graduate students participate in intercollegiate competitions, as well as the intramural athletic program. The Nautical Association welcomes graduate students as participants.

Organization of the Graduate School

The administration of the Graduate School rests with the President, the Chancellor, and the Provost of the Institute; the Dean, Associate Deans, and Assistant 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 program under general guidelines established for the Institute as a whole. Under the general responsibility of the Department Head, each department has a departmental Committee on Graduate Students, including one or more Graduate Registration Officers, to administer department graduate procedures. The Graduate Registration Officer and other members of departmental graduate committees advise and assist individual students in many aspects of their graduate work. The membership of the Committee on Graduate School Policy is listed with that of other faculty committees in Chapter VII of this catalogue.

The definitive statement of organization, rules, regulations, and procedures of the Graduate School is given in the *Graduate School Manual*. Copies are available from the Graduate School Office and from departmental graduate offices.

General Requirements for Graduate Degrees

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

The major fields for graduate study are listed. Each graduate program is described in individual department statements on graduate study in Chapter IV. These statements should be consulted for more specific information.

Each graduate student is officially enrolled in one department or Course. Departmental descriptions for each Course appear in detail in Chapter IV. 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 counsel of the faculty advisor to ensure that the overall program is integrated and well balanced with respect to a major field of study.

School of Architecture and Planning

Architecture, Course IV

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

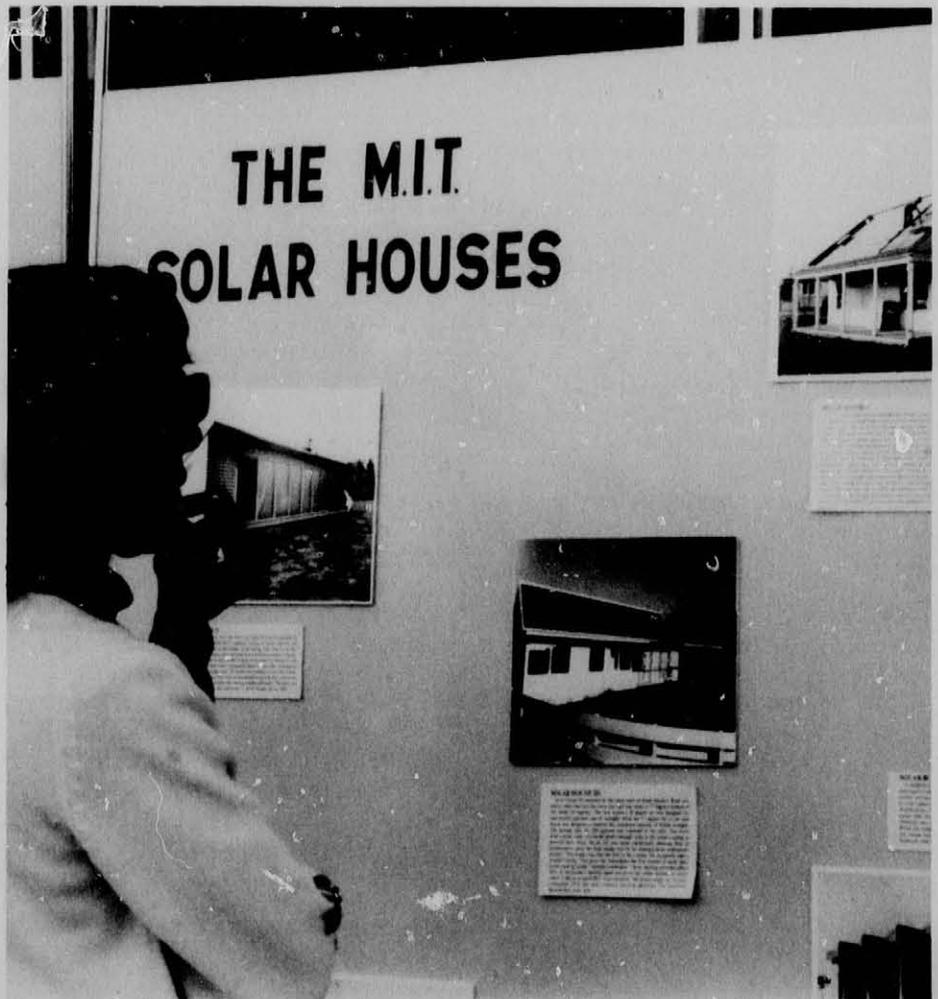
Urban Studies and Planning, Course XI

Urban and regional planning
Urban and regional studies

School of Engineering

Aeronautics and Astronautics, Course XVI

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



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

Chemical Engineering, Course X

Applied chemistry
 Biochemical engineering
 Biomedical engineering*
 Catalysis and reactor engineering
 Chemical engineering systems
 Engineering operations
 Environmental engineering*
 Fuel engineering
 Materials
 Materials engineering
 Polymers and plastics
 Technology and policy*

Chemical Engineering Practice, Course X-A

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

Oceanographic Engineering

Civil Engineering, Course I

Applied earth science
 Building systems
 Civil engineering
 Civil engineering systems
 Coastal engineering
 Construction engineering and management
 Earthquake engineering
 Environmental engineering*
 Geotechnical engineering
 Geotechnology
 Hydrodynamics

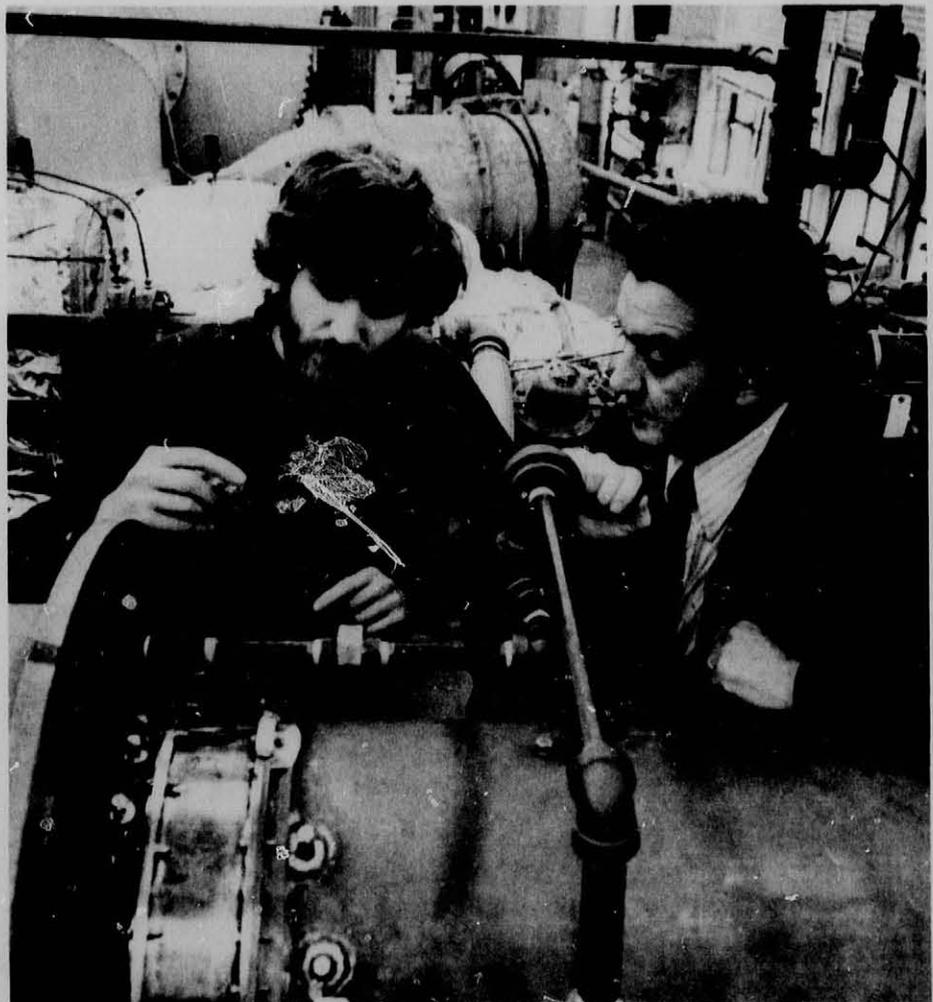
Hydrodynamics and coastal engineering
 Materials
 Materials engineering
 Operations research*
 Project management
 Soil mechanics
 Structural engineering
 Structural mechanics
 Structures
 Technology and policy*
 Transportation*
 Transportation systems
 Urban engineering
 Urban systems
 Water resources

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

Oceanographic Engineering

Electrical Engineering and Computer Science, Course VI

Electrical engineering
 Electrical science
 Artificial intelligence
 Bioelectrical engineering
 Biomedical engineering*
 Communications
 Computer science
 Control engineering
 Electric power systems



*Approved Interdepartmental Program

Electromagnetics
 Electronics
 Energy systems
 Operations research*
 Quantum electronics
 Solid state electronics
 System engineering
 Systems science
 Technology and policy*

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

**Materials Science and Engineering,
 Course III**
 Ceramics
 Materials engineering
 Materials science
 Metallurgy
 Polymeric
 Technology and policy*

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

Mechanical Engineering, Course II

Acoustics and vibration
 Applied mechanics
 Automatic control
 Biomedical engineering*
 Combustion
 Computational mechanics and finite
 element analysis
 Computation and microprocessor
 applications
 Computer-aided design/manufacturing
 Continuum mechanics
 Cryogenics
 Desalination
 Design
 Dynamics
 Ecosystems
 Energy conversion and conservation
 Environmental engineering*
 Fibers and polymers
 Fluid mechanics
 Heat transfer
 Internal and external combustion
 engines
 Man-machine systems
 Manufacturing
 Materials and materials processing
 Mechanical engineering
 Mining and resource engineering*
 Polymers and polymer processing
 Stress analysis
 Technology and policy*
 Thermodynamics
 Transportation*
 Tribology; friction, lubrication
 and wear

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

Ocean Engineering, Course XIII

Acoustics
 Applied mechanics
 Coastal zone utilization
 Environmental engineering*
 Fluid mechanics
 Hydrodynamics
 Marine data systems engineering

Marine engineering
 Marine resource development
 Marine transportation
 Naval engineering
 Ocean engineering
 Ocean engineering and law
 Operations research*
 Sea floor engineering
 Ship propulsion
 Ship systems
 Shipping and shipbuilding management
 Structural mechanics
 Technology and policy*

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

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

**Shipping and Shipbuilding
 Management, Course XIII-B**

Nuclear Engineering, Course XXII

Applied plasma physics
 Applied radiation physics
 Energy technology
 Fusion reactor engineering
 Nuclear fuel management
 Nuclear materials engineering
 Nuclear reactor engineering
 Nuclear reactor physics
 Technology and policy*

School of Humanities and Social Science

Economics, Course XIV

Linguistics and Philosophy, Course XXIV

Linguistics
Philosophy
Linguistics and Philosophy

Political Science, Course XVII

Psychology, Course IX

Brain science and behavior
Cognitive psychology
Developmental psychology
Experimental psychology
Neuroanatomy
Neurophysiology
Psycholinguistics
Sensory perception

Sloan School of Management

Management, Course XV

School of Science

Biology, Course VII

Biochemistry
Biophysics
Cell and developmental biology
Immunology
Microbiology
Physiology

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

Biological Oceanography

Chemistry, Course V

Analytical chemistry
Biological chemistry
Biophysical chemistry
Chemical physics
Inorganic chemistry
Organic chemistry
Physical chemistry

Earth and Planetary Sciences, Course XII

Geochemistry
Geology (classical geology, theoretical
geology)
Geophysics
Oceanography
Planetary sciences

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

Oceanography

Interdisciplinary Science Program, Course XXV (S.M. only)

Animal cell science
Environmental chemistry
Science communication
Science education
Special programs by arrangement

Mathematics, Course XVIII

Meteorology, Course XIX
Oceanography

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

Nutrition and Food Science, Course XX

Biochemical engineering
Food engineering
Food science and technology
Human and clinical nutrition
International nutrition planning
Neural and endocrine regulation
Nutritional biochemistry and
metabolism
Toxicology

Physics, Course VIII

Harvard-M.I.T. Division of Health Sciences and Technology

Biomedical sciences
Medical engineering
Medical physics



Master's Degrees

Candidates for advanced degrees must satisfactorily complete an approved program of study and research, including a major portion done in residence, before being recommended for a degree. The amount of time required to attain any one degree varies; candidates who lack undergraduate prerequisites for graduate work may be permitted to make up these deficiencies in the course of their graduate work, but those who do so must expect to spend a longer period of time in the Graduate School.

A student who expects to come to M.I.T. for an advanced degree after earning an undergraduate degree elsewhere should give careful attention to undergraduate subjects prerequisite for the advanced work which he or she intends to undertake as outlined by each department in Chapter IV. For advice on such subjects, a student should consult the chairman of the Committee on Graduate Students of the department in which he or she wishes to enroll.

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.

Residence Requirements

M.I.T. 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 minimum Institute residence requirement for Master's candidates is one academic term, not counting the summer term. For the Engineer's degree, two academic terms of graduate work must be completed with residence credit. Advanced study for the doctoral degree must be pursued for at least two academic years of full-time graduate work, including the research for and writing of a thesis, with residence credit. In the case of students who satisfy the Department Committee on Graduate Students that they have successfully accomplished advanced work of a standard comparable to that required at the Institute at another institution, the required period of residence may be reduced. In no case may the required period of residence be reduced to less than three terms, only one of which may be a summer term.

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. ("A" subjects are those intended primarily for graduate students. They are indicated in the descriptions of subjects given in Chapter V.)

A student who has obtained the degree of Bachelor of Science in Art and Design at the Institute or an equivalent degree at another institution may attain the degree of Master of Architecture in two years. A student who enters without previous experience in a department of architecture may take four years.

Master of Science, Master of Architecture in Advanced Studies, Master in City Planning

The degrees Master of Science, Master of Architecture in Advanced Studies,¹ and Master in City Planning are awarded upon the satisfactory completion of an approved program of study of at least 66 subject units (exclusive of thesis units), of which 42 units must be in "A" subjects, and the completion of an acceptable thesis. ("A" subjects are those intended primarily for graduate students and are so indicated in the descriptions of subjects given in Chapter V.)

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

¹ Students will not be admitted to this program after September 1979. See Department of Architecture for detailed information.

Engineer's Degrees

of the entire program must be obtained from this Committee and from the student's faculty advisor. A special interdepartmental committee, approved by the Dean of the Graduate School, may be appointed to supervise a program in an interdepartmental field.

The satisfactory completion of the Master's thesis generally requires the student to devote at least one term to research. 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.

Degrees With and Without Specification

In a program approved for a Master of Science degree, if 34 units of "A" subjects and the thesis are in a single field of science or engineering, the degree is recommended with specification in the field in which the student has thus specialized; otherwise, the degree is recommended without specification. The same high standard of academic performance in a program approved by a departmental Committee on Graduate Students is required for either degree.

Simultaneous Award of Two Master's Degrees

Occasionally an individual seeks two Master's degrees simultaneously or in sequence in different departments. When in the judgment of the departments concerned, good educational objectives are served, such a procedure is permissible within the following requirements.

If a single, common thesis is to be submitted to fulfill the requirements for both Master's degrees, the student must complete (in addition to thesis units) at least 126 subject units of which at least 60 subject units are unique to each departmentally approved program of 66

units. At least 42 units applying to each program must be "A" subjects.

If two separate theses are to be submitted, the student must complete (in addition to thesis units) 96 subject units of which at least 30 subject units are unique to each departmentally approved program of 66 units. At least 42 units applying to each program must be "A" subjects.

For the simultaneous award of two degrees, a student must file a petition stating the expected programs in both departments. This petition must be approved by the C.G.S.P. representative in each department and by the Dean of the Graduate School. Such a request must be filed with the Registrar **at least two terms** before the expected completion of the two degrees.

Please note that a common thesis may not be used to satisfy the requirements of more than two Master's degrees.

Simultaneous Award of Bachelor's and Master's Degrees

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

The requirements of a program leading to an Engineer's degree are at a more advanced level and a broader range of competence in engineering and science than that required for the Master's degree, but with less emphasis on creative 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.).

The requirement for such a degree is the satisfactory completion of a program of advanced study and research approved by the appropriate department or interdepartmental Committee of the School of Engineering. The minimum program consists of at least 162 subject units (exclusive of thesis units) and the completion of an acceptable thesis. The Engineer's thesis generally requires registration of a student for at least a term. Every degree candidate working on a thesis is expected to register for 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

M.I.T. offers the degrees of Doctor of Science and Doctor of Philosophy interchangeably in departments of science and engineering, as well as the degree of Doctor of Philosophy alone in urban studies and planning, economics, political science, biology, psychology, philosophy, linguistics, architecture, and management. These degrees certify to performance of original research of high grade and to creditable completion of an approved program of advanced study, principally at the Institute.

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

The program of advanced study and research may be selected in any field approved by the department in which the student is enrolled. The thesis is in this same field. The program often comprises 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, may 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.

Minor Program

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

Thesis

The caliber and scope of the doctoral thesis requires the equivalent of 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 M.I.T. faculty member or senior staff member approved by the department. Work already accomplished elsewhere which has not been under the supervision of an Institute faculty member cannot be accepted in fulfillment of the thesis requirement.

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

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

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 twice a year at the end of each term. Written and oral examinations in other approved languages are arranged individually upon request. A student who requests a written or oral examination in French, German, Russian, or Spanish at an unscheduled time, or in any other language at any time, is required to submit with the application a receipt from the Cashier indicating payment of a special fee of \$30 for this purpose.

Any student who fails to appear for a predoctoral language examination is subject to a fine of \$10.

Study at Other Institutions

Interdepartmental Programs

Many recent developments in the physical and social sciences and engineering reflect interdisciplinary trends. As a result of this, individual interests frequently span several conventionally defined fields. Thus a number of graduate students desire doctoral programs in fields that are adequate in both scope and depth to meet doctoral standards but whose boundaries overlap two or more departments. In certain areas, such as biomedical engineering, economics and urban studies, environmental engineering, instrumentation, medical engineering and medical physics, operations research, technology and policy, and transportation, special continuing committees provide guidance. In other fields, interdepartmental doctoral programs are administered by ad hoc committees appointed for each student and approved by the Dean of the Graduate School.

Harvard University

A graduate student at M.I.T. or Harvard University who is engaged full-time in study or in a combination of study and graduate student staff duties equivalent to full time may, by permission, enroll to take subjects (exclusive of thesis) at the other institution, 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 full-time Special Graduate Students who are registered at M.I.T. 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 by both M.I.T. and Harvard students wishing to enroll in subjects under this cooperative arrangement are given in the *Graduate School Manual*.

Wellesley College

Graduate students are eligible to participate in the Wellesley-M.I.T. Exchange Program. Details about the program may be found in *Wellesley-M.I.T. Exchange; Guide for M.I.T. Students*.

Woods Hole Oceanographic Institution

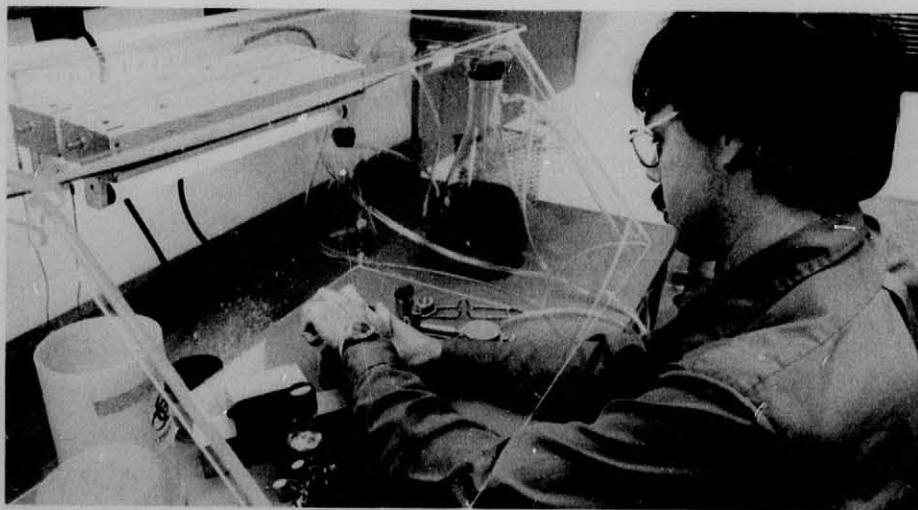
Information regarding the programs in Oceanography may be obtained from the Department of Earth and Planetary Sciences or from the Department of Meteorology at M.I.T. The Departments of Chemical Engineering, Civil Engineering, Electrical Engineering and Computer Science, Materials Science and Engineering,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

Boston University

An arrangement for cross-registration purposes has been made between the M.I.T. 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-M.I.T. cross-registration.

Brandeis University

A cooperative arrangement also exists between the M.I.T. Department of Urban Studies and Planning and the Florence Heller Graduate School for Advanced



General Academic Information

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 M.I.T.

Tufts University

A cross-registration agreement exists between the M.I.T. 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.

Foreign Study

The Graduate School Office, Room 3-136, has information on fellowship opportunities for graduate study and/or research abroad including the Marshall Scholarships, the Churchill Scholarships, Fulbright-Hays grants, and others. Since deadlines for the following year are in the early fall, interested students are encouraged to begin planning in the spring.

Registration

Each student is required to complete registration forms and present them to the Registrar on a date before the opening of each term specified in registration instructions. First-term registration is mailed during the early summer to newly entering students whose home address is in the US or Canada, and should be returned by the first week in August. Registration material for continuing students is usually available in May and can be picked up in the Building 10 Lobby for two days, after which it is available in the Registrar's Office. Second-term registration materials are available late in the first term in the Building 10 Lobby for two days and then in the Registrar's Office. An individual who has not completed registration procedures by the start of the sixth week of the term will be considered withdrawn and will be charged a pro-rated tuition for this period.

During the three weeks prior to the last day of classes of the regular term, or the last day of classes of the summer session, no subject may be dropped by a graduate student without a special petition approved by the departmental representative to the Committee on Graduate School Policy and the Dean of the Graduate School. The final date for canceling subjects without this approval will be posted outside Room 7-111 (the Information Center).

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 his or her approval.

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 field work; and preparation. The total unit credit for a subject is obtained by adding together all the units shown.

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 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 of the Graduate School 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.

Admissions

Regular Graduate Admissions

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, at a cost of \$2 per copy.

Graduate Academic Standards

Continuing registration of graduate students from term to term is contingent upon satisfactory academic performance. At the end of each term the Committee on Graduate School Policy reviews the academic performance of all graduate students. Particular attention is given to ratings below 3.5 to 4.0. In addition, departmental graduate committees may recommend to the Committee on Graduate School Policy that a student be warned or refused further registration or that he or she be allowed to register only for a less advanced degree.

Preprofessional Advising and Education

See the section on Preprofessional Advising and Education in Chapter III, Undergraduate Education at M.I.T., for a detailed discussion of programs and services in this area.

The term Regular Graduate Student denotes a student who is in residence at the Institute and is registered for a program of advanced study and research leading to any of the post-baccalaureate degrees offered by M.I.T. A Regular Graduate Student may concurrently hold a graduate student appointment such as research assistant, teaching assistant, instructor, or, rarely, assistant professor. 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 be admitted to the Graduate School for at least one academic term 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. The student's academic record and other credentials must indicate ability to accomplish satisfactorily an approved program of study and research.

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 applicants' capabilities, and any other pertinent data furnished by the applicants. While high academic achievement does not guarantee admission, such achievement, or other persuasive evidence of professional promise, is expected.

The engineering departments normally require students seeking a doctor's 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, 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. Customarily, the Departments of Architecture, Biology, Health Sciences and Technology, Psychology, Urban Studies and Planning, Economics, Political Science, Linguistics and Philosophy, and Management do not admit students in February or June.

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

Applicants attending colleges or universities on the semester system should not wait until the end of the fall semester at their institutions to submit an application for admission in June or September, but should apply before the end of the semester, submitting a transcript of fall grades as soon as it is available.

Applications for admission (except to the Sloan School of Management or to the Department of Chemistry) should be submitted to the Director of Admissions, Room 3-103, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139. A \$25 application fee must accompany the application form. Payment should be by check or money order, payable to the Admissions Office, M.I.T. 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.

Notification about admission for September is sent as soon as action is taken (usually before April 1); for February and June applicants, notification usually is sent as soon as the application is complete. The admission of a student who is in the final year of work toward a bachelor's degree is made conditional upon subsequently providing evidence that the degree has been awarded.

Requests for application material should be addressed to the Director of Admissions.

Applicants to the Sloan School of Management may request materials and information directly from the Graduate Office, Room E52-480, Sloan School of Management.

Inquiries about preparation or subject content should be addressed to the chairman of the appropriate departmental Committee on Graduate Students.

Graduate Record Examinations (GRE)

Applicants for admission to graduate study in the Departments of Biology, Economics, Materials Science and Engineering (only foreign applicants), Physics, Earth and Planetary Sciences, Political Science, Interdisciplinary Science Program, Health Sciences and Technology, Mathematics, and Psychology are required to submit scores in the Aptitude Test and in the appropriate Advanced Test of the Graduate Record Examination. The Department of Psychology also recommends that the Miller Analogy Test be taken. The Department of Biology will accept advanced test scores in either chemistry, physics, or biology. The Department of Chemical Engineering and the Operations Research Center normally expect to receive GRE aptitude scores and one Advanced Test score corresponding to the undergraduate major (usually chemistry or engineering). The Joint Programs in Oceanography and Oceanographic Engineering with the Woods Hole Oceanographic Institution require both the Aptitude and the appropriate Advanced Test. In the Department of Urban Studies and Planning, the GRE is required for Ph.D. but not for M.C.P. applicants.

The Department of Ocean Engineering highly recommends for all applicants and requires of all foreign students GRE scores including one Advanced Test. The Department of Electrical Engineering and Computer Science does not require, and makes no recommendation regarding these examinations.



International Graduate Admissions

All other departments recommend, but do not require, the submission of such scores, with the exception of the Sloan School. The Sloan School of Management requires scores on the Graduate Management Admissions Test, an aptitude test only. Applicants are urged to consult with appropriate departments to confirm test requirements and recommendations.

Information as to time and location at which these tests are given may be obtained by writing to Graduate Record Examination, E. T. S., Box 955, Princeton, New Jersey 08540. Inquiries from students in western states should be addressed to Box 1502, Berkeley, California 94701. M.I.T. students may obtain information about the tests from the Graduate School Office.

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 achieve distinction in an approved program of study and research. Admission is granted on a competitive basis. Successful applicants are chosen by the academic departments concerned according to an evaluation of their academic records and professional promise. Competence in written and spoken English is expected.

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.

Action on admission is not taken until complete application materials have been received by the Director of Admissions.

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 described in the section on Foreign Undergraduate Admission in Chapter III of this catalogue.

Some graduate departments recommend or require that an applicant take the Aptitude Test and the appropriate Advanced Test of the Graduate Record Examinations as a regular part of the admissions process. Applicants should consult the section on the Graduate Record Examinations, as well as the specific admission requirements set forth in the descriptions of departmental graduate programs.

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. Applications for the specific subjects desired will be evaluated by the Graduate Committee of the department(s) and must be approved by the departmental Graduate Registration Officer for each department in which a subject is taken. Approved applications are then processed through the Admissions Office. 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 \$25 application fee. To be allowed to continue as a Special Graduate Student, academic performance satisfactory to the Committee on Graduate School Policy must be maintained.

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 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 to what extent such subjects are acceptable and whether residence credit for them will be allowed.



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

Graduate School Admission for O.S. P. Staff

In view of their full-time responsibilities on assigned research and corresponding nonacademic salary scales, staff members of the Office of Sponsored Programs may not be full-time Regular Graduate Students, but may, under conditions outlined below, be granted the status of Special or Limited Graduate Student.

A graduate student may not interrupt an academic program to accept a staff appointment in the Office of Sponsored Programs (O. S. P.), the Charles Stark Draper Laboratory, or Lincoln Laboratory either during the academic year or during 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 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.

Many members of the O. S. P. staff study graduate subjects as Special Graduate Students. However, an O. S. P. appointee 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.

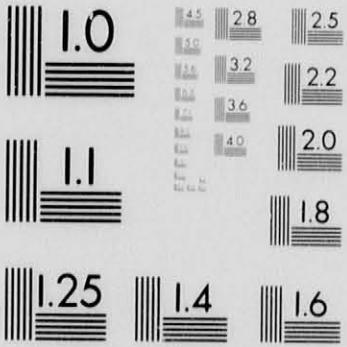
Any O. S. P. appointee may, by written permission from the director of the division (or his or her designate), apply for enrollment as a student in one subject only per term (but not thesis), either as auditor or for academic credit. Acceptance for such enrollment will be granted if, in the opinion of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

An O. S. P. appointee who at some previous time has held Regular Graduate Student status may, upon joint recommendation of a department graduate committee and the O. S. P. to the Dean of the Graduate School, be permitted to enroll as a Limited Graduate Student for the following purposes:

- 1
To take general doctor's or comprehensive Engineer degree examinations;
- 2
To take language examinations prescribed for advanced degrees;
- 3
To register or remain registered for thesis with simultaneous enrollment on a degree list, provided the student submitted the archive and library copies of the thesis before appointment in O. S. P., Lincoln Laboratory, or Draper Laboratory became effective;
- 4
To enroll on a degree list together with enrollment in one subject (not thesis).

However, not more than one of the above purposes may apply in any single term, nor will the privilege of taking one subject apply to terms in which permission is given for registration under aspects 1, 2, or 3 above. Furthermore, no request for enrollment on a degree list will be entertained (except under 4) until all degree requirements other than thesis presentation have been satisfactorily completed. O. S. P. appointees pay the fees or tuition as prescribed for Regular Students.

By approval of a Graduate Registration Officer, credits recorded for subjects completed as a Special Student may be accepted in partial fulfillment of advanced degree requirements of a graduate student of Regular or Limited status.



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS
STANDARD REFERENCE MATERIAL 1010a
(ANSI and ISO TEST CHART No. 2)

M. I. T. ANNUAL CATALOGUES AND BULLETINS

1979/80

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OF

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Costs for Graduate Students

The following are the basic tuition and fees at M.I.T. for the academic year 1979-80 (which are reviewed and likely to increase each year):

| | |
|---|---------|
| Tuition ¹ | \$5,300 |
| Hospital and Accident Insurance Policy ² | 130 |

The tuition for all regular graduate students, including graduate student staff, in the first and second terms is \$2,650 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 \$3,975, if not registered during preceding regular term. The tuition for all regular graduate students including fellows, trainees, and academic staff in the 1979 Summer Session was \$1,750. 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 are charged at the rate of \$85 per unit taken either for credit or not for credit. This unit fee applies up to a maximum of \$2,650 per term and is subject to the following minimum fees:

| | |
|--|-------|
| Members of the M.I.T. Community ³ | \$510 |
| Other Special Students | \$765 |

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 \$220 per week from the starting date of the term, with a minimum of \$220 for the Master's or

Engineer's degree and \$440 for the Doctor's degree. If the immediately preceding term was the summer term and if the graduate student was not registered for thesis in that summer term, but was registered for thesis in residence in the previous second term, the minimum tuition for thesis is \$1,325. 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 (\$400 per term for 1979-80). Following completion of the non-resident period, the student must return to resident status for completion and presentation of the doctoral thesis. If the student requires only part of this first term back in residence to complete the thesis, the tuition will be adjusted subject to a minimum of one-half of regular tuition. Please consult the *Graduate School Manual* for additional information on non-resident status.

Cooperative programs offered by M.I.T. 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), \$5,300

Chemical Engineering Practice, Course X-A
September-January or February-June, \$2,650

Electrical Science and Engineering or Computer Science and Engineering, Course VI-A
Materials Science and Engineering, Course III-B
July 1 to June 30, \$5,300

In each case, the first \$2,650 is due on the date when the first-term tuition is normally due, and the additional \$2,650 is due on the date when the second-term tuition is normally due. Upon recommendation of the Department, a special tuition rate for any cooperative program may be set by the Dean in an unusual case.

1

Payment of this fee entitles all regular and special registered students to comprehensive health care services at the M.I.T. Medical Department, including consultation with a wide range of specialists, diagnostic studies, and hospitalization in the M.I.T. Infirmary. Charges are made for routine eye examinations, contact lens services, ear piercing, dental care services, obstetrical care, 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 M.I.T. Student Insurance covers hospitalization (other than in the M.I.T. 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 with an \$850 maternity benefit is \$300. Hospitalization insurance for one or more children may be purchased for \$120.

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 \$160 per unit of registration, with a minimum charge of \$1,440. There is a maximum charge of \$4,800 per term for full-time special graduate students enrolled in the program. Students interested in the Accelerated Program of Graduate Study in Management should consult the Sloan School of Management with regard to fees.

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

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 Counselor 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.

Miscellaneous Fees

| | |
|--|------|
| Application Fee for Admission | \$25 |
| Late Registration Fee | 5 |
| Fee for Late Payments | 20 |
| Fee for Doctoral Degree Language Exam (given at an unscheduled time) | 30 |

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.

Graduate Living Costs

Living expenses for graduate students vary widely depending on such factors as marital status, availability of resources, interests, and tastes. Monthly living expenses for single graduate students generally range from about \$375 to \$630. This includes cost estimates for housing, food, medical insurance and fees, books, and other personal expenses. It does not include tuition. Campus housing for graduate students is limited and less than half of the graduate student population can be accommodated in Institute housing. On-campus dining opportunities are available to graduate students.

Payments

All payments are to be made to M.I.T., Cambridge, Massachusetts 02139, by the time specified in the financial registration instructions issued prior to the opening of each term. A late charge of \$20 is assessed for each payment that is not received when due. Registered student status can be withdrawn at any time for non-payment of fees. A student who expects to be a candidate for a degree must make satisfactory financial arrangements for any indebtedness prior to requesting entry of his or her name on the degree list.

A graduate student may arrange with the Student Accounts Office to defer payments over the term. (An administrative fee of \$20 will be charged for this service.) The deferred payment plan is currently being reviewed and may be modified (or discontinued) over the next several years as various alternatives are developed. Financial registration instructions and billings for tuition and fees will be sent to admitted and continuing graduate students prior to the beginning of each term.

Students and their families might consider the Parent Loan Plan, recently developed to help parents of M.I.T. students pay for educational expenses at M.I.T. 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 \$15,000 and \$60,000. Further information may be obtained from John Rogers, M.I.T. Parent Loan Plan Office, Box 160, Boston, Massachusetts 02101, (617) 253-3342.

Institute House Rentals and Meals

All term rentals for all houses and all fees for Commons meals are to be paid to the Cashier's Office, Room 10-180, prior to the beginning of each term.

Financial Aids

Fellowships, Traineeships, and Scholarships

Financial support is available to graduate students from a variety of sources and in several different forms — fellowships, traineeships, scholarships, teaching and research assistantships, work-study, and loans. Prospective students are strongly urged to explore all sources of aid available when considering means of financing their graduate education.

A fellowship or traineeship is an award to a graduate student which covers tuition 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. Awards are made on the basis of academic promise and financial need and are intended solely to assist students while pursuing 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 is fortunate to have received funds from individual donors and corporations which provide for the support of fellowships and scholarships each year. In addition, government agencies and foundations offer fellowships and other grants which they award either directly to outstanding students for use at institutions of their choice or, in a few cases, to M.I.T. 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 M.I.T., 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. All applicants are automatically considered for all awards for which they are eligible. 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 the previous January 15. Applications for fellowship aid filed after this date are considered only if funds are available. Applications for aid from prospective students will not be considered unless they have also filed the completed Application for Admission. 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 individually secures such an award is not considered further for a fellowship or traineeship by M.I.T.

Offers of financial aid from Institute resources are usually mailed for delivery by the end of March. In accordance with a resolution of the Council of Graduate Schools in the United States, endorsed by 180 graduate schools, 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 for the period of the award, pursuing a full program of studies (or the accepted equivalent in the case of teaching or research assistants). If a student with an award which is paid through M.I.T. 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. An award may be terminated for failure to maintain a satisfactory academic performance.

Teaching and Research Assistantships

M.I.T. employs about 450 graduate students each year as part-time or full-time instructors or teaching assistants to assist the faculty in grading undergraduate quizzes, instructing in the classroom and laboratory, and conducting tutorials. They receive salaries which, after taxes, are comparable to research assistant stipends, and in addition are usually awarded tuition scholarships.

After four years of intensive study at the undergraduate level, many students enjoy the new perspectives afforded by a teaching appointment. The departments regard seriously the benefits of a teaching assistantship as a preparation for a career in university teaching, and the Institute offers a prize each year — the Goodwin Medal — for conspicuously effective teaching by a graduate student.

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

Appointments to teaching assistantships are made upon recommendation of the head of a department. A student who wishes to be considered for a teaching appointment should write to the department; such applications from new students will be considered only after acceptance in a graduate program.

Each year about 1,200 graduate students at M.I.T. hold appointments as research assistants. They assist members of the faculty in the research projects that are a major characteristic of the academic life of the Institute and a prime reason for its vitality. It is a policy of the Institute to accept only such projects as will be in keeping with its educational objectives.

Most students prize the opportunity a research assistantship gives them to participate as junior colleagues of the faculty in an ongoing research project. The experience enlivens their course work and frequently influences their choice of thesis topic. In many cases a research assistant's thesis work contributes to the project.

Research assistants receive benefits comparable in attractiveness to fellowships. In view of the fact that the duties of a research assistant relate to the thesis work required for a degree, salary (which is applied in part to tuition) is considered the equivalent of a fellowship stipend for tax purposes, and taxes currently are not withheld. (A research assistant's stipend may be found liable to tax in an individual case.) The units for which a research assistant may register are determined by the department in the light of duties and program of study.

Appointments to research assistantships are made by the department head in the same manner as appointments to teaching assistantships.

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

Loan Funds and On-Campus Employment Opportunities

All M.I.T. students, regardless of financial strength, personal or parental, except those who are on foreign visa, are eligible for Guaranteed Student Loans, available generally through banks and other lending institutions in the student's state of legal residence. Students are expected to have explored this program before requesting loan funds from the Institute.

Prospective students would be well advised to inquire at the earliest possible date about their eligibility for such assistance. The interest rates and repayment provisions are fixed by Federal and state legislation but are more favorable than usual commercial terms.

M.I.T. administers a loan program under which financial assistance is available to all regular US graduate students upon submission of an application evidencing **need** according to College Scholarship Service and Federal guidelines. These applications may be obtained from the Student Financial Aid Office. This program augments the Guaranteed Student Loan (GSL) Program. Where possible, loans are made under the terms and conditions of the GSL Program. Loans from the Technology Loan Fund which are not guaranteed by the Federal or state programs must have a credit-worthy co-signer. In the interest of all its students, M.I.T. sets reasonable limits on the annual amounts borrowed from the fund, and on the total indebtedness allowed to accumulate to each borrower.

Scholarships and Fellowships for Graduate Students

Loans are not available to non-US students who are entering their first year of graduate study at M.I.T. Continuing non-US graduate students will be required to secure credit-worthy US or Canadian co-signers. Repayment rates for loans acquired from the Technology Loan Fund will be established on an individual basis by M.I.T. on graduation or termination of enrollment. GSL regulations established by the Federal government state a maximum repayment period of 10 years and a minimum annual repayment of \$360 on these notes.

Repayment begins nine months after graduation or withdrawal from school. Students may apply for deferment of repayment if they continue as students, or enter military service or the Peace Corps. A maximum of three years' deferment is allowed in the latter two cases.

A wide variety of on-campus employment opportunities exists at M.I.T., both for undergraduates and graduate students. Some of these may be funded under the Federally sponsored College Work-Study Program, which requires that a recipient be a US citizen or permanent resident, a degree candidate, and must demonstrate financial need.

Further information concerning loans, the College Work-Study Program, or other on-campus job opportunities may be obtained from the Student Financial Aid Office, Room 5-119.

National Fellowships for Graduate Study

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

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

Aid for Foreign Study

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

Numerous other fellowships exist for both graduate and postdoctoral study abroad. For an inclusive listing of international fellowships consult the Graduate School Office, Room 3-136, 253-4860. All of the above scholarships have early fall deadlines.

Aid for Study in Various Fields

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

Edward Austin
John F. Blackie Memorial
William Sumner Bolles
Helen Collamore
Marron W. Fort
Ida M. Green
Frank M. Greenlaw
Holland Hamilton Fellowship
Whitaker Health Sciences Fund
IBM
Johnson & Johnson Associated Industries Fund
John A. Lyons
Rockwell International
Henry Bromfield Rogers
Henry Saltonstall
Sandoz Foundation
James Savage
Susan H. Swett
Gerard Swope
Frank Hall Thorp
Thomas Upham
Jonathan Whitney
Xerox, Inc.
Hugh Hampton Young Memorial Fund

Aeronautics and Astronautics

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

Architecture

Avalon Foundation
Francis Ward Chandler Memorial Fund
W. Danforth Compton Memorial
William Emerson Fund
William Emerson
William and Frances Emerson
Samuel A. Marx
Floyd Narmore Architectural Memorial Fund

Chemical Engineering

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

Chemistry

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

Civil Engineering

W. H. Mills Construction Industry Fellowship

Earth and Planetary Sciences

Chevron (Standard Oil Company of California)

Special Loan Funds

Economics

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

Electrical Engineering and Computer Science

Gen Rad Foundation
 Grass Instrument Company
 Schlumberger Foundation
 Vinton-Hayes Fellowships in Communication

Management

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

Materials Science and Engineering

Allegheny-Ludlum Industries, Inc.
 American Metal Climax Foundation
 ASARCO Foundation
 Bethlehem Steel Corporation
 International Nickel Company, Inc.
 Owens-Illinois, Inc.

Mechanical Engineering

Allied Chemical Corporation Fellowship
 Alfred W. French
 Wilfred Lewis
 Polaroid Foundation Fellowship
 Weyerhaeuser Company Foundation Fellowship

Nuclear Engineering

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

Nutrition and Food Science

Bernard E. Proctor Memorial

Ocean Engineering

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

Physics

Karl Taylor Compton Fellowships

Research Laboratory of Electronics

RCA
 RLE

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

Walter Phelps Bliss Memorial Fund

Anna J. and Francesco Casaretta Loan Fund (1966)

Francis W. Chandler Loan Fund (1927)

Ruth Hornblower Churchill Memorial Loan Fund (1958)

Class of 1917 Loan Fund (1937)

Daunis Family Fund (1971)

George Freyberg Fund (1972)

Ethel I. Fryer Scholarship Loan Fund (1951)

Jerome C. Hunsaker Loan Fund (1970)

Rebecca R. Joslin Loan Fund (1924-36)

M. H. Rogers Loan Fund (1945)

Lillie C. Smith Fund (1965)

Gertrude W. Swartz Memorial Student Loan Fund (1971)

Technology Matrons Loan Fund (1960)

Robert Kelley Thulman Loan Fund (1963)

Timbie Memorial Fund (1954)

F. B. Tough Fund (1924)

Frank P. Wakefield Loan Fund (1955)

Prizes and Awards

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

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

Aeronautics and Astronautics

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

Architecture

Student Medal of the American Institute of Architects (1914)

Civil Engineering

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

Earth and Planetary Sciences

Christopher Goetze Prizes

Electrical Engineering and Computer Science

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

Management

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

Materials Science and Engineering

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

Mechanical Engineering

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

Meteorology

The Carl-Gustav Rossby Award in Meteorology





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 M.I.T. for faculty and students from different fields to work together in a variety of groups, laboratories, centers, and programs that cut across departmental lines. Out of these common research undertakings there are also emerging several education programs ranging from those which can be accommodated within certain departments to others which involve faculty from several Schools. Some of these educational programs lead to degrees, or form the basis for a "minor" program; many opportunities can be explored through the interdepartmental organizations and research facilities listed in this chapter.

Undergraduate Opportunities

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

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

Special Interdisciplinary Programs in Humanities
Study and Research in Education
Undergraduate Seminars
Unspecified Degree Programs

Graduate Opportunities

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

Acoustics
Biomedical Engineering
Cognitive Sciences
Economics and Urban Studies
Environmental Engineering
Environmental Studies
Interdisciplinary Science Master's Program
Law-Related Studies
Mineral Resources Engineering and Management
Oceanography and Oceanographic Engineering
Operations Research
Polymeric Materials
Power Engineering
Science, Technology, and Society
Study and Research in Education
Technology Adaptation Program
Technology and Policy
Transportation

Interdepartmental Organizations and Research Facilities

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

Arteriosclerosis Center
Artificial Intelligence Laboratory
Bates Linear Accelerator
Bitter National Magnet Laboratory
Cell Culture Center
Center for Advanced Engineering Study
Center for Advanced Visual Studies
Center for Cancer Research
Center for Cognitive Science
Center for Computational Research in Economics and Management Science
Center for Information Systems Research
Center for International Studies
Center for Materials Research in Archaeology and Ethnology
Center for Materials Science and Engineering
Center for Policy Alternatives
Center for Space Research
Center for Transportation Studies
Clinical Research Center
Division for Study and Research in Education (with faculty list)
Electric Power Systems Engineering Laboratory
Energy Laboratory
Innovation Center
International Nutrition Program
Laboratory for Computer Science
Laboratory for Information and Decision Systems
Laboratory for Manufacturing and Productivity
Laboratory for Nuclear Science
Laboratory of Architecture and Planning
Lincoln Laboratory
Mining and Minerals Resources Research Institute
Neurosciences Research Program
Nuclear Reactor Laboratory
Operations Research Center

Undergraduate Interdepartmental Opportunities

Plasma Fusion Center
 Research Laboratory of Electronics
 Sea Grant Program
 Spectroscopy Laboratory
 Technology Adaptation Program
 Wallace Astrophysical Observatory
 Wallace Geophysical Observatory

Other Opportunities

A number of research organizations in the Boston-Cambridge area have close ties with M.I.T. faculty members which may lead to opportunities for interdepartmental research. In particular, the Charles Stark Draper Laboratory which maintains a relationship with the Institute that permits students to engage in joint research activities.

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

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

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

Astronomy and Astrophysics

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

Biomedical Engineering

An area of study which is of increasing interest to undergraduate and graduate students alike lies at the interface between the engineering and life and health sciences. Investigations on such varied topics as biomaterials, biological control systems, and mechanisms of sensory perception, to name only a few, involve faculty and students from most of the engineering departments. Much of this research is carried out in interdepartmental laboratories in collaboration with workers from medical centers in the Boston area. The undergraduate wishing to explore this developing area has ample opportunity within his or her regular departmental major through elective subjects, special laboratory projects, and the senior thesis. These studies should be of special interest to students who are enrolled in a premedical curriculum. The Committee on Biomedical Engineering serves as an advisory body which can assist students in setting up interdepartmental programs. Further information may be obtained from Professor L. R. Young, Room 37-207, M.I.T., Cambridge, Massachusetts 02139, (617) 253-7759.

Concourse Program for First-Year Students

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

Environmental Studies

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

Undergraduates whose interests span more than one discipline may arrange a coordinated program of interdisciplinary environmental study by entering one of the unspecified degree programs sponsored by many of the departments. Undergraduate students who have a disciplinary commitment but desire a coherent minor program of environmental study may do so through use of the unrestricted electives available to them. Further information, lists of departmental advisors, and subjects offered on environmental issues are available through the Office of the Provost, Room 4-246.

Experimental Study Group (E.S.G.)

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

Once students join E.S.G., they decide on a course of studies with the assistance of E.S.G. advisors with whom they meet regularly throughout the term. Different styles of learning chosen by students in the past have included independent study, tutorials, self-paced materials, and small seminars and study groups. Freshmen are able to take one or two courses in the regular curriculum along with their studies in E.S.G. As

sophomores, they can take up to half of their courses in E.S.G. Some students stay on to become tutors to the new freshmen in the following years. In E.S.G., staff members, freshmen, upper-classmen, and alumni all share in a process of personal and intellectual growth. Throughout the program's 10 years of existence, the emphasis on personal interaction has made E.S.G. a unique part of M.I.T.

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

Interdisciplinary Research Opportunities

The Undergraduate Research Opportunities Program (UROP) provides undergraduates the opportunity to participate with M.I.T. 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. A "How to Participate" section in the UROP *Directory*, which is published each year, gives details on how to get started. Students are urged to read this before they embark on a project. Information on current projects is posted on the UROP bulletin board in the main corridor of the Institute, and in the UROP Office, Room 20B-141. New listings are announced each week in *Tech Talk*. Further information may be obtained by contacting the staff at the UROP Office, (617) 253-5049.

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

Interdisciplinary Science Degree Program (S.B.)

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

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

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

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

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

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

Law-Related Studies

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

In recent years, a substantial number of M.I.T. undergraduates from nearly every department have gone on to law school. The technically oriented undergraduate training serves students well in law school, and the combination appears to fill an important societal need as our technological world becomes progressively more regulated. In addition to the above subjects, there is a series of open seminars, held several times a year, designed to acquaint students with what lawyers actually do. Field research and work opportunities offer other means for testing an interest in the law. Last year an estimated 90 undergraduates worked off-campus in law-related research or other activities, including a summer Urban Legal Studies Program.

The Office of Preprofessional Advising and Education, Room 10-186, (617) 253-4158, and members of the Pre-law Advisory Council provide guidance and information for students interested in going to law school. They and the Coordinator of Law-Related Studies also have additional information regarding the Law-Related Studies Program at M.I.T.

Mineral Resource Studies

Study of many aspects of mineral resources for undergraduates at M.I.T. is possible through a variety of programs and laboratories. Related activities may be found in the Departments of Civil Engineering, Materials Science and Engineering, Mechanical Engineering, Chemical Engineering, Ocean Engineering, Earth and Planetary Sciences, Economics, Political Science, and the Sloan School of Management. Departments offer educational and research (UROP) opportunities in the fields which are related to their own disciplines. A student's interest often can be met through a minor program with the use of available electives.

Information on department advisors and special programs of study, and on issues of importance relating to mineral resources, is available at the Mining and Minerals Resources Research Institute, Room 4-140, M.I.T., Cambridge, Massachusetts 02139.

Science, Technology, and Society

The Program in Science, Technology, and Society focuses on the ways in which scientific, technological, and social factors interact to shape modern life. It traces the impact of scientific ideas and technological practices on society and culture and examines the role of social, political, and cultural considerations in shaping developments in science and technology. The Program's aim is to provide students with a better understanding of the human ramifications of science and engineering and to help them think more realistically and creatively about intellectual, moral, and social issues related to scientific and technological change.

The Program, which is the developmental phase of a prospective College of Science, Technology, and Society, draws its faculty from the social and natural sciences, engineering, and the humanities. The S.T.S. curriculum is organized around five general areas of inquiry: 1) the history of science; 2) the history of technology; 3) contemporary problems in science and technology; 4) science, technology, and the organization of industrial society; and 5) cultural dimensions of science and technology. Subject offerings examine such topics as the influence of ethical and political values on the work of scientists and engineers; the ways in which scientific concepts and ideas have contributed to the development of modern Western culture; how technological changes have altered the character of human work and affected the relationships people form with machines; and what constraints and areas of choice are created by the technologies of advanced industrial societies.

All S.T.S. undergraduate subjects can be counted toward the Institute Requirement in the Humanities, Arts, and Social Sciences; several Distribution subjects are offered, and Science, Technology, and Society can be chosen as a Field of Concentration. Although at present there is no undergraduate major in Science, Technology, and Society, special versions of the Humanities and Engineering and Humanities and Science majors in Course XXI are available for students who wish to integrate rigorous study in science or engineering with a systematic understanding of an area of humanistic knowledge.

A more detailed description of the Program is given in Chapter VI of this catalogue under the School of Humanities and Social Science. Further information may be obtained from the Director's office, Room 20D-213, M.I.T., Cambridge, Massachusetts 02139, (617) 253-4062.

Special Interdisciplinary Programs in Humanities

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

Study and Research in Education

The Division for Study and Research in Education focuses on fundamental questions of how individuals and institutions learn. The scope of the inquiries on individual learning spans work at different ages and in different educational settings.

Along the lines of this research orientation, the Division offers several elective subjects for undergraduate and graduate credit. As far as possible, students enrolled in each of these subjects will be involved in practical as well as theoretical work.

The Division for Study and Research in Education does not offer an undergraduate major in education. However, subjects offered in the Division (and many other subjects treating a wide variety of topics in education and offered in a number of M.I.T. departments) are available as electives for undergraduates interested in educational issues. Students especially interested in secondary school teaching should also see *A Handbook for Students Interested in a Career in Education*, prepared by the Committee on Preprofessional Advising and Education and available in Room 10-186. Further information may be obtained from the Education Division Administrative Officer, James McCarthy, Room 20C-126A, (617) 253-7362.

Undergraduate Seminars

The Undergraduate Seminar Program offers an opportunity for students to interact with faculty members in small, informal class settings. Seminars vary tremendously both in style and topic, some being oriented around small, informal class discussions while others may bring in speakers, go out on field trips, or involve extensive laboratory projects. Many of the topics are interdisciplinary, some being taught jointly by members of several departments; some others are topics of interest to faculty outside of their department's usual scope, so it is helpful to look through all of the offerings for topics that may be of interest.

For more specific details, including titles and descriptions of seminars, see the *Freshman Handbook* or the *Undergraduate Seminar Booklet*. These publications are available from the Undergraduate Seminar Office, Room 7-105, (617) 253-3621.

Unspecified Degree Programs (S.B.)

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

Graduate Interdepartmental Opportunities

Acoustics

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

In the main, the acoustical work within each department is in support of the "main-line" activities within the department such as communications, machine design, propulsion and guidance, and structural design. Most acoustical studies are interdepartmental in the sense that the subjects of instruction have few prerequisites and can be readily taken by students from any department. It is possible to set up more specialized interdepartmental programs of study and research in acoustics. One mechanism is the unspecified Master's degree in Engineering or Interdisciplinary Science. Another possibility is the establishment of a special faculty committee under the Office of the Dean of the Graduate School for doctoral students. Students normally enter the doctoral program by entry into one of the departments. If an interdisciplinary program is appropriate, a special faculty committee is established with representatives of the appropriate departments. The degree received may be departmental, or designate a specialty in acoustics.

Acoustics subjects fall generally within three categories. The first of these consists of basic subjects at both undergraduate and graduate levels. Beginning acoustics subjects are taught within the Departments of Electrical Engineering and Computer Science, Mechanical Engineering, and Architecture. A second group of subjects is in support of the various research activities in acoustics. These include subjects in speech communication, neural physiology and perception of speech, sound vibration and wave propagation, aerodynamic noise,

and medical ultrasonics. A third set of subjects are in the "professional practice" category, and include noise control, architectural acoustics, and sonar applications. A complete listing of these subjects is contained in the brochure *Acoustics at M.I.T.*

Students wishing further information regarding interdepartmental programs in acoustics should contact Professor Richard H. Lyon, Department of Mechanical Engineering, Room 3-366, (617) 253-2214.

Biomedical Engineering (S.M., Ph.D., Sc.D.)

The interdepartmental program in Biomedical Engineering focuses on engineering, the physical sciences, and mathematics as they relate to human biology and medicine; it leads to master's and doctoral degrees. These curricula are aimed at developing biomedical engineers who can function well in both the fields of engineering and life sciences, as, for example, bioengineers concerned with control systems, and with instrumentation for life support mechanisms; biomaterials scientists interested in developing materials for artificial organs and prosthetic devices; experts in fluid flow who are seeking a deeper understanding of how the cardiovascular system functions; and systems engineers interested in designing automated laboratories, model emergency rooms, operating rooms, and patient facilities that utilize the advantages afforded by modern science and technology.

Cognitive Sciences

Research and training in cognition are intensely pursued both within and across departments at M.I.T. and through the Center for Cognitive Science. Subjects appropriate for training in the cognitive sciences are offered in the following departments: Electrical Engineering and Computer Science, Linguistics and Philosophy, Psychology, and also in the Division for Study and Research in Education. No interdisciplinary program is formally available at present. However, graduate students who wish to have information or guidance about available resources across departments should consult members of the Committee on Graduate Studies in the Cognitive Sciences. Its members are: Professors Jonathan Allen (Electrical Engineering and Computer Science), Room 36-575, (617) 253-2509; Sylvain Bromberger, (Chairman, Linguistics and Philosophy, Philosophy Section), Room 20D-105, (617) 253-2645; S. Jay Keyser (Linguistics and Philosophy, Philosophy Section), Room 20D-105, (617) 253-4141; Mary C. Potter (Psychology), Room E10-032, (617) 253-5526; and Daniel Osherson (Division for Study and Research in Education), Room 20C-103, (617) 253-7367.

Economics and Urban Studies (Ph.D.)

A Ph.D. is offered jointly by the Departments of Economics, and Urban Studies and Planning at M.I.T. 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. It 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, (617) 253-2674, or from Professor William C. Wheaton, Room E52-262B, (617) 253-6663.

Environmental Engineering (Env.E.)

The School of Engineering offers an interdepartmental graduate program in environmental engineering leading to the degree of Environmental Engineer. The program is directed by a standing interdepartmental committee composed of faculty members from the various departments in the School of Engineering and is administered through the Office of the Dean of Engineering.

The program is designed to prepare students for careers in government, industry, and private practice where technical decision making is integrated with environmental planning and management functions. In addition to intensive preparation in an environmentally related area of engineering, this requires a background in relevant areas of social science, management, and law.

The purpose of this professional degree is to provide appropriate recognition and certification for a coordinated program of graduate study which is characterized by its breadth of scope and overriding concern with the interactions between technology and the environment.

Degree requirements include the completion of 162 approved subject units (exclusive of thesis units), of which at least half must be in graduate "A" subjects, and the completion of an acceptable thesis. Subjects will include basic engineering subjects, environmental engineering subjects, environmental policy subjects, and free electives. The thesis must deal with both the technical and the policy aspects of an environmental engineering problem. Thesis proposals must be approved by the standing interdepartmental committee.

Additional information about the Environmental Engineer degree may be obtained from Professor Michael W. Golay, chairman of the standing interdepartmental committee, Room NW 13-222, (617) 253-5824.

Environmental Studies

Environmental studies for graduate students at M.I.T. are available through a variety of departmental and interdepartmental subjects and laboratories. Through its several departments, the School of Engineering sponsors the degree of Environmental Engineer. The Energy Laboratory, an interdisciplinary, mission-oriented laboratory, supports research on environmental issues which cross academic departments and Schools. The Program in Technology and Policy promotes careers in the development and implementation of policies for the productive use and control of technology. Major research with opportunities for graduate study in environmental policy and impact assessment is undertaken by the Laboratory of Architecture and Planning and the School of Architecture and Planning. There also are opportunities in the environmental area under the auspices of the joint programs of M.I.T. and the Woods Hole Oceanographic Institution.

Many departments offer educational and research opportunities in those aspects of the environment which are closely related to their own disciplinary interests. Graduate students may also arrange special programs with the help of their advisors, and they may pursue interdepartmental programs leading to advanced degrees under the auspices of the Dean of the Graduate School. The courses of study available at M.I.T. include: air and water quality; pollution control; water, energy, and ocean resource management; public policy and planning for the environment; and the impacts of technology on the environment. See environmental listings under individual departments for more specific information.

Information concerning environmental education and research activities at M.I.T. is centered in the Office of the Provost, which works with faculty members and appropriate centers and laboratories. Further information and lists of departmental advisors are available through this office, Room 4-246.

Interdisciplinary Science Master's Program (S.M.)

A Master of Science degree is offered under the auspices of the Interdisciplinary Science Program. The objectives of this program are to provide an opportunity for graduate study in an interdisciplinary area with a strong science core, and to prepare students for positions in industry, government, education, or medicine where training beyond a bachelor's degree is required. Further details of this degree program, including a list of curriculum requirements for the degree, are given at the end of the School of Science in Chapter VI. The faculty member in charge of this program is Professor John M. Buchanan; the office is Room 6-219, M.I.T., Cambridge, Massachusetts 02139, (617) 253-5723.

Law-Related Studies

M.I.T. graduate students with interests in the legal or public policy aspects of their field can find a number of subjects, research projects, and people at M.I.T. concerned with law. There are subjects in the American legal structure and the judicial process, graduate seminars, and associated research in the legal aspects of the environment, urban planning, ocean resources, planning for legal institutions, construction, transportation, industrial safety, and computer science fields. In some areas, work is undertaken collaboratively with law schools in the area. In addition to several lawyers on the teaching staffs of five different departments, there are lawyers on the administrative staff with experience in a variety of fields which they are willing to share with students.

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

The M.R.E.M. program provides formal educational opportunities to students with interests in the mineral resources field, ranging from mining and processing to resource allocation and policy setting. The combination of academic subjects and research from the entire Institute makes it possible to offer programs in several areas of concentration, through which students are able to pursue a variety of careers in the mineral resources field. The M.R.E.M. program is a part of the Mining and Mineral Resources Research Institute at M.I.T., which coordinates activities in the Mineral Resources field. Studies in the M.R.E.M. program can lead to the Master of Science, Engineer, or Ph.D.

The M.R.E.M. program consists of four subprograms in exploration, extraction, processing, and resource management. The exploration subprogram exposes students to the geological, technical, and decision theoretical aspects of exploration. The student thus will become familiar with the important levels of planning and performing mineral exploration. The extraction subprogram provides a background for design of surface or underground mines, selection and development of mining machinery, management of large projects, and resolution of environmental problems. The processing subprogram deepens the student's physical and chemical education and, based thereupon, leads to the analysis and design of industrial processes including their managerial and environmental aspects. The resource management subprogram encompasses the widest range of all the subprograms. Appropriate aspects of systems engineering, economics, and public policy are covered, as well as problems of substitution and of related resources (water, energy). Depending on the student's inclination, the emphasis of the resource management subprogram can be placed on engineering, management, or public policy. The resource management subprogram also provides the framework for an M.R.E.M. general overview, which is aimed at students desiring a broader education. Such students would take resource management subjects and selected subjects from the other three subprograms.

In studying for the Master of Science, a student usually will take at least 75 percent of the required credit units from one of the subprograms and the remaining credit units from one of the other subprograms. Engineer and Ph.D. students usually will concentrate at least half of their credit units in one of the subprograms and take the remaining credit units from at least two of the other subprograms. Research projects that are suitable for thesis work are conducted in most of the participating departments.

Students desiring to pursue their studies in the M.R.E.M. program should apply for admission to graduate studies in the department best suited to their interests. This can be in the department in which most of the subjects will be taken, the department in which the thesis research will be conducted, or the department corresponding to the student's prior education. Students will be awarded the graduate degree in this department.

The participating departments are: Civil Engineering, Mechanical Engineering, Materials Science and Engineering, Chemical Engineering, Urban Studies and Planning, Earth and Planetary Sciences, Ocean Engineering, Economics, Management, and Political Science.

A prospectus containing detailed information on the M.R.E.M. program, including listings of academic subjects in each of the subprograms, possible research areas, and the M.R.E.M. faculty contacts in each of the participating departments, may be obtained from Herbert H. Einstein, Room 1-330, (617) 253-3598.

Oceanography and Oceanographic Engineering (Eng., Ph.D., Sc.D.)

M.I.T. and the Woods Hole Oceanographic Institution (W.H.O.I.) on Cape Cod offer joint programs of graduate study and research for students with special interests in biological oceanography, chemical oceanography, marine geology, marine geophysics, oceanographic engineering, and physical oceanography. These graduate programs are administered by committees drawn from the faculty and staff of both institutions. Students accepted to the Joint Program have access to the extensive intellectual and physical resources available for advanced study at both W.H.O.I. and M.I.T.

The Joint Program involves several departments at M.I.T. — Biology, Earth and Planetary Sciences, and Meteorology in the School of Science and Chemical Engineering, Civil Engineering, Electrical Engineering and Computer Science, Materials Science and Engineering, Mechanical Engineering, and Ocean Engineering in the School of Engineering. Details concerning entrance requirements, examinations, financial aid, etc. may be found in the descriptions of each individual department and the description following the School of Engineering and the School of Science sections. Information on the overall Joint Program may be obtained from the Dean of Graduate Studies, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts 02543, or from the Joint Program Office, Room 54-912, M.I.T., Cambridge, Massachusetts 02139.

The Department of Earth and Planetary Sciences and the Department of Meteorology offer programs with the Woods Hole Oceanographic Institution in **chemical oceanography, marine geology, marine geophysics, and physical oceanography**. The programs are coordinated by either department and may involve research in other departments at M.I.T., such as Chemistry. The programs all lead to the Doctor of Philosophy or the Doctor of Science.

Programs in **biological oceanography** are offered jointly with the Woods Hole Oceanographic Institution and lead to the Doctor of Philosophy or Doctor of Science. The programs are coordinated by the Department of Biology and may involve research at W.H.O.I., or other departments at M.I.T. such as Nutrition and Food Science. Program requirements are tailored to individual needs and include preparation in basic areas of biology and marine ecology.

The Departments of Chemical Engineering, Civil Engineering, Electrical Engineering and Computer Science, Materials Science and Engineering, Mechanical Engineering, and Ocean Engineering offer joint programs in **oceanographic engineering** with W.H.O.I. These programs lead to the Engineer, the Doctor of Philosophy, or the Doctor of Science. Students interested in oceanographic engineering, oceanography-related engineering problems, engineering in the ocean, or the control of the ocean and its resources can be served by the Joint Program in Oceanographic Engineering.

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

The Operations Research Center, established in 1953, provides educational and research opportunities for students and faculty interested in the interdepartmental field of operations research. Varied programs leading to the master's and doctoral degrees with emphasis on either applied or theoretical areas are available. Students usually take a core of basic subjects which provide sound understanding of operations research methodology. This allows considerable flexibility to continue into theoretical research or to begin any of a variety of applications. Current areas of active theoretical research include mathematical programming, decision analysis, and stochastic systems. Areas of application include both industrial and public problems. Industrial applications include production and distribution systems and marketing. Public systems applications encompass health services, police operations, housing, energy, and transportation. In most applications emphasis is laid on the successful integration of field data and measurements with mathematical models and computers to assist managerial decision making.

Entering students wishing to concentrate specifically in operations research at the doctoral level may apply directly to the interdepartmental doctoral program. This can be done by inserting the phrase "Operations Research — Interdepartmental Program" at all places in the admission materials which require filling in "Department of ____." The assignment of a formal department of registration for these students is arranged by the Operations Research Center, and the supervision and administration of the entire doctoral program is provided by an interdepartmental committee on operations research.

Doctoral candidates wishing to enter a specific department, either because they wish to combine substantial content in some specific field with their operations research study or because they are uncertain as to their interests at the time of application, should apply to the academic department of their choice. These students may wish to pursue graduate programs within their departments while taking subjects related to operations research and engaging in research which uses methods of the field. Or, during the first or second year of their graduate program, they may decide to apply for admission to the interdepartmental doctoral program in operations research. Subsequent steps to the attainment of the doctoral degree are the same as for people entering directly.

The goal of the doctoral program in operations research is to enable a person to contribute to research in his or her specialty at M.I.T. and during a professional career. The program provides a strong background in the theoretical foundations of operations research and the techniques used to develop and analyze mathematical models of complex systems arising in economic, social, and physical contexts.

The master's program in operations research prepares students for professional work in a broad variety of public and private institutions. A person takes a core of basic theoretical materials and adds specialized subjects to suit particular educational objectives. Individuals wishing to specialize specifically in operations research should insert "Operations Research — Interdepartmental Program" at appropriate places in the admissions materials as described above. Students seeking a departmental master's degree with relatively less emphasis on operations research should apply to the department of their choice.

The Operations Research Center is particularly interested in minority and women applicants. The Center offers research and teaching assistantships in most of the fields in which the Center is active. Further information on financial assistance and on admissions procedures in general may be obtained by writing directly to the Operations Research Center, Room 24-215, or by calling (617) 253-3601.

Polymeric Materials

Polymeric materials span a remarkable range of structures and properties, presenting a diversity of challenges and opportunities for several interacting disciplines. Considering both the fundamentals and technology involved, polymer science and engineering is now one of the most rapidly expanding areas in the field of materials. Polymers can exist in various combinations of amorphous and crystalline states, leading to properties that may be described as rubbery or glassy, strong or weak, tough or brittle. They also exhibit unique rheological behavior which permits the processing into many forms, including fibers, films, and composite materials.

Interdepartmental graduate degree programs focusing on polymeric materials are available to students enrolled in polymer-related departments. For example, a student may register in the Department of Civil Engineering, Mechanical Engineering, Materials Science and Engineering, or Chemical Engineering, and have his or her program of classwork and research specially arranged in consultation with an ad hoc interdepartmental committee chosen for the purpose. This procedure allows for a high degree of flexibility, depending on the candidate's central interests.

In addition to the core subjects in the program, students may concentrate in one or more areas related to polymers, such as synthesis, processing, characterization, structure-property relationships, surface phenomena, biopolymers, fiber technology, and composites.

More specific information concerning interdepartmental study and research on polymeric materials may be obtained from Professor F. J. McGarry, Departments of Civil Engineering and Materials Science and Engineering; Professor A. S. Argon, Department of Mechanical Engineering; Professor D. R. Uhlmann, Department of Materials Science and Engineering; or Professor E. W. Merrill, Department of Chemical Engineering.

Power Engineering

Academic and research programs in power engineering exist on an interdepartmental basis in the Departments of Aeronautics and Astronautics, Electrical Engineering and Computer Science, Mechanical Engineering, Ocean Engineering, and Nuclear Engineering. These programs cover a diversity of energy-related issues.

Research in power systems is carried on by individual professors in various departments as well as at the Gas Turbine Laboratory, Electric Power Systems Engineering Laboratory, Sloan Automotive Laboratory, Energy Laboratory, Engineering Projects Laboratory, Heat Transfer Laboratory, Cryogenics Laboratory, and at the Nuclear Reactor.

A student enrolled in any department may construct from among various subject offerings and research activities an academic program and thesis research which he or she wishes to pursue. In addition to subjects treating specific topics in power engineering, many other related subjects are available on such topics as thermodynamics, fluid mechanics, heat transfer, control theory, materials, stress analysis, vibrations, cryogenics, and combustion.

Research assistantships are available for graduate students, and some part-time employment is available for undergraduates. For further information on the programs and on financial support, the Graduate Registration Officer of one of the participating departments should be contacted.

Science, Technology, and Society

The Program in Science, Technology, and Society focuses on the ways in which scientific, technological, and social factors interact to shape modern life. It traces the impact of scientific ideas and technological practices on society and culture and examines the role of social, political, and cultural considerations in shaping developments in science and technology. The Program's aim is to provide students with a better understanding of the human ramifications of science and engineering and to help them think more realistically and creatively about intellectual, moral, and social issues related to scientific and technological change.

The Program, which is the developmental phase of a prospective College of Science, Technology, and Society, draws its faculty from the social and natural sciences, engineering, and the humanities. The S.T.S. curriculum is organized around five general areas of inquiry: 1) the history of science; 2) the history of technology; 3) contemporary

problems in science and technology; 4) science, technology, and the organization of industrial society; and 5) cultural dimensions of science and technology. Subject offerings examine such topics as the influence of ethical and political values on the work of scientists and engineers; the ways in which scientific concepts and ideas have contributed to the development of modern Western culture; how technological changes have altered the character of human work and affected the relationships people form with machines; and what constraints and areas of choice are created by the technologies of advanced industrial societies.

S.T.S. offers several graduate-level subjects jointly with other M.I.T. departments, but does not yet have a formal graduate program. Graduate students who wish to pursue questions concerning interactions among science, technology, and society are encouraged to consult with S.T.S. faculty members about the variety of arrangements which can be made to meet their needs and interests. Students can participate in research and reading seminars, become involved in faculty research projects, and, with departmental permission, structure a special field of study or minor in S.T.S. as part of their degree program. Individually tailored interdepartmental degree programs also can be arranged.

A more detailed description of the Program is given in Chapter VI of this catalogue under the School of Humanities and Social Science. Further information may be obtained from the Director's office, Room 20D-213, M.I.T., Cambridge, Massachusetts 02139, (617) 253-4062.

Study and Research in Education (Ph.D.)

The Interdisciplinary Ph.D. program offered by the Division for Study and Research in education is open to graduate students interested in research and professional careers in fields related to education. There are considerable resources for such study at M.I.T. and the D.S.R.E. offers a unique learning opportunity. Like the Education Division itself, the Interdisciplinary Ph.D. program encourages new paradigms of education research for students who wish to take the initiative and responsibility for shaping their programs of study and research. Currently, graduate students in the Division have joint programs with the Departments of Electrical Engineering and Computer Science, Linguistics and Philosophy, Management, Mathematics, Physics, Psychology, and Urban Studies and Planning.

Insightful research in education requires a combination of skills from many disciplines; professionals need competence in the subject matter (architecture, chemistry, history, mathematics, physics, etc.), knowledge about the nature of thinking at different ages, and insight regarding the nature of instruction. The training of such professionals requires combinations of theoretical and practical work, and the development in the individual of new syntheses of fields which are appropriate to his or her specialty.

Most of the members of the Education Division are deeply engaged in the study of both formal and informal thinking. The following examples are presented to give a sense of the current range of interests within the Division. The LOGO project is engaged in important new approaches to education under the general heading, "Learner as Model Builder." Examples of this work are: the common sense thinking of ordinary life as well as

the intuitive-heuristic thinking of scientists; and model building underlying problem-solving processes. A study of the "generative processes" examines how people come to see something in a new way and how they learn to restructure their underlying ways of making sense of some phenomena. Research into professional education studies what an architect, planner, teacher, or lawyer does while engaged in doing his or her job in contrast to what he or she teaches or is taught in preparation for that job.

The Division encourages multiple approaches to similar phenomena. Thus, the study of relationships between "Mathematics" and "non-math" thinking and the relationship between "verbal" and "visual" thinking also are being developed.

Another major interest within the Division is the study of how organizations (particularly educational institutions) learn, make decisions, and change. The subtle and overt processes operating within and on educational institutions are explored by means of actual case studies. This area is being developed jointly with several departments, including faculty from Urban Studies and Planning and the Sloan School.

The Admissions Committee of the Interdisciplinary Ph.D. program is interested in the student's overall academic record, professionally related experience, and intended course of study. The Admissions Committee looks for evidence that a particular candidate will be able to design and follow an effective strategy of inquiry and/or interests which can be investigated adequately at M.I.T. For these reasons, the Admissions Committee reads with great care the personal statement of the applicant. This statement should be a thorough and detailed discussion of the applicant's experience, thinking, and professional objectives; and as specifically as possible, his or her chief academic inter-

ests. For admission to the Interdisciplinary Ph.D. program, applicants must be qualified for admission according to the regular criteria of the department to which they apply.

The M.I.T. Graduate School application material, together with a statement of interest in the program and career objectives, should be submitted to the Admissions Office, Room 3-108. Application for financial aid should accompany the admissions application. Following concurrent department and program acceptance, applicants will be notified before April 1 of admission to the program for the subsequent year.

Following established procedure for interdepartmental graduate programs, the Dean of the Graduate School will appoint a faculty committee to supervise all aspects of the Ph.D. program for each student. This committee will include representatives from the student's department of registration and the D.S.R.E. Each student is expected to present a thesis in education or interdisciplinary research. The Ph.D. will be awarded through the student's department on recommendation of his or her faculty.

Further information may be obtained by contacting the Dean of the Graduate School, Room 3-134, or the Education Division Administrative Officer, James McCarthy, Room 20C-126A, (617) 253-7362.

Technology Adaptation Program

The Technology Adaptation Program (TAP) provides educational and research opportunities for Master's candidates who are interested in the transfer and adaptation of the technologies of their own areas of specialization to the needs of developing countries.

Students who elect this program submit a proposed program for approval of the TAP Advisory Committee. This program includes the subjects required for the chosen area of concentration, and

- 1
At least one subject which deals with management techniques of special importance to developing countries;
- 2
at least one graduate subject in economics which includes material related to the needs of developing countries;
- 3
at least one subject in the social sciences area which deals with the structures required to support the application of technologies in developing countries; and
- 4
at least one graduate subject in an engineering area related to the transfer, adaptation, and/or development of new technologies for developing countries.

Students' proposed thesis topics also require approval of the TAP Advisory Committee, as well as of the departments in which the students are registered. The thesis is to include material relating to the transfer or adaptation of some aspect of the technology of the area of specialization to the needs of developing countries, or to the development of some aspect of the area of specialization for the use of developing countries.

Students interested in working on TAP projects who cannot fulfill all the requirements of the program may be accepted for participation provided they submit a statement with the program proposal which describes the circumstances which, from their point of view, make the deviation justifiable. Each case is judged on its own merits.

Students who elect this program should note that depending upon the number of subjects required for their area of specialization, the total units required for graduation may be higher than the 66 units minimum required by the Institute.

Students may receive financial support in the form of research assistantships associated with current TAP research projects.

A list of these projects and/or further information about the program may be obtained by contacting the TAP Administrative Office, Room 39-525, (617) 253-7227.

Technology and Policy (S.M.)

The Program in Technology and Policy is an educational program that promotes careers in the development and implementation of policies for the productive use and control of technology. It is unique in the opportunities it affords students for pursuing their own educational program from a strong basis in engineering and science.

Broadly speaking, the Program educates "engineers with a difference," that is, persons with strong technical foundations and competence in dealing with policy issues.

Challenging jobs are open to men and women who combine a base in technology with skills in identifying, analyzing, and implementing policy issues. Former Technology and Policy students now fill important positions in private industry, Federal, state, and local government, and in independent consulting. Many are also working on the problems of developing areas.

Students may study problems of interest in any of the fields of technology. These cover a wide range, reflecting the concerns of faculty and staff at M.I.T. The following issues now under investigation suggest some possibilities:

- How should pollution by toxic chemicals be controlled? When is it technically efficient to intervene in the cycle of use, and what legal or economic restraints are effective?
- How can energy consumption be reduced through materials recycling, and how would this policy be implemented? What are the technical, economic, and political trade-offs of different strategies?
- What kind of international arrangements might lead toward a sound development of marine resources in petroleum and minerals?
- What are the effects of government research and development policies on industrial innovation?

The Program leads to a Master of Science in Technology and Policy from which graduates may enter directly into public or private practice. Alternatively, they may elect to continue graduate or professional study at M.I.T. or elsewhere.

The Program provides a supportive context for its students, and encourages close interaction. The size of the Program helps — about 25 students enter

each year. Also, students are provided office spaces so that they may work closely together. The Program's supportive environment is a matter of deliberate policy. We anticipate and operate on the expectation that all new students are highly qualified and will do well in their courses at M.I.T. We encourage collegial and cooperative relationships, not competitive ones.

The Program intends to develop proficiency in policy analysis and implementation for technological problems. This requires 1) an advanced competence in a specific technological area of the student's choice, 2) skills in policy analysis, 3) an understanding of the context of policy issues, and 4) project and thesis work in bringing the above together.

Students either take or demonstrate competence (on the basis of prior courses or experience) in 1) a concentration of three advanced subjects in a chosen field of technology, 2) an introductory and an advanced subject in systems analysis, and two intermediate level subjects in economics, and 3) two subjects in law and political processes. Academic credit is routinely granted for comparable studies elsewhere.

Individual curricula are developed in consultation with individual faculty advisors. Students are encouraged to take full advantage of the wide range of subjects available at M.I.T. in arranging programs of study appropriate to their aspirations and interests. To provide a common base of development for all participants in the Program, students are generally expected to enroll in the following subjects: 1.146J/2.192J/3.56J/13.62J Engineering Systems Analysis; TPP 11 and TPP 12 Project Proseminar in Technology and Policy; 14.120 Microeconomic Theory or 15.012 Applied Micro and Macroeconomics; 17.750J/TPP 22J The Policy-Making Process.

The Proseminar and thesis are especially important aspects of the student's program. The Proseminar helps students confront policy issues as they really are: very complex and difficult, often ill-defined, and full of conflicting values. It is frequently a frustrating experience but, in the end, is generally felt to provide a unique and necessary experience. The Proseminar is the element that distinguishes this Program from just a set of subjects. It provides the common ground where students meet to discuss issues of technology and policy.

The thesis is a major effort by the student to do a serious analysis in his or her field of interest. Theses frequently are published by M.I.T. as reports or professional papers. They represent the equivalent of two or three subjects and are often done over the summer.

Students in the Program can proceed to doctoral studies through either departmental or interdepartmental arrangements. Indeed, the Program serves as a good base for helping students identify fruitful areas of research and further studies. At present, about one-fifth of the students are availing themselves of these opportunities.

Students with prior interests and capabilities in technology and policy are expected to complete the degree program in one calendar year. Other students may have to extend for an additional semester.

A number of full and partial fellowships are available. As they will be distributed to qualified students at the time their applications are reviewed, prospective students are urged to apply early so that they have the greatest chance for favorable consideration.

All applicants are encouraged to apply for other fellowships that may be available to them, for example through the National Science Foundation, professional societies, or other organizations. Information on aid from governmental agencies, as well as private foundations, may be found in *The Grants Register* available in most public or university libraries. Experience indicates that the kind of student admissible to graduate school at M.I.T. has a good chance of receiving a fellowship. The Program itself is also more favorably inclined to helping those who have taken the initiative to look for support themselves.

Students can obtain professional, part-time jobs as research assistants on M.I.T. projects that match their areas of specialization. Many students regularly work in either the Center for Policy Alternatives or the Energy Laboratory, both at M.I.T. These are best arranged once the student has become acquainted with current activities and has developed basic expertise in technology and policy. In exceptional cases, these jobs may be arranged before the student arrives at M.I.T.

Prospective US students are advised that, under the prevailing government terms for deferred, low-interest loans for college study, it is probably financially advantageous for them to borrow money in order to proceed full-time with graduate studies and enter jobs as soon as possible. Foreign students also can receive low-interest loans from M.I.T.

Applicants should have a strong basis in technology. Applications will be reviewed by the interdepartmental steering committee of the Program and by M.I.T. departments corresponding to their particular interests. This process starts January 30, and candidates will be notified as rapidly as possible.

The Steering Committee for the Program consists of Nicholas Ashford, Associate Professor, School of Engineering and Senior Research Associate, Center for Policy Alternatives; Joel Clark, Associate Professor of Materials Systems; Richard de Neufville, Professor of Civil Engineering and Chairman of the Technology and Policy Program; Judith Tegger Kildow, Associate Professor of Ocean Policy, Department of Ocean Engineering; Jeffrey Meldman, Associate Professor of Management Science; David Noble, Assistant Professor of History of Technology, Program in Science, Technology, and Society; Amedeo Odoni, Associate Professor of Aeronautics and Astronautics; Jack Ruina, Professor of Electrical Engineering; Thomas Sheridan, Professor of Engineering and Applied Psychology, Department of Mechanical Engineering; Marvin Sirbu, Jr., Research Associate, Center for Policy Alternatives; Lawrence Susskind, Associate Professor and Head, Department of Urban Studies and Planning; Martha Weinberg, Associate Professor of Political Science; David Wood, Associate Director, Energy Laboratory and Senior Lecturer, Sloan School of Management.

Further information may be obtained by contacting Richard de Neufville, Room 1-138, (617) 253-7694.

Transportation (S.M.)

The Center for Transportation Studies promotes cooperation in interdepartmental and intermodal matters, facilitates innovative research in transportation, and provides a focal point for educational programs within the Institute. Graduate programs leading to the master's and doctoral degrees and professional training are available through the departments associated with the Center.

A new interdisciplinary degree, the Master of Science in Transportation, is offered by graduate departments in cooperation with the Center. This degree is designed to prepare students either for careers in transportation or for additional graduate work. Students with a variety of backgrounds such as engineering, social sciences, management, architecture, urban studies, and operations research are encouraged to participate in the program. An entering student should have a background in economics, calculus, and probability.

The degree requirements include the satisfactory completion of at least 72 units and the presentation of an acceptable thesis. The program establishes the basic methodological framework for analyzing transportation problems and offers a number of areas of concentration. It consists of the following three components:

- 1) Core subjects — 33 units
- 2) Program area — 18 units
- 3) Electives — 21 units

A specific core is required to ensure breadth and a common frame of reference for all students in the program. The core includes one required subject which establishes the basic concepts used in the analysis of transportation systems. In addition each student must take at least three of the following five core subjects: Transportation Economics, Transportation Institutional Analysis and Policy, Transportation Management, Transportation Performance and Technology, or Transportation Demand and Activities.

Some students may enter the program having already completed material similar to one or more of the core subjects. For such students, the core requirement would be reduced and, where appropriate, the student could receive credit toward the overall degree requirements.

The remainder of the program builds upon a series of program areas, each of which may be considered to be a professional interest group with which a student can associate. Current program areas are: air transportation; ocean transportation; urban transportation; 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.

A student must take at least two subjects from one program area. A student also may formulate a new program area with the approval of three faculty members and the Program Officer.

The research associated with the required Master's thesis usually requires two terms to complete, so students should generally expect to take three to four terms to complete the program. Some exceptional students can complete the program in less time.

The Center for Transportation Studies attempts to provide financial assistance, including graduate fellowships and research and teaching assistantships, in most of the fields in which the Center is active. Financial requirements can be indicated on the admission forms.

Students interested in coming to M.I.T. for transportation studies should write to: Center for Transportation Studies, Room 1-123, M.I.T., 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. Alternatively, students may apply directly to their department of choice.

Interdepartmental Organizations and Research Facilities

Arteriosclerosis Center

The Arteriosclerosis Center is an interdepartmental, interinstitutional center for the study and treatment of arteriosclerosis. It is unique in that it is run by physicians from M.I.T. and the Massachusetts General Hospital and engineers from both institutions in physical sites on both sides of the Charles River. While the Center's Headquarters is in the Seeley G. Mudd Building at the east end of the M.I.T. campus, the Center's laboratories are in the Cardiac and Hematology Units of the MGH's Department of Medicine and in the Department of Pathology at the MGH, as well as in the Departments of Chemical Engineering, Electrical Engineering and Computer Science, Mechanical Engineering, and Nutrition and Food Science at M.I.T.

The Center's projects encompass the entire spectrum of arteriosclerosis research and range from clinical studies in the life history and treatment of arteriosclerosis to *in vitro* studies of fluid flow in models of the arterial tree.

Opportunities for undergraduates are available in the several laboratories of the Center. Opportunities for graduate students for thesis research and opportunities for postdoctoral fellows are available both in the M.I.T. laboratories and in those at the Massachusetts General Hospital. Opportunities for physicians are available in all of the Center's activities.

Interested people should contact the Center's Director, Dr. Robert S. Lees, Room E17-421, (617) 253-3012, or the several members of the Center in the departments and laboratories mentioned above.

Artificial Intelligence Laboratory

The Artificial Intelligence Laboratory is a center for cognitive science and engineering. "Cognitive science" reflects a primary interest in understanding the class of phenomena associated with the layperson's use of words like "meaning," "intelligence," "purpose," "perception," and "planning." "Cognitive engineering" involves an approach to those subjects which is quite different from that of philosophers and psychologists, in that the cognitive engineer tries to produce intelligence. Currently both cognitive science and cognitive engineering are being studied through a combination of several broad efforts: representation of knowledge, expert problem solving, common-sense reasoning, learning, vision, manipulation, language, education, and theory of computation.

Representing Knowledge and Solving Problems Sophisticated schemes for representing and manipulating symbolic representations are a major research theme. Accomplishments in this area include new computer languages; new representation techniques like the procedural embedding of knowledge and frame systems; and the development of expert programs to test these ideas. These test programs have focused on learning, program understanding, engineering design, and common-sense reasoning.

Computer Vision Studies in computer vision and the problem of enabling a computer to look around its world involve a range of topics from special-purpose schemes for use in practical automation applications to highly speculative and experimental systems aimed at scene understanding as accomplished by humans in the real world. A central problem is the formulation of representations and procedures for the automatic construction of an internal symbolic model of the three-dimensional world from an image.

Shading, stereo, motion, and texture are among the issues that receive concentrated effort. The exploitation of natural constraints is emphasized.

Productivity Technology The Laboratory has developed a simple, compact set of modules forming the basis of a robotics laboratory. Vision sensors and highly dextrous hands for practical use have been developed. These may find application in microcircuit assembly, small mechanical assembly, underground and undersea mining, agriculture, and even medicine.

Natural Language The Laboratory's approach to understanding natural language places heavy emphasis on the problem of meaning. In this respect our efforts differ from the more classical work in linguistics. Successes in this area, pushed ahead by work in limited domain discourse, have led to rapid progress toward advanced machine competence.

Education Studies in intelligence have led to new insights about how intelligence develops in people and to some radically new concepts of how it can be made better. Work on education takes several forms in the Laboratory: the development of computer coaches that serve as A.I.-based tutors for computer games; work on curriculum developments and experimental teaching aimed at finding a substitute for the elementary school as an environment for young children; and studies of how to teach skills such as riding bicycles, juggling, musical perception, philosophical puzzlements, and mathematical thinking.

Further information is available from Professor Patrick H. Winston, Room NE43-816, M.I.T., Cambridge, Massachusetts 02139, (617) 253-6218.

Bates Linear Accelerator

During the past few decades, the study of the nucleus and its components has necessitated equipments of size that require them to be available essentially as national facilities and to a wide community of investigators. The William H. Bates Linear Electron Accelerator, funded by the Energy Resources Development Agency for use by M.I.T. research staff (principally in the M.I.T. Laboratory for Nuclear Science and the M.I.T. Department of Physics), is available for use through a formal user's organization to eligible researchers in the New England area and the nation as a whole. Toward this latter purpose, particularly, a scientific Program Advisory Committee for the Accelerator has been established, comprising representative non-M.I.T. membership from among recognized leaders in the field.

The Accelerator is being applied actively to high-precision electron scattering experiments using electron beams ranging in energy up to more than 300 MeV. Taken together with a large novel magnetic analyzer which was built to detect the scattered electrons, the high quality of the Bates electron beam provides exceptional and unprecedented capability for the study of nuclear structure by this method. Although this program is at present the dominant one, a number of experiments are under way using gamma rays that can be produced by the electron beam to excite nuclear reactions. Serious plans are under development both for broadening the research capacity of the Accelerator as a facility, and for increasing the energy of its electron beam.

The research participation of students, as undergraduate laboratory assistants and through graduate thesis work, is encouraged and forms an important part of the Bates program. A large number of students, from the universities of user

physicists as well as from M.I.T., are so involved. Further information may be obtained from the office of the Director, Room 20B-038, (617) 253-7592.

Bitter National Magnet Laboratory

The Francis Bitter National Magnet Laboratory, supported by the National Science Foundation, conducts a program of research and development in science and engineering in areas involving magnetic fields. Continuous fields up to 23 teslas and pulsed fields to 75 teslas are available in a variety of configurations. High magnetic field, high resolution nuclear magnetic resonance spectrometers are used for the study of molecules of biological interest. A magnetically shielded room of walk-in size is available for ultralow magnetic field experiments. The special facilities of the Laboratory are made available to research groups from other M.I.T. departments and from institutions throughout the world.

The Laboratory's solid-state physics research program is an experimental and theoretical study of semiconductors, magnetic materials, and superconductors. The research effort in plasma physics includes work on laser-induced breakdown and heating of magnetically confined plasmas, and the Alcator thermonuclear fusion experiment. 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, medical applications of magnetism, design of superconducting magnets for magnetohydrodynamic

generators, studies of magnetic separation techniques, and development of magnetic acceleration systems for space travel.

Additional information may be obtained from the Director, Professor Benjamin Lax, at the Laboratory, Building NW14, or at (617) 253-5541.

Cell Culture Center

The Cell Culture Center has been established and funded by the National Science Foundation to serve as a facility and resource for cell biologists in New England and the northeastern part of 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. Special consideration is given to requests for cell and virus preparations from young investigators with limited resources. The Center is working directly with individual scientists on basic research problems, and is carrying out an active program for the development of new techniques for large-scale cell and virus production. In addition, the Cell Culture Center sponsors a master's degree program in animal cell and tissue culture sciences being offered by the M.I.T. Interdisciplinary Science Program. The Program offers course work in both the Department of Biology and the Department of Nutrition and Food Science, and laboratory experience in the Cell Culture Center. The Program provides students with excellent preparation for vocations that require a broad knowledge of the techniques of cell culture and animal virology. Inquiries concerning the facility are always welcome, and may be addressed to Donald J. Giard, Room E17-321, (617) 253-6430.

Center for Advanced Engineering Study

The M.I.T. Center for Advanced Engineering Study provides opportunities for experienced engineers and scientists to attain and maintain the competence needed for continued leadership in an age of technological change. The Center offers educational programs for experienced men and women from industry, government, and educational institutions to acquire the understanding and skills needed to open technical frontiers.

The Center operates three major programs and a program of research and development in continuing education:

- 1) The Advanced Study Program — for engineers and scientists who come to M.I.T. to study in advanced subjects;
- 2) The Self-Study Program — based on the use of specially prepared, high quality videotape presentations of advanced technology; and
- 3) Conference and seminar programs — technical meetings in support of continuing education.

Under the Advanced Study Program experienced engineers, applied scientists, technical managers, and educators attend regular M.I.T. classes in programs individually tailored to their needs and objectives. Special programs have been developed in Air Transportation, Nutrition Planning, Public Management, and Operations Research. Each year special subjects beyond those regularly offered to M.I.T. graduate and undergraduate students are offered by C.A.E.S. for Fellows in the Advanced Study Program.

Students in the Advanced Study Program are often on temporary leave of absence from industry or government or are sent to M.I.T. for specialized instruction. For further information about the Advanced Study Program, inquire at Room 9-335, (617) 253-6161.

The Self-Study Program provides a library of approximately 500 videotapes, 16mm films, and study guides made at M.I.T. plus offerings from other institutions of higher learning. These films, tapes, and study guides are available for purchase or rental. Inquiries should be directed to the Self-Study Program, Center for Advanced Engineering Study, Room 9-234, (617) 253-7061.

The Conference and Seminar Program is designed to support our continuing education efforts by bringing to the campus, to other parts of the country, and to other places in the world, people with similar interests. These meetings are expected to be from three days to one month in duration. They will provide for an intensive exchange of information. Further information may be obtained in Room 9-268 or by calling (617) 253-7411.

The Center is developing a new approach to continuing education for engineers, Project PROCEED, in which *problem-centered* educational materials, as distinguished from *subject-centered* materials, are prepared to assist engineers working on specific problems. Instruction and assistance are provided via printed modules and a computer-based Adaptive Reference System. The first topic, Industrial Energy Conservation, will be followed by several more each year.

Brochures describing the above programs and current offerings are available upon request.

For further information about C.A.E.S. programs, inquire at the office of the Director, Room 9-215, (617) 253-4961.

Center for Advanced Visual Studies

The Center for Advanced Visual Studies provides artists of achievement with the opportunity to explore new artistic forms. Collaboration through a working dialogue between artists, and scientists and engineers is of primary importance in the exploration of new creative objectives. Mutually beneficial contact between artist and scientist allows the artist to develop the technical competence to utilize advanced technology.

The Center's main areas of interest are: environmental art and design; developmental artistic media work; interaction of art, science, and technology; celebrations; education toward the new arts — video, holography, computer-aided design and programming, public art.

A limited amount of work space also is available for a small number of research affiliates and graduate students. A catalogue listing the Center's educational offerings, in association with the Department of Architecture, is available at the C.A.V.S. office in Building W 11, 40 Massachusetts Avenue. (617) 253-4415.

Center for Cancer Research

The Center for Cancer Research provides facilities for interdepartmental work in various phases of fundamental cancer research. Graduate students in any of the Courses may ask to do doctoral thesis research under the supervision of the faculty of the Center. If accepted, they may be eligible for support as research assistants in the Center. Opportunities for undergraduate research are available, both for credit and in the Undergraduate Research Opportunities Program. Seminars in cancer research both for credit and as public colloquia of the Center are available. Further information may be obtained by contacting Ms. N. Ahlquist, Room E17-110, (617) 253-6400.

Center for Cognitive Science

The Center for Cognitive Science provides an intellectual and administrative focus for individual and collaborative research in cognitive science at M.I.T. In addition, a committee of the Center coordinates graduate and undergraduate study in cognitive science by working in conjunction with the relevant committees of the faculty.

The members of the Center's Policy Committees represent the Departments of Linguistics and Philosophy, Psychology, Electrical Engineering and Computer Science, the Division for Study and Research in Education, the Artificial Intelligence Laboratory, and the Research Laboratory of Electronics.

A number of cooperative activities involving members of the Center and scientists at other institutions with programs in cognitive science are planned or in progress, and the members of the Center maintain active relations with scientists working at other academic, medical, and research institutions in the Boston area.

The Center now administers an extensive program of postdoctoral and predoctoral fellowships designed to attract outstanding young scholars to M.I.T. for an extended interaction with members of the Center.

In addition to the Fellowship program, the Center coordinates a number of research projects in the areas of cognitive science pursued by visiting and permanent members of the Center. Limited laboratory and research facilities are maintained within the Center to support the conduct of such research.

A Joint Seminar and an informal series of colloquia serve to assist in the dissemination of scientific information, and in the mutual exchange of students and workers in the field.

Further information regarding the activities of the Center may be obtained from the Administrative Assistant, Melissa Monroe, at the Office of the Director, Room 20D-105, M.I.T., Cambridge, Massachusetts 02139, (617) 253-4141.

Center for Computational Research in Economics and Management Science

This Center performs algorithmic research and related software development for the purpose of advancing knowledge about modeling in economics, statistics, and management. The Center focuses a unique set of resources on this task. Algorithmic research is performed by researchers representing the varied quantitative disciplines that underlie modern computer-intensive modeling. These disciplines include econometrics, statistics, numerical analysis, and operations research. Computer implementation is performed by a programming staff with special skills in designing and coding easily used interactive tools, of which the single most important is a comprehensive software environment called TROLL. TROLL itself is the Center's third major resource: it contains programming tools and standard functions that facilitate the rapid implementation of experimental algorithms. In addition to being a software-development environment for algorithmic research, TROLL is also a modeling environment for applied studies.

Recent research at the Center has focused increasingly on the evaluation and improvement of model reliability. In the effort to mimic complex reality,

economists, engineers, and others are building ever more intricate models, and in this task they are abetted by cheaper and more powerful computation. But intuition, judgment, and analytical tools are falling behind the capacity to build models of great size and complexity. As a result, the research community is increasingly uncertain about attainable levels of precision and confidence in model results.

Other major research efforts focus on simultaneous equation estimation, nonlinear optimization, robust estimation, semiportable implementation of stable statistical and econometric algorithms, mixed integer programming, and a new mathematical programming language.

The Center's research complements activities in several M.I.T. departments and laboratories. The links include active participation in Center projects by faculty members of the Sloan School of Management; collaboration with 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.

Much of the Center's current research depends on TROLL. TROLL exemplifies the concept of the discipline-oriented (or application-oriented) operating system. In TROLL's case the discipline is econometrics and statistics; the system provides all standard techniques, and many experimental ones, for building and using econometric models. (These techniques are also applicable in other disciplines that model time-dependent phenomena.)

Further information about the Center and its research program may be obtained from the Director, Professor Edwin Kuh, Room E38-210, (617) 253-8413.

Center for Information Systems Research

The Center for Information Systems Research (C.I.S.R.) was established at the M.I.T. Sloan School of Management in mid-1974. C.I.S.R.'s activities focus on research aimed at improving the effectiveness of information-processing tools and techniques available to managers in the private sector and policy makers in the public sector. Of primary interest are several critical aspects of computer-based information systems.

The Center is taking a multifaceted approach to the task of improving the effectiveness of information processing in organizations today. A set of private sector corporate sponsors provides assistance in defining and investigating significant research areas. The sponsoring organizations represent several different commercial viewpoints and consist both of computer vendors and major users of information systems. In the public sector, C.I.S.R. is developing and testing state-of-the-art management information systems to assist public policy makers. Basic research on fundamental issues (e.g., centralization and decentralization of computing, data base research) affecting both sectors is being performed. Finally, C.I.S.R. is dedicated to disseminating significant research findings to the information systems user community through teaching, seminars, working papers, and publications.

Research at C.I.S.R. is pragmatic, problem based, and application driven. Research efforts are performed primarily in application areas of immediate interest to managers and policy makers and are performed in areas in which results are expected to have a fruitful payoff within one to five years.

The Center was established in the Sloan School of Management, in part due to the recognition by the School of the increasing complexity of the managerial job today and the need for vastly improved information-processing tools and techniques to carry out this job. Secondly, there was an evident need to institute more effective relationships between academics and private and public sector managers in a joint effort to improve computer-based information systems.

C.I.S.R.'s faculty brings a wide range of specialized training to information systems problems. This disciplinary training ranges from the technical fields of computer science and electrical engineering to the people-focused disciplines of law, psychology, and organizational behavior.

Further information about the Center may be obtained by contacting Sarah S. Fitzgerald, C.I.S.R., Room E53-301, Sloan School of Management, 50 Memorial Drive, Cambridge, Massachusetts 02139, (617) 253-3372 or 253-2930.

Center for International Studies

The Center for International Studies is a research center focusing on the social, political, and economic problems of the contemporary international scene, 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 M.I.T. departments, and there are opportunities for graduate students to participate in the Center's research programs. The following are the areas of current research focus:

- science and public policy
- arms control and defense studies
- energy policy
- international nutrition planning
- environmental monitoring
- communications policy
- migration
- technology and development
- problems of advanced industrial societies
- international business
- international political problems and conflict
- political and economic development and
- social science methodology

Further information about the Center and its research program may be obtained from the Director, Professor Eugene B. Skolnikoff, Room E38-648, M.I.T., Cambridge, Massachusetts 02139, (617) 253-3140.

Center for Materials Research in Archaeology and Ethnology

The Center for Materials Research in Archaeology and Ethnology is a major undertaking whose purpose is to encourage a new direction for research in anthropology, archaeology, art history, and related humanistic and social science disciplines by providing them with an expanded technical base in the sciences of organic and inorganic materials. The new Center was established in 1977 by nine educational, research, and cultural institutions in the greater Boston area: Boston University, Brandeis University, Harvard University, the University of Massachusetts, M.I.T., the Museum of Fine Arts of Boston, Robert S. Peabody Foundation for Archaeology, Tufts University, and Wellesley College.

The Center's research activities will be carried out in a network of shared laboratories at member institutions and used by students and faculty of those institutions as well as by visiting scholars and graduate students who will join the Center for shorter periods. The materials research laboratories are likely to include, among others, metallurgy, ceramics, lithics, palaeoethnobotany, and zoo-archaeology. The research program of the Center will emphasize rigorous laboratory study of artifacts and other kinds of cultural remains in order to determine the nature and structure of the materials of which they are composed and the extraction and processing regimes they have undergone. The Center is convinced that research aimed at understanding the relations among materials, technology, and society will be advanced most effectively by scholars who have a grounding in both a science and a social science or humanities discipline. Its subjects, offered at the graduate level, aim to educate such scholars.

Heather Lechtman is Director of the Center in addition to maintaining her present responsibilities as Associate Professor of Archaeology and Ancient Technology in the M.I.T. Departments of Humanities, and Materials Science and Engineering. M.I.T. serves as the Center's coordinating institution.

Further information about the Center and its programs may be obtained from the Director, Room 8-138, (617) 253-1375.

Center for Materials Science and Engineering (C.M.S.E.)

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) deformation and fracture of multiphase materials at high temperatures; 2) structure and properties of microcrystalline and glassy metallic alloys produced by rapid quenching; 3) surfaces, with emphasis on catalytic materials; 4) optical and electronic materials; and 5) phase transitions. Major funding for these interdisciplinary programs is provided under the NSF-MRL program.

Participating in C.M.S.E. research programs are faculty groups from the Departments of Chemical Engineering, Chemistry, Electrical Engineering and Computer Science, Materials Science and Engineering, and Physics. Opportunities for postdoctoral, graduate, and undergraduate research can be investigated by contacting C.M.S.E. faculty members directly.

C.M.S.E. maintains excellent modern central service facilities such as crystal growing and characterization laboratories for insulators, semiconductors and metals; optical and infrared spectroscopy; Fourier transform spectroscopy; scanning electron and transmission electron microscopy; electron microprobe; ion microprobe; analytical laboratory; X-ray diffraction; microelectronics and a Scanning Auger Microprobe. Also available are additional special and general purpose facilities such as the Von Hippel Reading Room and Machine Shop. An annual report, *Research in Materials at M.I.T.*, is published by C.M.S.E. covering all research in materials at M.I.T. including that portion performed through support by the NSF-MRL program. This report is available through the Center by contacting the Administrative Office, Room 13-2098, (617) 253-6841.

Center for Policy Alternatives

The Center for Policy Alternatives was established in the School of Engineering in April 1972, with the intent that it serve the Institute as a whole. The Center's primary function is to identify the major issues facing society, to assess the consequences of present policies and practices, and to develop and appraise alternative actions which will improve and affect society. In carrying out its activities, the Center also seeks to find new ways to connect technology and social and economic welfare beneficially, and to stimulate faculty and students to participate in activities which have the greatest potential for social or economic utility.

The Center studies and investigates substantive issues for a wide spectrum of pressing sociotechnical problems in government, industry, and education, particularly those in which technology and engineering could play significant roles. It differs from most centers for policy analysis in that, based on its

studies of actual problems, it develops a number of alternatives for action and policy, identifies possible means of implementing them, and evaluates the possible consequences of their implementation. The alternatives developed are often in the form of factual presentations of possible specific programs, regulations, or legislation.

In addition to its sponsored activities, the Center has many opportunities for graduate and undergraduate students to participate with faculty and Center staff in establishing new program areas, developing individual research projects, and developing new subject offerings. During 1978-79, some of the Center's program areas included: science, technology, and public policy; manufacturing technology, the nature of work and job satisfaction; natural resources, recycling, and substitution; regulation of the general and work environments; energy policy; communications policy; and industrial innovation.

Graduate and undergraduate students interested in participating in Center research programs or in developing new policy research projects should contact the Office of the Director, Center for Policy Alternatives, Room E40-250, M.I.T., Cambridge, Massachusetts 02139, (617) 253-1661.

Center for Space Research

The Center for Space Research offers an opportunity to students, faculty, and professional research staff to participate in a broad program of space-related research. Its projects draw upon the interests and expertise of physical, social, and life scientists and engineers from many disciplines. Topics of current research include theoretical studies in cosmology and astrophysics such as: stellar evolution and stellar pulsation; the behavior of supernovae, pulsars, and quasars; and the development of

models illustrative of the processes associated with novae, planetary nebulae, neutron stars, protostars, X-ray binaries, and bursters.

Space science studies include measurements of the properties of the interplanetary plasma, hard and soft X rays, and gamma rays using experimental techniques such as high altitude balloons, sounding rockets, orbiting satellites, and interplanetary spacecraft. Other space science studies include dose-response relationships between intensity of light exposure and the biological effects of light on humans, vestibular experiments to measure the changes in sensitivity of otolith function during weightlessness and the carry-over of any such changes to post-flight conditions. Coupled with the foregoing laboratory and flight experiments are ground-based optical infrared and radio frequency observations of astrophysical phenomena of current interest. The Center supports these field measurement programs with exploratory and developmental studies in the laboratory on interference spectrometry, X-ray counters, high-resolution collimators, high-accuracy pointing and stabilization systems, and star sensor aspect systems. Laboratory facilities include X-ray sources, particle accelerators, vacuum chambers, and conventional electronic test and machine tool equipment. Extensive data handling and computational facilities are available for the analysis and reduction of scientific data. An experienced and well-equipped Laboratory for Space Experiments group provides design, construction, and testing support of the flight programs.

The variety of scientific and technical problems that arise in these investigations affords numerous opportunities for graduate thesis research as well as for graduate and undergraduate participation in research projects and seminars. Further information may be obtained in Room 37-241, M.I.T., Cambridge, Massachusetts 02139, (617) 253-7501.

Center for Transportation Studies

The Center for Transportation Studies has been established to promote cooperation in interdepartmental and intermodal matters, facilitate innovative research in transportation, and provide a focal point for educational programs within the Institute. The Center's research emphasis is on problem-oriented, interdepartmental, multimodal research. It covers a wide spectrum ranging from broad conceptual planning through operation and management of transportation problems to new methods of transportation analysis, planning, and decision making.

The Center has developed a structure which promotes interaction among faculty members from all schools at M.I.T. as well as other universities and organizations concerned with transportation. Interdepartmental cooperation is essential in dealing with the complex problems found in this area since their solution requires close ties between technological possibilities and their social, economic, ecological, and political ramifications. The Center has developed a sense of community that promotes cooperation, the exchange of ideas, a wider perception of the opportunities, and a common purpose.

The research program of the Center is broadly based, incorporating both interdepartmental and intermodal elements. Research capability extends from the areas of social science and management to the technological research associated with the development of new

modes of transportation. Recent research projects have concerned application of new methods to transportation planning, transportation energy contingency planning, railroad reliability and network planning, innovative urban transportation systems, transportation in developing countries, urban freight movements, airport planning and development, commodity movement, industry location, freight terminal simulation, energy transport, superport location, air traffic control, assessment of STOL/VSTOL air service potential, local service air carriers, and the logistics of freight modal choice and inventory control. Research sponsorship includes a range of government and industry organizations affording students wide opportunities to be involved in newly evolving research frontiers.

A new interdisciplinary degree, the Master of Science in Transportation, is offered by graduate departments in cooperation with the Center. For more information on graduate programs, see the section on Transportation Studies under Interdepartmental Graduate Study.

Clinical Research Center

The M.I.T. Clinical Research Center, a small, fully equipped and staffed research hospital on campus, opened in 1964. The major purposes of the Center are to enable interested scientists to perform research with human subjects and to allow students at all levels to gain experience in working directly with human subjects and human disease. Many research projects are in progress, including those in nutrition, psychology, cardiology, endocrinology, gastroenterology, and mechanical, chemical, and electrical engineering. The studies in most cases are collaborative, involving both basic scientists and clinical scientists.

Patients and normal subjects may be seen as outpatients or may stay in the Center as inpatients for long periods of time at no cost to them. The facilities of the Center are open to all departments in the Institute, and its staff consists of members from many of those departments. Although most patients hospitalized in the Clinical Research Center come from the Boston metropolitan area, a significant number are referred from other parts of the United States, and some are referred from abroad.

Numerous routes of entry are available to undergraduates and graduate students who wish to take advantage of the Center's programs. These include a freshman seminar in medicine, undergraduate research projects, graduate study with human subjects in medical sciences and biomedical engineering, and postdoctoral research for those who already have the M.D. or Ph.D. degree. Further information may be obtained from the Center in Room E18-473, (617) 253-6302 or 6303.

Division for Study and Research in Education

The Division for Study and Research in Education is a special setting at M.I.T. for learning about learning. The Division offers formal courses on both theoretical and practical problems in education, as well as seminars on issues of special interest. The Division provides opportunities for research and for working directly with learners in a variety of learning situations.

The members of the Division bring to their shared educational interests a wide diversity of academic experience, professional perspective, and personal concern. The resulting interplay of insights and methodologies has led to the emergence of several major themes: individual learning, institutional learning, educational technology. Multidisciplinary clusters of faculty, students, and research staff apply theories of cognitive processing, insights into social processes, and educational technologies, to investigate the ways in which people think, solve problems, and learn to learn.

The Division for Study and Research in Education provides opportunities for faculty and students from departments of the Institute to join in its research on educational problems.

Among these opportunities is a program which provides a small number of Ph.D. candidates with experience in educational research. For details of this program, see the section on Study and Research in Education under Interdepartmental Graduate Study.

Further information may be obtained from the Education Division Administrative Officer, James H. McCarthy, Room 20C-126A, (617) 253-7362.

Faculty members associated with the program are:

Benson R. Snyder, M.D.
Professor of Psychiatry
Director

Barbara Scott Nelson, Ed.D.
Assistant Professor of Education
Associate Director

Jerome S. Bruner, Ph.D.
Professor of Psychology
and Education
(Visiting)

Howard E. Gruber, Ph.D.
Professor of Education
(Visiting)

Thomas F. Jones, Sc.D.
Professor of Engineering
Vice President for Research

Roy Kaplow, Sc.D.
Professor of Materials
Science and Education

Seymour A. Papert, Ph.D.
Professor of Education and Mathematics,
Cecil and Ida Green Professor of
Education

Martin Rein, Ph.D.
Professor of Sociology and
Education

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

Judith L. Schwartz, Ph.D.
Professor of Engineering Science and
Education

Hermine Sinclair-de Zwart, Ph.D.
Professor of Education and
Developmental Psychology
(Visiting)

Sheldon H. White, Ph.D.
Professor of Education
(Visiting)

Harold Abelson, Ph.D.
Associate Professor of Computer
Science and Education

Jeanne S. Bamberger, M.A.
Associate Professor of Education and
Music

Susan Carey, Ph.D.
Associate Professor of Psychology
and Education

Daniel Nathan Osherson, Ph.D.
Associate Professor of Education
and Psychology

Andrea Al-Vin di Sessa, Ph.D.
Assistant Professor of Education

Sherry Turkle, Ph.D.
Assistant Professor of Sociology
and Education

Edwin F. Taylor, Ph.D.
Senior Research Scientist

Karen C. Cohen, Ph.D.
Senior Research Associate

Magdeline Cawley, M.A.
Research Associate

Eleanor Duckworth, Ph.D.
Research Associate

Michael Garet, Ph.D.
Research Associate

Edwina Michener, Ph.D.
Research Associate

Sylvia Weir, M.D.
Research Associate

Krisnappa N. Rao, Ph.D.
Senior Lecturer

Bertrand Schwartz, Sc.D.
Senior Lecturer
(Visiting)

Sir Geoffrey Vickers
Senior Lecturer
(Visiting)

John Terry, Ph.D., Lecturer
Stanley Russell, Ed.D., Lecturer

James H. McCarthy, M.A., S.T.L., S.E.O.L.
Administrative Officer

William T. Martin, Ph.D.
Professor of Education and Mathematics,
Emeritus

Jerrold Reinach Zacharias, Ph.D., L.H.D., Sc.D.
Institute Professor, Emeritus
Professor of Physics, Emeritus

Electric Power Systems Engineering Laboratory

The Electric Power Systems Engineering Laboratory (E.P.S.E.L.) is an inter-departmental laboratory within the School of Engineering. It is principally concerned with problems related to the generation, transmission, distribution, and utilization of electric energy, but work in the field of high power semiconductor devices and their application also is under way in the laboratory. Several faculty members within the group have had experience in the electric power industry, and close contact with the industry is maintained through on-campus research, consulting activities, and participation in the activities of professional societies.

Research programs currently in progress include contamination flashover of insulation; design, construction, and testing of an alternator with a superconducting field winding; an electromagnetically scaled model of a power system; induction heating; motor controls; energy storage systems; control of power systems and power plants during emergency situations; load demand modeling, innovative load management (cogeneration pricing), dynamic control schemes; the development of new simulation techniques for studying power electronic energy conversion and control systems; magnetically levitated ground transportation systems; and concentrator systems for photovoltaic energy conversion. Since most of the research is experimentally oriented, design and instrumentation is a major concern almost comprising an additional research area.

Further information may be obtained by contacting Professors G. L. Wilson, F.C. Scheppe, J.L. Kirtley, Jr., J.G. Kassakian, or G. C. Verghese in Room 10-171, M.I.T., Cambridge, Massachusetts 02139, (617) 253-4631.

Energy Laboratory

Current Energy Laboratory research projects involve about 75 research staff, 50 faculty, and 225 students from various departments in all five M.I.T. Schools. The educational aspects of this research are significant as both graduate and undergraduate students become an integral part of the interdisciplinary research teams working on mission-oriented projects that address the technical and socioeconomic aspects of important energy issues.

The **International Energy Studies** program of the Energy Laboratory focuses on the international markets in which energy is traded. These markets are complex and are strongly affected by, and affect, the national political, economic, and strategic interests and policies of supplier and consumer governments alike. A multidisciplinary approach is thus essential. For the world oil market, aggregated and disaggregated studies of oil demand and supply are supplemented with models of OPEC behavior and analysis of financial factors to provide detailed analytical and policy insights. Research on nuclear fuels involves analysis of: the structures and performance of the interrelated markets in which fuel materials are developed, processed, and allocated internationally; trends in these markets; and the national and international policies that affect access to them. In response to expectations of expanding international trade in steam coal, a substantial domestic coal research effort is being expanded to the international sphere. The importance of energy as an issue of security and balance of payments for developing countries, and as a source of increasing conflict between rich and poor nations, has led to exploratory research on the problems of energy and development, in the context of international studies already under way.

The **Utility Systems** program brings together faculty and research staff from engineering and policy science departments at M.I.T. to analyze utility operations and growth both in the short run (over the next five years) and in the longer run (to and beyond the turn of the century). Research, writing, and teaching have concentrated on three major areas: 1) Electric operations and control. Basic research in control devices and in the economics of the electric marketplace has been initiated. 2) Economics and policy decisions associated with adoption of new, generally utility-interfaced energy technologies. This research has focused on the acceptance of the photovoltaic technology and on the impact of solar hot water and space heating systems on electric utility demand. 3) The development of modeling tools for both utility operation and utility capacity expansion analysis. Work has proceeded on the development of a new generation of capacity expansion models that are able to include electric power generated from stochastic, weather-dependent sources such as solar and wind systems.

The **Energy System Modeling and Analysis** program includes work in two areas: 1) research on energy supply, demand, and the interaction of energy markets with the macroeconomy and 2) evaluation and assessment of major energy policy models. Historically, research and modeling of primary energy supplies has concentrated on coal, oil, and gas. Recently, preliminary research has begun on the economics and productivity of uranium exploration, and similar studies for other primary resources are planned.

Research on energy demand focuses on major consuming sectors (household, industrial, and transportation) and the likely response of these sectors to new energy conversion technologies. This research is the basis for efforts to model the interactions between energy and the macroeconomy. Here the emphasis has been on how changes in energy prices and availability affect aggregate inflation and real output in the short and intermediate term (1 to 20 years). Of particular interest is the relation between energy and physical capital.

The second major area of activity concerns independent assessment and evaluation of important energy policy models. As these models become increasingly prominent and visible in energy policy research, independent assessments are necessary to ensure model credibility for the various constituencies concerned with energy policy issues. In the past these policy model assessments have been performed as part of the research program. More recently the demand for such independent evaluations had led to the formation of an ad hoc policy model assessment group and to preliminary research on the role of formal models in the policy research process.

The **Center for Energy Policy Research** gives special focus to policy research and analysis in the Energy Laboratory, with particular emphasis on making results available and useful to policy makers. With support from a wide range of corporate and noncorporate interest groups (called Associates), the Center holds conferences and seminars to bring together key government and private organizations to work on energy policy issues. The work of the Center is carried out by professional staff members from the Energy Laboratory and faculty and students from several M.I.T.

departments (with heavy involvement of the Sloan School of Management and the Departments of Economics and Political Science). Specialists from the Center's Associates are also involved in the work.

Research in the Energy Laboratory concerning fossil fuels utilization is organized into the following program areas: Energy Conversion, Stationary Combustion, Fuel Conversion and Health Effects, Process Modeling, Transportation Propulsion, and Advanced Technology.

The **Energy Conversion** program emphasizes high temperature gas turbines with related hot gas cleanup and cooling, fluidized and electrofluidized beds, environmental assessments of advanced energy conversion systems, and MHD power generation. The fluidized bed project is concerned with the development of a mathematical system model for fluidized bed combustion systems as well as the establishment of a data base management system that reposit all relevant data of the technology in one site. The MHD program is a large, interdisciplinary effort considering topics such as coal combustion and devolatilization, ash behavior, magneto fluid dynamics of MHD generators, magnet design, materials and electrodes problems, and system study of MHD plants.

The **Stationary Combustion** program emphasizes parallel modeling and experimental investigations of combustion processes of gaseous, liquid, and solid fuels in both steady and unsteady operation. Specific projects include: turbulent combustion in furnaces and combustors; reduction of pollutant emissions from liquid fuel spray flames; radiative heat transfer from flames in furnaces; soot formation; behavior of nitrogen in coal; fluidized combustion; NO_x emission from shale- and petroleum-derived liquids; and spray combustion.

The **Fuel Conversion and Health Effects** program includes research activities in both fossil fuel conversion and in the health effects of increased utilization of lower quality fossil fuels. Research on fuel conversion focuses primarily on the production of clean fuels by thermal and catalytic processing with emphasis on both coal and renewable resources (biomass) as primary feedstocks. Specific project areas include: fundamental studies of coal pyrolysis and hydrolysis; catalytic denitrogenation and pyrolytic desulfurization of liquid fuels; fluidized bed pyrolysis of coal for energy storage; chemistry of coal liquefaction; and fluidized bed and fundamental kinetic studies of biomass pyrolysis. Health effects research concentrates on determining the mutagenic, carcinogenic, and respiratory toxicity of combustion-generated particulates and polycyclic compounds. A unique feature of the program is a direct coupling of research teams in engineering, analytical chemistry, and the biological sciences. Specific projects focus on determining emissions toxicities for combustion equipment and fuel types of varying degrees of complexity.

The **Process Modeling** program focuses on computer simulation of industrial processes. The ASPEN (Advanced System for Process Engineering) project is developing a next-generation process simulator to perform steady-state heat and material balances, equipment sizing, and cost estimation and economic evaluation. Areas of research include physical property estimation of coal-derived materials, modeling of unit operations such as chemical reactors, flowsheet convergence techniques, processes for coal liquefaction, gasification, and combustion, and waste treatment processes. The modeling effort supports related work in policy analysis.

The **Transportation Propulsion** program is based on the activities of the Sloan Automotive Engine Laboratory. The work falls into four general areas: fundamental combustion studies; internal combustion engine research; gas turbine and burner research; and policy and technology studies. The fundamental areas under investigation include laminar flame propagation, flame quenching, and spark-ignition. Current engine research topics are in-cylinder gas motion, turbulent flame propagation, hydrocarbon formation mechanisms, detonation, engine operation with alternative fuels, particulate formation, and computer simulation of engine operating and emissions characteristics in conventional spark-ignition, stratified-charge, and diesel engines. Gas turbine and burner research focuses on the problem of fuel-air mixing in fuel sprays and jets, ignition and blowout, the influence of fuel characteristics on particulate formation, and the conversion of fuel-bound nitrogen to NO_x. Policy and technology studies are considering the Federal government's role in R&D on alternative automotive engines, and automobile regulation. The fundamental combustion activities are being carried out with the Department of Mechanical Engineering's Energy and Chemical Physics Laboratory. The policy and technology studies are normally joint programs with the Center for Energy Policy Research.

The **Advanced Technology** program examines new and emerging technologies and provides supportive research for more near-term programs. Electrochemistry research concerns electrodes and electrolytes for high density batteries and fuel cells, and electrochemical processing. In directed energy processes, ceramic powders are being synthesized and modified using laser heat sources. Other programs are concentrating on microstructural control in materials for ceramic processing. Solar

energy research centers on solar heating/cooling, amorphous photovoltaics, and broad band anti-reflective coatings.

Research in the **Environmental Management** program seeks to identify and reduce the environmental impacts of energy-related facilities and includes a diverse range of research projects. Current efforts include the design of open- and closed-cycle cooling systems for electric power plants, transport of buoyant effluents, water management issues associated with coal development, and environmental implications of ocean thermal energy conversion.

The **Nuclear** program has the following broad objectives: 1) to provide direct technical contributions to nuclear plant reliability and safety; 2) to develop and/or investigate possible improvements in nuclear plant design for fuel management that could lead to reduced power costs and more efficient utilization of nuclear fuel resources; and 3) to develop and communicate data and information that will contribute to public understanding of nuclear power. Projects presently under way are primarily technically oriented and focus on the following areas: fuel performance analysis; heat transfer and fluid flow; uranium/thorium utilization; and reliability analysis.

Students interested in participating in Energy Laboratory research projects should apply to the graduate program of one of M.I.T.'s academic departments. Upon acceptance, the student should contact William Jones in the Energy Laboratory to determine if there are research assistantships available in his or her area of interest. The address is Room E40-155, M.I.T., Cambridge, Massachusetts 02139, (617) 253-3413.

Innovation Center

The M.I.T. Innovation Center is for students who want to become innovators and entrepreneurs. These are the people who patent inventions, develop ideas into products, start new companies, or provide the creative leadership for new enterprises within larger organizations. The Innovation Center is organized by the School of Engineering with the support of the School of Management to serve students from throughout the Institute. Logistic support is provided by the Department of Aeronautics and Astronautics.

There are two major branches to the organization. The Innovation Education Program uses conventional classroom and project laboratory subjects to guide students through the earlier phases of learning the innovation process. The Innovation Co-op is a product development laboratory which provides a professional push in the marketing of products and gives the student clinical exposure to the latter phases of the innovation process.

Students at any level, both graduate and undergraduate, and from all departments, may participate.

Students who wish to participate in the program should contact the Innovation Center, or register for 16.671J Invention or 16.672J Entrepreneurship, 16.675 Invention Development Laboratory, 16.676 Internship in New Enterprise Development, 16S10 Introduction to Innovation. (16.671J, 16.672J, and 16S10 also have subject numbers for Chemical Engineering, Ocean Engineering, Electrical Engineering and Computer Science, and Mechanical Engineering.)

Further information may be obtained by contacting the Innovation Center, Room 33-111, M.I.T., Cambridge, Massachusetts 02139, (617) 253-6947.

International Nutrition Program

The International Nutrition Program (I.N.P.), jointly established by the Department of Nutrition and Food Science and the Center for International Studies, responds in an interdisciplinary fashion to the urgent need for increasing and broadening the knowledge required for improving the nutritional status of people, especially in the poor countries of the world. Individuals involved in the I.N.P. select their primary discipline and graduate degree objectives in M.I.T. departments including Nutrition and Food Science, Political Science, Economics, Urban Studies and Planning, and the Anthropology/Archeology Section of the Humanities Department. I.N.P. is affiliated with both the Center for International Studies of M.I.T. and the Office of International Health of the Harvard School of Public Health. Courses at M.I.T. and Harvard are available to full-time students at either institution.

Primary activities of the I.N.P. include:

- 1 Graduate-level courses that provide comprehensive and in-depth analysis of problems and issues of primary significance in understanding the central role of nutrition in national policy and development.
- 2 Applied and operational research including that to fulfill thesis requirements in a relevant discipline. Frequently the research is based on field activities in developing countries aimed at identifying and improving effective approaches to national and regional nutrition planning, and implementing and evaluating programs to combat problems of malnutrition among target populations.

3

Provision of advisory and training services to governments and international agencies dealing with specific aspects of nutrition planning, policy identification, and programming.

4

An International Food and Nutrition Policy advanced study program, in collaboration with the Office of International Health and relevant departments of the Harvard School of Public Health, designed primarily for agencies such as the Agency for International Development and the United Nations University World Hunger Programme supporting fellows in this area. Students with relevant disciplinary training and an opportunity to influence the nutrition programs and policies of their countries are given an opportunity for highly multidisciplinary and practical training. This program receives six to eight United Nations University Fellows per year and others sent by other international organizations, bilateral assistance agencies, foundations, and governments.

I.N.P. sponsors a weekly seminar series involving distinguished visitors, a Summer Session Program, and two series of publications.

Further information may be obtained from Dr. Nevin S. Scrimshaw, Director of the Program, Room 20A-224, M.I.T., Cambridge, Massachusetts 02139, (617) 253-3131.

Laboratory for Computer Science

The Laboratory for Computer Science is an interdepartmental laboratory for research and development in computer science. The Laboratory includes 14 research groups, currently staffed by approximately 260 people including faculty, students, and staff members. The academic members of the Laboratory are from the Departments of Electrical Engineering and Computer Science, Humanities, Mathematics, Architecture, 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 M.I.T. Computation Center. Subsequently, the Laboratory developed Multics, an improved system that introduced several new concepts in time-sharing. These two major developments stimulated a number of research activities in the application of on-line computing to diverse disciplines, such as engineering, architecture, mathematics, biology, library science, and management. The Laboratory now is conducting a broad program aimed at anticipating and resolving problems posed by the maturation, growth, and potential of the computer field. Current research includes the study and development of intelligent programs, the use of natural language (such as English) for human-computer communication; fundamental studies on the limitations of computing; studies in computer structures and in programming languages, as well as the use of computers for automation. A major focus of Laboratory research is the analysis and synthesis of geographically distributed computer systems. Also, since the ongoing evolution of computers is expected to have a major impact on, and be influenced by,

socioeconomic factors, the Laboratory is doing studies on privacy and security and on the social implications of computers.

The Laboratory for Computer Science fosters participation in research by undergraduate and graduate students. Research assistantships are available to graduate students for work in all aspects of the research program, and undergraduates may work at the Laboratory under the Undergraduate Research Opportunities Program. Facilities are provided for thesis research and special projects to both graduate and undergraduate students. All jobs at the Laboratory are unclassified.

Further information may be obtained by contacting Eva I. Kampits, Room NE43-103, M.I.T., Cambridge, Massachusetts 02139, (617) 253-3568.

Laboratory for Information and Decision Systems

In the Laboratory for Information and Decision Systems (formerly the Electronic Systems Laboratory) fundamental and applied research is carried out in broad interdisciplinary areas closely coupled with graduate study. The major portion of the research effort falls in the following main areas:

System science and control engineering

Communication science and systems

Computer and information systems

The research in the Decision and Control Sciences Group deals with theoretical advances in mathematical system theory, modern estimation, and control.

Areas of intensive investigation are related to basic understanding of large-scale systems, decentralized control strategies, stochastic and adaptive control, reliable synthesis methods, distributed parameter systems, numerical methods, and bilinear systems. Concurrent with the theoretical investigations is a major effort to apply the state of the art to advanced application areas. Typical application areas currently receiving attention are: dynamic stochastic control of freeway corridor networks, interconnected power systems, biological systems, control of macroeconomic systems, design of adaptive digital stability augmentation systems for aircraft, design of data management systems for failure detection and isolation, air traffic control, command-and-control systems, automotive engine control, and control of complex manufacturing processes. The application-oriented research is often done in collaboration with industry.

The research in the Communication Systems Group deals with broad theoretical and applied issues in communication theory, information theory, and related disciplines. A major research program deals with the basic understanding of analyzing and controlling data communication networks, with special emphasis on routing algorithms. Other research programs deal with fundamental issues in theory of images, digital signal processing algorithms, digital communications technology, and cable TV systems.

The research in the Computer and Information Systems Group deals with basic problems in the use of computers in complex information transfer and retrieval systems. A specific study involves the coupling of interactive information systems that interface heterogeneous data bases. Another study deals with the use of computers to problems related to newspaper operation and production (automated

newspaper layout, digital storage of newspaper graphics). The use of computers, especially microprocessors, in several application areas (avionics, vehicle identification, traffic control, bioengineering) is also under intensive investigation. Further information may be obtained by contacting the Director, Professor M. Athans, at (617) 253-2141, Room 35-308 or the Associate Director, Professor R. Gallager, at (617) 253-2533, Room 35-204, M.I.T., Cambridge, Massachusetts 02139.

Laboratory for Manufacturing and Productivity

The Laboratory for Manufacturing and Productivity of the School of Engineering was established in 1977 to provide a new focus for research and education in manufacturing and productivity at M.I.T. The purpose of the Laboratory is to address the technical problems and the related social and economic issues associated with the field by providing major conceptual developments for technical needs and human issues, by advancing the knowledge base for manufacturing, and by developing human expertise. The Laboratory seeks to establish a rational foundation for productivity increase by providing innovative methods and devices, a systematic understanding of the complex interactions among the many facets of manufacturing, and an important talent base of bright young people in manufacturing. The Laboratory is also committed to addressing the issues of the impact of technology on workers, the role of labor in technology-based society, and the impact of new manufacturing technology on society.

The Laboratory builds on the broad-ranging expertise in manufacturing and productivity of individual faculty and staff in such academic departments and laboratories as Mechanical Engineering, Electrical Engineering and Computer Science, Chemical Engineering, Materials Science and Engineering, the Sloan School of Management, and the Center for Policy Alternatives. The students, faculty, and staff members in the Laboratory have innovated many new processes, machines, and manufacturing concepts, which may have significant impact on the future technology. Topics of current interest are:

- Manufacturing Technology: devices, intelligent machines, materials, and processes — the "hardware" of manufacturing, especially synthesis of new processes and machines.
- Manufacturing Systems: the methods, analysis, logic, and information required to plan, synthesize, optimize, and manage complex manufacturing systems.
- Manufacturing Policy: improving the ability of manufacturing firms to adapt to and influence the rapidly changing social, economic, and political environment.
- Societal Issues: creation of safe, satisfying, and productive manufacturing environments and assessing the total impact of new manufacturing technologies on society.

The Laboratory also has cooperative research programs with consortia of industrial firms in various industries. Three active cooperative research programs are the M.I.T.-Industry Polymer Processing Program, the M.I.T.-Industry Flexible Materials Processing Program, and the Machine Dynamics Program. These programs deal with generic

issues involved in these fields. They offer exciting opportunities for basic research in areas of technological importance to industry.

Opportunities for undergraduate and graduate students are available for thesis research and a limited number of postdoctoral research positions also are available.

Additional information can be obtained from Professor N. P. Suh, Director, or Dr. Frans Van Dyck, Assistant Director, the Laboratory for Manufacturing and Productivity, Room 35-136, M.I.T., Cambridge, Massachusetts 02139, (617) 253-2225.

Laboratory for Nuclear Science

The Laboratory for Nuclear Science performs basic research in nuclear and elementary particle physics, supporting research interests of faculty in the Department of Physics by maintaining and administering support facilities adapted to studies in high-energy and nuclear structure physics. The Bates Linear Accelerator, a high-intensity electron machine, has greatly extended the Laboratory's capabilities. In addition to M.I.T. physicists, this facility is made available to other users on a nationwide basis. The Laboratory operates an IBM 360-65 computer as a facility available to staff and students. Among many projects are theoretical studies of the atomic nucleus and elementary particles; experimental programs using bubble chambers, spark chambers, and counter hodoscopes to study strong, electromagnetic and weak interactions of elementary particles and other high-energy phenomena; programs oriented toward the application of high-speed electronic computer techniques to the problems of nuclear and elementary particle data analysis; a broad program of nuclear studies using heavy-ion accelerators; and programs in radioactivity and in medium- and low-energy photonuclear

and nuclear particle research. As part of the nuclear physics program, members of the Laboratory are engaged in experiments at the M.I.T. Bates Linear Accelerator and the Brookhaven Tandem Accelerator. The high-energy physics program involves experiments at the National Accelerator Laboratory, Batavia, Illinois, the Brookhaven alternating gradient synchrotron facility, the Stanford Linear Accelerator, the intersecting storage ring facility at the CERN laboratories, Geneva, and at the German high-energy electron synchrotron at Hamburg.

Further information may be obtained from Laboratory for Nuclear Science Headquarters, Room 26-505, (617) 253-2395.

Laboratory of Architecture and Planning (L.A.P.)

The Laboratory of Architecture and Planning was created in 1973 as part of the School of Architecture and Planning for the purpose of fostering research which contributes to the understanding, education, and practice of architecture, planning, and closely related fields.

Projects currently administered by the Laboratory include: studies of energy conservation and appropriate technology; projects concerned with the development of techniques for assessing the environmental impacts of development and for mediating disputes concerning such developments; demonstrations of solar architecture; projects about neighborhood and community development; projects focusing on the use of media as a tool for public participation in community planning; and innovative approaches to communicating research findings to the public.

The L.A.P. provides a range of continuing education opportunities for the architectural and planning professions. The Laboratory also promotes the integration of research into the educational environment of the School and the Institute through the sponsorship of lectures, seminars, and conferences, publication support, and a program of architecture case studies.

A significant feature of the Laboratory's method is its involvement of a wide variety of people and institutions both inside and outside M.I.T. These include faculty and students from M.I.T. departments and centers, as well as from other educational institutions; the alumni of the School of Architecture and Planning; architectural and planning practitioners; and client groups, including firms, public agencies, and community organizations.

The Laboratory will undertake a developmental program in several areas of research defined by a School-wide agenda, as distinct from the Department's research interests which will continue to reflect the research interests of individual faculty members. Areas of priority concern will include: housing in developing nations and housing for special population groups in the United States; environmental management and design; communications; building technology; and neighborhood development.

Further information may be obtained from the Laboratory, Room 4-209, M.I.T., Cambridge, Massachusetts 02139, (617) 253-1350.

Lincoln Laboratory

The Lincoln Laboratory, located in Lexington, Massachusetts, is a Federally sponsored center for research and development in advanced electronics, with special emphasis on applications to national defense. The Laboratory is staffed and operated by M.I.T.

Lincoln Laboratory activities extend from fundamental investigations in science, through technological development of devices and components, to the design and development of complex systems. A continuing program of research in advanced electronics techniques provides a background of experience and ideas for work in specific programs, as well as a source of new scientific and technological advances for civilian and military application.

Specific programs include space communications, re-entry studies and technology, seismic detection and discrimination of nuclear explosions, computer systems and digital signal processing, space surveillance, photovoltaic power systems, and air traffic control. Research also is conducted in the fields of optics, solid-state devices, radio physics, and radar systems.

Opportunities for research in many of these technical areas are available to M.I.T. faculty members and qualified students. Inquiries may be directed to Dr. Frederick C. Frick, Assistant to the Director, LIN A-163, extension 181-225.

Mining and Minerals Resources Research Institute

In recent years there has been a reawakening as to the importance of mineral resources, and their engineering and management, to the well-being of modern industrial society. The Mining and Minerals Resources Research Institute (M.M.R.R.I.) at M.I.T. has been established with support from the Office of Surface Mining under the control of the US Department of the Interior. The support includes an annual institutional grant, funding for a limited number of fellowships and scholarships, and support of research, the last being obtained through proposals which are made to the Department of the Interior. A major responsibility of the M.M.R.R.I. is to support the interdisciplinary activities related to mineral resources at M.I.T. for both undergraduate and graduate students, and to bring to the attention of the community opportunities for careers in mineral resources engineering and management. The M.M.R.R.I. at M.I.T. also has the responsibility for developing a coordinated program on mineral resources among M.I.T. and several other universities in Massachusetts, in particular, the University of Massachusetts and Boston College. Information on the various activities of the Mining and Minerals Resources Research Institute may be obtained from the Office of the Director, Room 4-140, M.I.T., Cambridge, Massachusetts 02139.

Neurosciences Research Program

The Neurosciences Research Program (N.R.P.) is an international, interdisciplinary, and inter-university organization of scientists operating as a research center of M.I.T. Its main purpose is to facilitate and promote the development of theoretical interpretations bridging the gaps separating the data and concepts of traditional scientific disciplines engaged in research on the nervous system at its various levels of organization: molecular, cellular, neurophysiological, and behavioral. Theoretical breakthroughs are essential if the flood of new information is to be transformed into a scientific understanding of how the nervous system mediates the behavior of animals, including the mental life of human beings.

The N.R.P. consists of a center staff located in Boston, Massachusetts, in the House of the American Academy of Arts and Sciences, and operating with the advice and guidance of almost 40 scientists in various parts of the world (N.R.P. Associates).

There is opportunity for a few M.I.T. graduate students and postdoctoral fellows to participate in a seminar, 20.515 Seminar in Neuroscience Research Topics, offered through the Department of Nutrition and Food Science.

Further information may be obtained by contacting F. G. Worden, Director, 165 Allandale Street, Jamaica Plain Station, Boston 02130, (617) 522-6700.

Nuclear Reactor Laboratory

The Nuclear Reactor Laboratory (N.R.L.) provides the focus for a wide range of research programs which involve the use of nuclear radiations. Research programs in various M.I.T. departments and centers including Physics, Materials Science and Engineering, Earth and Planetary Sciences, Chemical Engineering, Nuclear Engineering, and Nutrition and Food Science are made possible and supported by the capabilities in the N.R.L. Outside institutions also make use of the unique facilities.

Current areas of research include:

- applications of nuclear trace analysis to problems in the physical and engineering sciences, in the life sciences, geosciences and the environment
- neutron and nuclear physics
- neutron scattering studies of solids, liquids, and dense gases
- radiation effects on materials, bulk and near surface radiation damage studies of nuclear and fusion reactor materials
- reactor physics and reactor engineering
- nuclear medicine
- isotope development

Facilities of the Nuclear Reactor Laboratory are also used for teaching activities by several departments and other institutions. The N.R.L. also provides special services to regional hospitals and industries, e.g., short-lived isotopes for medical purposes, where these services are not readily available from other sources.

The N.R.L. operates a 5-million watt research reactor (MITR-II), originally completed in 1958, which is one of the largest university reactors. Recent redesign and rebuilding of MITR-II has significantly enhanced this reactor's capabilities. Experimental facilities and instrumentation at the N.R.L. 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
- fast reactor blanket facility
- thermal column with large hohlraum
- radiochemistry laboratories
- hot cells for dismantling or testing, including mechanical property measurements
- a variety of nuclear detection equipment and software
- trace analysis facilities
- a materials characterization laboratory with equipment for mechanical property measurements and microstructural characterization
- shielded hot cells for handling and testing radioactive materials

The Nuclear Reactor Laboratory provides facility users with both scientific and technical assistance as required for the optimum use of N.R.L. facilities.

A current summary report is available which describes the activities at the N.R.L. in greater detail. For information, inquire at the office of the Director, Room NW12-208, (617) 253-4201 or 253-4202.

Operations Research Center

Operations research seeks to build a science and technology of decision making. The field is concerned with the operational and systems aspects of engineering, scientific, and management problems. For example, operations research deals with the optimal geographic location of nuclear power plants rather than the design of nuclear reactors; the management, organization, and scheduling of production rather than the technology of machines; and the collection, allocation, and distribution policies of a blood bank rather than the chemistry of preserving blood. In these and other cases, the operational analysis of a system may influence the technological developments, and vice versa, so that operations research studies are frequently interdisciplinary in character and may arise in widely different fields. Operations research also is concerned with the mathematical abstraction and analysis of the methods used in these studies.

The Operations Research Center, established in 1953, provides educational and research opportunities for students and faculty interested in the interdisciplinary field of operations research. Varied programs leading to the master's and doctor's degrees with emphasis on either applied or theoretical areas are available.

The Center interacts with faculty members from all the Schools at M.I.T.; its staff members and students are affiliated with numerous departments, including Urban Studies and Planning, Management, Mathematics, Physics, Aeronautics and Astronautics, Electrical Engineering and Computer Science, and Civil, Mechanical, and Ocean Engineering.

For more information on graduate programs in operations research, see the section on Operations Research under Interdepartmental Graduate Study.

Plasma Fusion Center

The Plasma Fusion Center, formed in 1976, provides an intellectual and administrative focus for experimental and theoretical studies in plasma fusion physics and related engineering disciplines. The primary objective is to provide the strong technical and administrative leadership required for effective coordination and implementation of all Department of Energy sponsored fusion research at M.I.T. The timely development of fusion energy is one of the most urgent and technically complex challenges facing society.

Outstanding technical excellence keynotes administrative and technical decisions made by the Plasma Fusion Center, along with providing the intellectual environment that fosters and encourages independent creativity, and integrating the collective fusion activities into a cohesive program. The Plasma Fusion Center also works closely with the Institute administration to achieve the following broader Institute goals:

- To provide, both nationally and internationally, the strong technical leadership required for the timely development of fusion energy;

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

Fusion research activities fall into four major programmatic Divisions.

Technology Development. The objective of this Division is to identify and investigate the technological problems associated with fusion reactors and advanced fusion systems and explore the possibility of mitigating technological constraints by optimal choice of plasma physics regimes. The subprogram areas include:

Safety and Environmental Studies
Blankets and Structures
Advanced Fusion Concepts
Tokamak System Studies
Component Development

Engineering Systems. This Division aims to provide critical engineering support for operating confinement experiments and advanced design projects. It also develops advanced superconducting magnet technology for the national fusion program. The subprogram areas include:

Project Engineering and Advanced Design
Superconducting Magnet Development
Superconducting Materials Development

Confinement Experiments. This Division develops practical understanding of the stability transport and radiation properties of high-temperature fusion plasmas at near-reactor conditions and methods for heating plasmas to fusion temperatures. The subprogram areas include:

Alcator A
Alcator C

Applied Physics Research. The aim of this Division is to develop the basic experimental and theoretical understanding of plasma heating and confinement properties. The subprogram areas include:

Experimental Research-Tokamak Systems
Experimental Research-Mirror Systems
Fusion Theory and Computations
Macsyma
Diagnostic Development and Laser Systems

Compact high-field (magnetic field) toroidal field confinement experiments have dominated the experimental program to date. Recently, work on Toratrons, an offshoot of stellarator research, has been undertaken. M.I.T.'s first ALCATOR machine, ALCATOR-A, has established a number of world records in obtaining the highest value for the product of plasma density times confinement time. A second machine, the recently completed ALCATOR-C, is expected to achieve higher values even closer to those required for a breakeven fusion device. Two smaller machines, VERSATOR-II and CONSTANCE-II, are used to study particular aspects of toroidal and mirror-confined plasmas, respectively. Other work related to this family of phenomena is being pursued. Conceptual designs for fusion reactors are undertaken, and the program has a balance between experimental and theoretical studies. Fusion activities in the Departments of Electrical Engineering and Computer Science, Materials Science and Engineering, Nuclear Engineering, Physics, the Francis Bitter National Magnet Laboratory, and the Research Laboratory of Electronics are affiliated with the Plasma Fusion Center.

People interested in exploring the interdepartmental aspects of the Plasma Fusion Center should contact Dr. James W. Meyer, NW16-203, M.I.T., Cambridge, Massachusetts 02139, (617) 253-3403.

Research Laboratory of Electronics

Established at the end of World War II as the Institute's first interdepartmental laboratory, the Research Laboratory of Electronics has evolved an on-campus research environment which seeks to provide faculty members and their students with the diverse services and facilities of a large laboratory. Participants from approximately 10 academic departments conduct research in three broad areas: general physics, plasma dynamics, and communication sciences. At present there are approximately 20 research groups.

Research in **general physics** is primarily concerned with the structure of matter, in all its forms. This work covers a wide range of topics in atomic and molecular physics, and in condensed matter science. The experimental techniques used in these studies include radio frequency and optical spectroscopy, X-ray scattering, laser light scattering, photo-acoustic spectroscopy, and nonlinear optics. The laser is a primary tool in many of these investigations.

The plasma dynamics program seeks to understand the basic properties of ionized media. Plasmas are the most common ingredient of the universe; they also play a crucial role in controlled thermonuclear fusion. Research in this area includes studies of plasma turbulence, heating, confinement, and stability. Plasma diagnostic techniques involve measurements in various portions of the electromagnetic spectrum (microwave, millimeter wave, infrared, optical).

Research in **communication sciences and engineering** spans a broad range of topics pertinent to communication processes in manufactured and living systems, as well as interactions between them. Fundamental studies of signals and systems are coupled with various applications such as speech and picture transmission, seismic detection, and optical communication channels.

Almost all of the research in R.L.E. is conducted or supervised by academic faculty members and students. Approximately 100 members of the faculty are affiliated with the Laboratory, and work with 250-300 graduate students and 50-100 undergraduates. Because the research in R.L.E. includes such a broad spectrum of topics it provides opportunities for a wide variety of student thesis projects.

Additional information may be obtained by contacting the Director's Office, Room 36-413, M.I.T., Cambridge, Massachusetts 02139, (617) 253-1557.

Sea Grant Program

Dedicated to advancing the vital roles of engineering and science in the development of ocean and coastal resources, the Sea Grant Program funds, promotes, and coordinates multidisciplinary research projects, educational opportunities, and advisory services on marine affairs. Following the lead of the National Sea Grant Program, created by Congress in 1966 to foster wise utilization of America's coasts, continental shelf, and offshore waters, M.I.T. recognizes the need to respond to new opportunities in the oceans and coastal zones, 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 M.I.T. as the nation's twelfth Sea Grant College, the first private institution to achieve this distinction, strengthened the Institute's commitment to furthering wise use and development of the ocean's resources.

The Sea Grant research program reflects the conviction that the Institute's expertise and facilities, applied to improving and to understanding scientific and engineering methodologies and nontechnological and environmental constraints, can solve critical problems in marine resource utilization and coastal zone development. Sea Grant research strives for balanced use of oceans and coasts, greater harvests of food and useful materials from the sea, the prudent extraction of offshore oil and undersea minerals, and the application of engineering to improved methods of working in and on the seas.

In addition to research, the Sea Grant Program supports innovative education at M.I.T. in ocean utilization and coastal zone development. Each year, an interdisciplinary design subject and a summer laboratory provide graduate and undergraduate students with the chance to apply classroom knowledge to "real-world" situations. The Program has supported pioneering textbooks and new curricula in and related to the field of ocean engineering. This year Sea Grant broadened its education program by supporting a project to develop a marine curriculum and new materials for pre-university students in grades kindergarten through 12.

The third part of the M.I.T. Sea Grant Program, the Advisory Services, publishes technical reports on the Institute's marine research projects, sponsors symposia and lectures on ocean-related topics, and through outreach activities, works with local governments, business, and organizations. The Advisory Services staff supplies comprehensive information on many facets of resource development in the oceans and coastal zones, and on the work done at M.I.T. to further marine activities.

More information on Sea Grant Program projects and services may be obtained by contacting Mr. Dean A. Horn, Director, or Ms. Elizabeth Harding, Communications Officer, (617) 253-3461.

Spectroscopy Laboratory

The M.I.T. Spectroscopy Laboratory is dedicated to advancing our knowledge of the structure and dynamics of atoms and molecules and the properties of liquids and solids, utilizing the techniques of modern spectroscopy. These techniques include the use of lasers and high-resolution spectrometers. As an interdepartmental laboratory, the Spectroscopy Laboratory encourages participation and collaboration among staff members in various disciplines of science and engineering.

At present, several departments conduct research programs in the Spectroscopy Laboratory. In addition, frequent scientific visitors, both from the US and abroad, participate in the work of the Laboratory for stays of various lengths.

Current research areas include high resolution laser spectroscopy of excited vibrational and electronic molecular levels, optically pumped molecular lasers, various kinds of double resonance experiments using coherent sources, laser saturation spectroscopy in both the steady state and time-delayed modes, dichroism spectroscopy of low temperature solids, spectroscopy kinetics and energy transfer in flames and other reactive systems, precision determinations of wavelengths and the speed of light, laser-nuclear spectroscopy, superradiance, structural studies of biological molecules using Raman techniques and X-ray diffraction data, and photoacoustic spectroscopy of biological materials.

A recent addition to the Spectroscopy Laboratory is the Tunable Laser Facility, available to qualified M.I.T. users. The Facility is equipped with a set of state-of-the-art pulsed and continuous dye laser systems (with frequency mixing capabilities), and provides intense tunable radiation from the ultraviolet to the near infrared.

Technology Adaptation Program

The Technology Adaptation Program (T.A.P.) is concerned with:

- 1 Developing an understanding of the characteristics of technologies that are appropriate to countries in various stages of development;
- 2 identifying criteria for the selection and adaptation of technologies appropriate for use in developing countries;
- 3 developing an understanding of the processes by which technological knowledge and skills can be effectively introduced, disseminated, and used in developing nations; and
- 4 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 an Advisory Committee which draws its members from the Schools of Engineering, Humanities and Social Science, and the Sloan School of Management. Members of the faculty who either have, or have had, specific research projects under the sponsorship of this program come from the following departments: Aeronautics and Astronautics, Architecture, Civil Engineering, Economics, Electrical Engineering and Computer Science, Materials Science and Engineering, Mechanical Engineering, Political Science, Sloan School of Management, and the Energy Laboratory.

The M.I.T./Cairo University Technological Planning Program was initiated in 1976, under T.A.P. auspices, to assist Cairo University in developing capabilities which could contribute to the formulation and implementation of science- and technology-related policies, to the end of aiding in the realization of Egyptian development goals. Three specific objectives have been identified:

- mobilization of academic interest in applied research on specific development plans
- organization of technical research in collaboration with Egyptian government ministries
- establishment of an institutional framework through which permanent applied research and training capability can be organized.

Graduate students from various departments participate under faculty supervision in the research carried on under this program.

Further information may be obtained from the T.A.P. Administrative Office, Room 39-525, (617) 253-7227.

Wallace Astrophysical Observatory

The George R. Wallace, Jr. Astrophysical Observatory is a versatile facility for research and teaching in optical astronomy, one of the oldest branches of science. It directly supports the growing student and faculty interest at M.I.T. in astronomy and related sciences.

Located in Westford, Massachusetts, the nucleus of the facility is a 24-inch optical telescope and its associated computer, which permits the monitoring and real time reduction of data outputs. A 16-inch telescope primarily for instruction purposes has also been installed, providing the Observatory with the flexibility to support a range of activity from observation to instruction, including the testing of new instrumentation and methods of data analysis. Several departments of the School of Science and the School of Engineering are participating in the work of the Observatory, along with interdepartmental centers and laboratories on the campus.

Further information may be obtained by contacting Professor James L. Elliot, Room 54-612, M.I.T., Cambridge, Massachusetts 02139.

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 M.I.T.'s 10-station network in New England.

The Observatory, located 35 miles north of Boston in Westford, Massachusetts, has a large, multi-room underground vault and a surface control room. The vault has a controlled temperature environment and instrument piers resting directly on the basement granite. The Observatory contains sensitive seismometers and instruments for monitoring ground tilts and the earth's tidal motions. The surface building houses a work area and control and recording instruments, although most of the data is telemetered directly to the Department of Earth and Planetary Sciences for recording and analysis. Data from the Observatory along with the numerous resources of the Department provide students and staff with a unique facility to pursue research concerning the interior of the earth.

Further information may be obtained by contacting Professor M. Nafi Toksoz, Room 54-518, M.I.T., Cambridge, Massachusetts 02139, (617) 253-6382.

Other Opportunities

Draper Laboratory

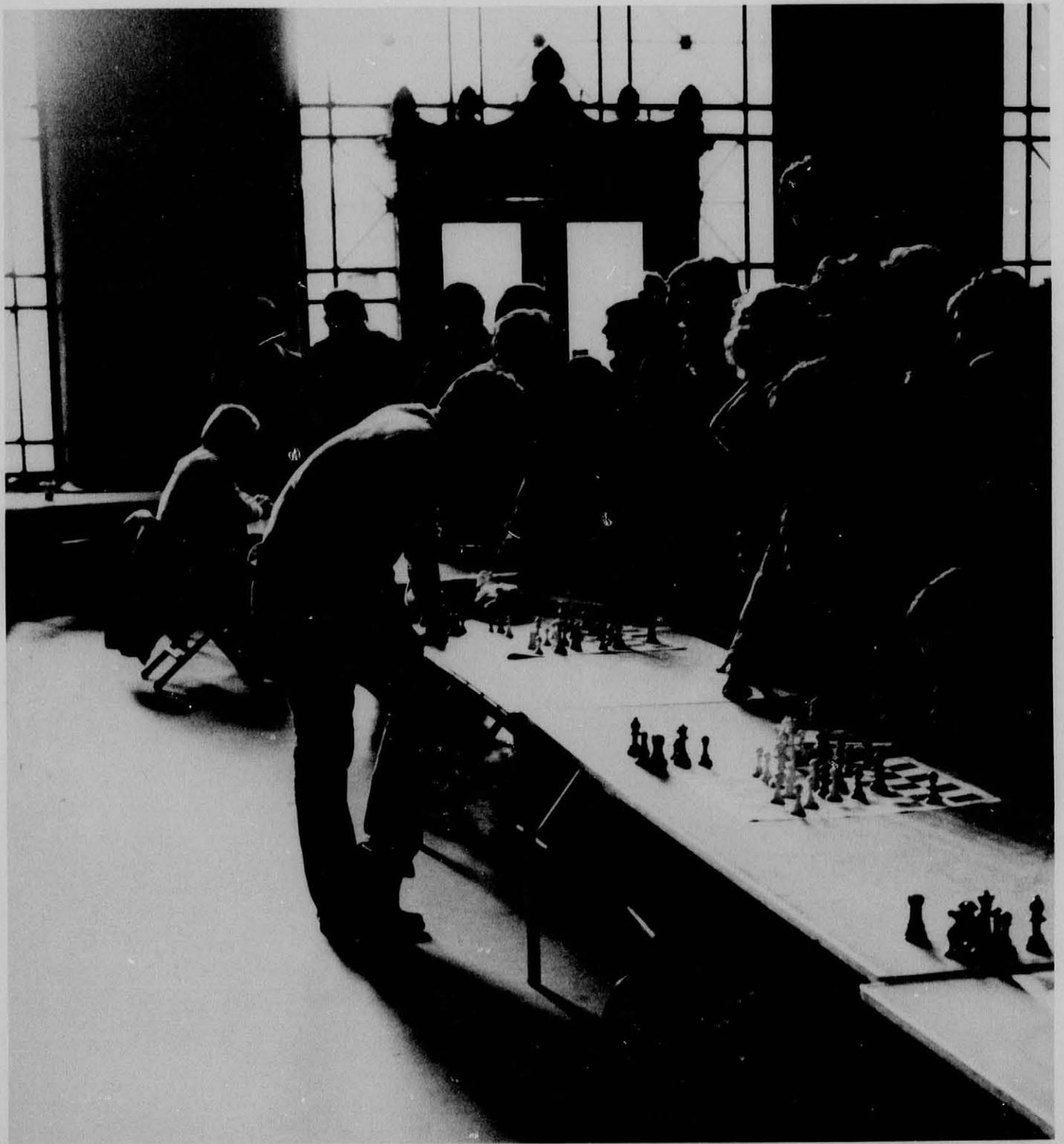
The Charles Stark Draper Laboratory (formerly the Instrumentation Laboratory) separated from M.I.T. on July 1, 1973 to become an independent non-profit research and educational organization. Both M.I.T. and the Laboratory recognize the mutual advantages of maintaining close and special relationships, and mechanisms exist to permit the continuation of joint research activities and to allow the Laboratory to continue its unique contributions to the Institute's educational program.

The professional field of interest has traditionally been the instrumentation of practical problems in dynamic geometry — e.g., guidance and control of aerospace and marine vehicles. The Laboratory is mission oriented, in that its goal is the design, development, and realistic testing of the theory, components, subsystems, systems, and their interrelationships that lead to a complete operational system. Probably the most publicized achievement of the Laboratory has been the technical development and supervision of the production and operation of Apollo guidance and control systems. During the past several years, the Laboratory has been broadening its areas of activities in instrumentation to other fields such as biomedical, geophysical, and oceanographic engineering which have a growing need for the application of the Laboratory's unique talents and resources. These new activities are expected to continue to grow in the future, as the needs and benefits for improved instrumentation are recognized and acknowledged.

The Laboratory experience in instrumentation has introduced information processing requirements resulting in new computer science activities and software applications in industrial automation, control for advanced energy systems, and specialized communication.

A number of M.I.T. faculty members maintain a close association with the Laboratory, and thesis research opportunities exist which fulfill the residency requirement for an M.I.T. degree in all phases of systems engineering beginning with basic theory, mathematical analysis, computer studies, component design and evaluation (mechanical, electrical, and optical), and system synthesis. These areas of research are live and up-to-date, with the student in direct daily association with the professional staff of engineers and scientists of the Laboratory. In this way, the student learns to appreciate the economic and human, as well as the technical, aspects of a system. Students also may be employed by the Laboratory and work directly on a project. These opportunities provide an excellent technical internship which greatly broadens the student's educational experience.

C.S.D.L., within walking distance of the main campus, is located at 555 Tech Square, Cambridge, Massachusetts 02139. Further information may be obtained by contacting W. Manlove, (617) 258-1590, or Institute extension 182-81590.



Departmental Programs and Requirements



School of Architecture and Planning



The School of Architecture and Planning offers educational programs that will prepare students for practice, research, and further study on the frontiers of professions that determine the form and quality of the physical environment and shape social and environmental policies and opportunities. The programs are intended to prepare students to understand and structure successfully the complex interaction of cultural influences, social policies, human requirements, and aesthetic values that are an integral part of social and environmental change.

The School offers undergraduate, graduate-professional, and doctoral programs in architecture, visual arts, and planning. Special mid-career programs allow students to formulate curriculum plans that meet their particular requirements. Consequently, the School must select students who will exercise a high degree of responsibility and initiative in the formulation of their educational career plans.

Degrees and Special Programs

The Department of Urban Studies and Planning offers an undergraduate S.B., a graduate-professional M.C.P., and the Ph.D. It also offers a five-year S.B./M.C.P. program for undergraduates. The Department's special programs include the Community Fellows Program and the Special Program for Urban and Regional Studies (SPURS). These programs allow mid-career practitioners who work in urban and regional development from minority communities in the US and developing countries to study and do research independently during one academic year.

The degree programs now offered by the Department of Architecture include: Bachelor of Science in Art and Design; Master of Architecture; Master of Science in Architecture Studies; Master of Science in Visual Studies; and the Ph.D. program which focuses in the area of history, theory, and criticism of art and architecture.

Members of both departments offer subjects during M.I.T.'s Independent Activities Period. In conjunction with the Harvard Graduate School of Design there is a small program of continuing education throughout the year.

Undergraduate Education

At the undergraduate level the departments offer both preprofessional and general educational programs in architecture, art, and urban studies and planning. Undergraduate concentrations are available in Environment and Policy in both departments. While they are not preprofessional, these programs may be preludes to work and graduate education in a number of different fields.

Media and Visual Arts

In addition to the scholarly study of the history and criticism of art and architecture, the School offers studio experience in direct visual expression. There are four centers in the visual arts, established over the last 10 years. The Creative Photography Laboratory, the Visible Language Workshop, and the Film Section combine teaching, practice, and research in publication, graphics, film and photography. The Center for Advanced Visual Studies; in association with the Department of Architecture, provides an opportunity for students to work on projects related to art on an environmental scale. This nucleus offers possibilities for undergraduate concentrations in the visual arts, and attracts students from other M.I.T. Schools and departments as well.

Departmental Interaction

Departmental self-sufficiency is balanced by strong interaction with other academic units at M.I.T. Several faculty members hold joint appointments in both departments in the School. Others have joint appointments in departments outside the School such as Economics, Psychology, Civil Engineering, and Humanities. Teaching and research in several areas such as urban economics, building construction, energy, communications, law, operations research, and the arts are linked to other parts of the Institute across departmental lines. Students and faculty from the Departments of Architecture, Urban Studies and Planning, and Mathematics, and the Schools of Management and Engineering work together on research projects in solar energy, transportation, and resource planning.

Research

The School's research, amounting to \$1.8 million last year, offers important educational opportunities for students. As research assistants, students not only carry out work on existing projects but also help to formulate ideas for new proposals.

Current research reflects the wide spectrum of student and faculty interests. These include: a study of reinvestment in urban neighborhoods; environmental impact assessment; a study of the design professional's representations of public space, urban form, and human activity; the development of a large computer-based model for the purpose of informing regional development policy choices; study of the effect of housing and its environs on the elderly; the study of passive solar energy systems; computer graphics for design; land use and facilities siting; multi-regional input/output analysis of transportation; revenue sharing; and national housing goals.

Many of these research projects are administered through the Laboratory of Architecture and Planning which fosters the growth and development of research in the School. Research, particularly in the field of housing policy, is also conducted at the Harvard-M.I.T. Joint Center for Urban Studies.

Field-Related Opportunities

In architecture and planning, students have had a wide variety of opportunities to participate in field-related experiences. These have included the programming of public services for the City of Cambridge; the provision of research assistance to Boston neighborhood organizations; opportunities to staff citizen land use planning organizations on the state and local levels; and advocacy planning for minority groups in public housing in both Boston and Cambridge. Students have been engaged in design and development work, ranging from the restoration of an old church to the preliminary design of a religious community. Adaptive planning and building projects for centers and community residences, which serve special needs groups such as the physically handicapped, have provided opportunities for students. Students have worked with such organizations as the Office of State Planning, the Department of Mental Health, the Federal Reserve Bank of Boston, local government planning, finance, and housing committees, community organizations, and design, construction, and planning firms. Summer student internships have provided the opportunity for students to work with the General Service Administration on planning the reuse of closed military bases.

Additional opportunities for student fieldwork are provided through research and community service projects and internship programs in the US Departments of Housing and Urban Development, and Health, Education and Welfare. Design and planning projects for government and private agencies have been the focus of several projects in the Department of Architecture and the Department of Urban Studies and Planning.

Design for special clientele has been the focus of several projects in the Department of Architecture. Classroom and field settings have been used for the study and demonstration of the role of the architect for groups which traditionally have been restricted in their use of the environment or in their access to professional design services.

Students

In 1978-79 there were 531 students in the School — 311 in architecture and 220 in planning — of whom two-fifths were undergraduates. The backgrounds, undergraduate majors, and previous job experiences of the students entering the graduate programs vary widely. The School also serves a large number of students, particularly undergraduates, from other departments at M.I.T. A limited number of non-degree special students are also admitted to the departments each term for the study of particular subject areas and the development of specialized skills.

The School encourages shifts in its composition in response to the necessity for minorities and women to become effective architects, artists, planners, researchers, and teachers. Minority graduate students, including Puerto Ricans, blacks, Chicanos, and Asian Americans, comprised approximately 25 percent of the total 1978-79 enrollment. Within the graduate degree programs, more than one-third of the students were women.

William L. Porter
Dean of the School of Architecture and Planning

Office of the Dean

William L. Porter, Ph.D.
Professor of Architecture and Urban Planning
Dean

Barbara Barlow
Assistant to the Dean

Lois A. Craig, B.A.
Special Associate to the Dean
Principal Research Associate,
Laboratory of Architecture
and Planning

Michael Joroff, M.C.P.
Director, Laboratory of Architecture
and Planning

Department of Architecture

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

Leon Bennett Groisser, Sc.D.
Associate Professor of Structures
Executive Officer
Acting Head of the Department, fall

Professors

Wayne V. Andersen, Ph.D.
Professor of the History of Art
(On leave, fall)

Stanford Anderson, Ph.D.
Professor of History and
Architecture

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

Horacio Caminos, Arq.
Professor of Architecture

Imre Halasz, Dipl. Arch.
Professor of Architecture

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

Henry Armand Millon, Ph.D.
Professor of History and
Architecture

John Randolph Myer, B.Arch.
Professor of Architecture

Otto Piene, M.A.
Professor of Visual Design
Director, Center for Advanced Visual
Studies
(On leave)

William Lyman Porter, Ph.D.
Professor of Architecture and
Urban Planning
Dean, School of Architecture and
Planning

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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Muriel Cooper, B.F.A.
Associate Professor of Visual
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Eric Dluhosch, Ph.D.
Associate Professor of Building
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Richard Filipowski, B.A.
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Sandra C. Howell, Ph.D.
Associate Professor of Behavioral
Sciences

Shun Kanda, M.Arch.
Associate Professor of
Architecture

Tunney F. Lee, M. Arch.
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Architecture and Urban Planning

Nicholas Peter Negroponte,
M. Arch.
Associate Professor of
Computer Graphics

Starr Ockenga, M.F.A.
Associate Professor of Photography

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

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

Jan Wampler, M. Arch.
Associate Professor of
Architecture

Assistant Professors

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Assistant Professor of
History and Architecture

Stephen K. Gregory, Ph.D.
Assistant Professor of
Computer-Aided Design

M. David Lee, M. Arch.
Assistant Professor of Architecture
and Urban Planning

Ronald L. MacNeil, S.B., M.F.A.
Assistant Professor of Visual
Studies

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Assistant Professor of Photography

Beeke Seu Tower, Ph.D.
Assistant Professor of the History
of Art

Anne Vernez-Moudon, B.Arch.
Assistant Professor of
Architecture

Barry Zevin, M.Arch.
Assistant Professor of Architecture

Adjunct Professors

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

Edward R. Pincus, B.A.
Adjunct Professor of Cinema

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

Principal Research Associate

Timothy E. Johnson, S.M.

Research Associates

Richard A. Bolt, Ph.D.
Reinhard Goethert, M.Arch.
Andrew Lippman, M.S.

Lecturers

James A. Champy, S.M., J.D.
Gunter Nitschke, Dipl. Arch.

Technical Instructors

Nishan Bichajjan
Ignacio Garabieta-Orueta, Dipl.
William F. Kelley, B.B.A.
George Lockhart, M.S.
Theodore P. O'Brien, Jr.
Joel Slayton, M.A.
Robyn Wessner, B.A.

Administrative Officer

Anne Shepley, B.A.

Assistant to the Head of the Department

Nancy Jones, B.A.

Administrative Assistants

Linda Laplante, M.A.
Beth Luchner, M.A.

Professors Emeriti

Lawrence Bernhart Anderson,
M.Arch.
Professor of Architecture,
Emeritus
Dean of the School of
Architecture and Planning,
Emeritus

Herbert Lynes Beckwith, M.Arch.
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Pietro Belluschi, Dott. Ing., LL.D.,
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Dean of the School of
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Eduardo Fernando Catalano,
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Professor of Architecture,
Emeritus

Albert George Henry Dietz, Sc.D.
Professor of Building
Engineering, Emeritus

Gyorgy Kepes, M.A.
Institute Professor, Emeritus
Professor of Visual Design,
Emeritus
Director, Center for Advanced
Visual Studies, Emeritus

Department of Architecture

The Department of Architecture includes a number of diverse fields of interest in architecture and the arts. The education that it offers encourages students to combine theoretical interest with tangible application and to consider the social consequences of their work. The diversity of attitudes and working methods found in these fields enriches a student's experience in the Department and suggests a variety of alternative career paths. Undergraduate and graduate students have the opportunity to structure their own academic programs to suit their special aptitudes and interests within an overall curriculum framework. While there are general distribution requirements and specific degree program requirements, it is possible to concentrate on any of these departmental fields: architectural design, building technology, the visual arts, and the history, theory, and criticism of art and architecture.

The Architectural Design curriculum for undergraduate and graduate students provides a flexible framework for study which places responsibility on the students individually to define their own educational directions. There is no single core curriculum. In each of the three levels of design studios, students have the opportunity to choose among several offerings which reflect some of the range of interests in the Department. Though the faculty who conduct or who participate in these studios may have intellectual and professional concerns that incorporate many areas in the Department, studio offerings usually relate to the following general areas.

Studios concerned with the Built Form of the physical environment work with additive processes for the design and construction of environments responsive to people's needs and activities. Building Technology studios focus on building processes, materials, systems, and technology as important factors in

architectural design. Another group of studios pays special attention to the uses of the physical environment, often by concentrating on specific client groups including the handicapped, the elderly, the poor, minorities, and urban populations in developing countries. The field of Environmental Design extends the concern for users to a scale embracing both physical and institutional design. This area of the Department is most closely allied with the Department of Urban Studies and Planning.

Studio offerings in all interest areas can and do establish ties to real world issues through investigation of actual building sites and/or programs, or through connection with ongoing departmental research in social and technological issues in architecture. The Department believes that through exposure to varying approaches to architecture, students can better select and define their own roles in the architectural world.

Students, faculty, and research staff in Design Technology principally use the School's computer center to experiment with modeling techniques, graphic representations, and design methods. Students may take subjects in this area and may participate in the research work which is concerned with developing the computer's capabilities in assisting with the design process.

Building Technology includes research and teaching in building structures, construction processes, industrialized building systems, and environmental controls. Members of the building technology faculty offer subjects examining the technical or contextual aspects of their fields, and also either conduct or participate in architectural design studios. Students may then, for example, have the opportunity both to study problems of energy resources and technologies, and to use what they have learned in designing physical environments.

The character of each arts program in the Department of Architecture reflects the interests and directions of its faculty and students, and its position within the Department and within the Institute's scientific and technological community. Each of the arts fields offers a full range of subjects which may be followed independently or in conjunction with other programs. These fields include: Film and Video, Photography, Visible Language Workshop, Environmental Art, and Visual Design, and are related to History, Theory, and Criticism. In these programs, students explore the potentialities and technical imperatives of the media being used through direct involvement in workshop contexts. These practical studies are supplemented by analytical, critical, and introspective studies which are concerned with the relation of the work to the maker, the viewer, the user, and the subject. In becoming familiar with both expressive and technical means offered by the medium, the student acquires the ability to form and transmit new discoveries about the environment.

The existence of these arts activities in the context of the Department and of the Institute also offers diverse interdisciplinary opportunities which are important to the intellectual life of the school. These opportunities, as illustrated by the following examples, span disciplines and interests within the Department, among departments, and even between beginning and advanced professional levels. The Visible Language Workshop, for instance, combines interests in publications media shared by photographers, visual designers, and others in the Department. Architecture students may explore the film medium as a tool in programming and design processes. Students in architecture, visual design, or environmental art may become involved in some of the research conducted at the Center for Advanced Visual Studies.

Undergraduate Study

The History, Theory, and Criticism program is organized in two parts for the study of art and of architecture and urban form. Studying history, theory, and criticism is important for artists and architects because it offers ways of developing and organizing concepts and because it increases one's understanding of the physical and social context of one's work. The faculty are most concerned with the creative process itself, both in understanding the meanings of an artist's or architect's actions, and more importantly, in being able to contribute directly to analytical and design processes. Thus, some of the faculty in this field work in conjunction with design studios.

The History of Art offerings reflect the research interests of the faculty, and concentrate on 19th- and 20th-century painting and sculpture. Their studies and teaching methods often use material drawn from psychology, anthropology, and other disciplines. 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 are also offered. Advanced work in history, theory, and criticism is possible through the Department's Ph.D. program in Architecture, Art, and Environmental Studies.

The Department offers two undergraduate programs 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 five possible areas of concentration: visual arts (including visual design, photography, the Visible Language Workshop, environmental art and filmmaking); architectural design; building technology (including structures, building process, energy systems, and environmental control); history, theory, and criticism of art; 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 counselor 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 five 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 will require 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 art and architecture should consult with an appropriate faculty member to design a program of study within this curriculum which will establish the basis for graduate study.

Graduate Study

Bachelor of Science Course IV-B

Course IV-B is offered for students who find that their basic intellectual commitments are to subjects within the Department of Architecture but whose educational interests and goals cut across departmental boundaries. These students may, with the approval of the Department, plan a course of study that directly suits their interests while including the fundamental areas within the Department. For example, students might profitably combine subjects in architecture with subjects in urban studies and planning, computer sciences, systems analysis, acoustics, etc., creating a coherent program of study especially designed to meet individual needs and interests.

In following this curriculum, students are required to fulfill the General Institute Requirements, departmental restricted electives, and planned electives selected by the student. Students desiring to follow this curriculum must submit to the Department, not later than the beginning of the fall term of their junior year, a statement of educational goals, including a list of the restricted, planned, and unrestricted electives selected to achieve these goals. At an earlier date, interested students should discuss their interests and intended programs with faculty members in the Department.

The School's developing interdisciplinary program in Environment and Policy can be pursued within this Course IV-B framework. This program covers both design and policy issues which affect the built and natural environment and spans the full range of offerings in the Departments of Architecture and Urban Studies and Planning.

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 will limit 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.

The Department offers four graduate degree programs — the Master of Architecture, the Master of Science in Architecture Studies, the Master of Science in Visual 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 profession, that is an essential step toward licensure for architectural practice. The Master of Architecture in Advanced Studies is a second professional degree awarded to students who extend their studies beyond the M.Arch. in areas of study not conventionally included in a professional program.¹ Both programs are designed as a preparation for practice and may also attract students who are preparing for teaching, writing, or research.

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.

¹
No students will be admitted to the Master of Architecture in Advanced Studies program after September 1978.

Entrance Requirements for Graduate Study

Undergraduate preparation in architecture usually differs from preparation leading to advanced scientific and engineering degrees. The following requirements apply to those seeking the advanced degrees in Architecture: four term subjects at the college level in mathematics and/or the physical sciences, and six term subjects in the humanities and/or the social sciences. M.I.T. students who have fulfilled the requirements for the Bachelor of Science in Art and Design normally are able to satisfy the requirements for the graduate M.Arch. in two years if they have taken the special program in architectural design and carefully planned their electives.

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 is 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.

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 Architecture Studies

This is a new program 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 will be 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 will share 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. And it will allow 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 group 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. 3) Building Systems Design — concentrating on the architectural applications of various aspects of the technology of building and their related systems. Each of these study areas has its core in the Department, and strong relationships outwards to other departments and academic groups.

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 will take advantage of research and study opportunities in the Institute setting.

There are five areas of concentration: film/video, centered in the Department's Film Section; environmental art, focusing on teaching and research in the Center for Advanced Visual Studies; graphics design, in the Visible Language Workshop; photography, centered in the Creative Photography Lab; and computer graphics, based in the Architecture Machine Group. Students may pursue the degree either in a single area of concentration or in a joint combined area — for example, computerized typography, environmental graphics, or digital video.

The degree is awarded upon completion of an approved program including core subjects from each of the five areas of concentration, and an acceptable thesis. The program requires two full academic years of residency.

Doctor of Philosophy in Architecture, Art, and Environmental Studies

The Ph.D. program, initiated in the area of History, Theory, and Criticism, is a new program designed to draw on the unique range of disciplines and professions within the Department of Architecture. It emphasizes the study of modern art, architecture (19th and 20th centuries), 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 the visual arts.

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 also is recommended. 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 M.I.T., and at Harvard and Wellesley; active collaboration with M.I.T.'s gallery and exhibitions program and with other institutions in the Boston-Cambridge area also is possible.

Inquiries

Further information concerning academic programs in the Department, admissions, financial aid, assistantships, etc. may be obtained from: Department of Architecture, Room 7-303, M.I.T., Cambridge, Massachusetts 02139, (617) 253-7791.

Subjects in Architecture

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|--|--|-------------|--|-------|--|
| (A) following the name of the subject indicates that it is an approved subject for a graduate degree and is given primarily for graduate students. | | 4.291 | Special Topics in Design Information | 4.59 | Special Topics in Industrialization of Building (A) |
| | | 4.295-4.299 | Special Topics in Design Information (A) | 4.601 | Topical Studies in the History and Theory of Art |
| | | 4.30 | Basic Structural Theory | 4.602 | Introduction to the History and Theory of Architecture |
| | | 4.315J | Structural Engineering Laboratory | 4.604 | Topical Studies in Modern Art |
| 4.U.R. | Undergraduate Research in Architecture | 4.331 | Synthesis of the Behavior of Structural Systems I (A) | 4.616 | Selected Topics in Architecture of the Ancient World |
| 4.01 | Issues in Architecture | 4.332 | Synthesis of the Behavior of Structural Systems II (A) | 4.626 | Selected Topics in Architecture in the Middle Ages |
| 4.071J | Design with Microclimate | 4.341 | Framing Systems for Small Structures (A) | 4.636 | Introduction to Renaissance Architecture |
| 4.125 | Architectural Design | 4.342 | Structural Design and Application (A) | 4.641 | Painting and Sculpture in the 19th Century |
| 4.126 | Architectural Design | 4.343 | Industrialization of Structural Systems (A) | 4.642 | Modern Art from Impressionism to Cubism |
| 4.131 | Architectural Design | 4.348 | Structural Design Workshop (A) | 4.643 | Advanced Study in 19th Century Art (A) |
| 4.132 | Architectural Design | 4.39 | Special Problems in Structural Design (A) | 4.647 | Selected Topics in Architecture 1750 to the Present |
| 4.143 | Architectural Design (A) | 4.402J | Basic Building Construction | 4.648 | American Landscapes, Towns and Buildings |
| 4.144 | Architectural Design (A) | 4.403J | Design of Building Systems | 4.651 | Modern Art from Cubism to the Present |
| 4.155 | Architectural Design (A) | 4.404 | Practical Workshop in the Technology of Construction | 4.653 | Modern Architecture in Europe from 1895 to the Bauhaus (A) |
| 4.156 | Architectural Design (A) | 4.407 | Elements of Buildings (A) | 4.655 | American Painting and Sculpture: 1940 to 1970 |
| 4.160 | Urban Settlement Design in Developing Countries I (A) | 4.408 | Integrated Design of Buildings (A) | 4.656 | Dada and Surrealist Imagery in the Arts (A) |
| 4.161 | Urban Settlement Design in Developing Countries II (A) | 4.409 | Special Problems in Building Technology (A) | 4.658 | Advanced Study in 20th Century Art (A) |
| 4.162J | Environmental Design III (Total Studio) (A) | 4.41 | Materials, Techniques and Form | 4.659 | Advanced Studies in Iconography and Symbolism (A) |
| 4.163 | Advanced Environmental Design (A) | 4.42 | Materials | 4.661 | Theory and Method in the Study of Architecture and Art (A) |
| 4.164 | Housing Design and Methods (A) | 4.43 | Environmental Control — Acoustics | 4.662 | Meaning in Architecture (A) |
| 4.17 | Special Problems in Architectural Design | 4.431 | Special Problems in Architectural Acoustics (A) | 4.663 | Form in Architecture (A) |
| 4.171 | Design | 4.45 | Uses of Energy in Buildings | 4.664 | Physical Considerations in Architecture (A) |
| 4.19 | Special Problems in Architectural Design (A) | 4.454 | Environmental Retrofit of Historic Buildings (A) | 4.665 | Criticism of Architecture (A) |
| 4.191 | Architectural Design (A) | 4.46 | Solar Architecture | 4.666 | Studies Toward a Theory of Architecture (A) |
| 4.201 | Introduction to Computers and Graphics | 4.468 | Energy Conscious Design (A) | 4.667 | Studies Toward a Theory of Environmental Design and Form (A) |
| 4.202 | Advanced Computer Graphics and Animation | 4.49 | Special Problems in Environmental Controls (A) | 4.668 | Studies in Environmental Cognition (A) |
| 4.211 | Intervention and Urban Habitats | 4.50 | Organization of the Building Industry | 4.671 | History of Urban Form (A) |
| 4.224 | Design and the Everyday Environment (A) | 4.51 | Introduction to Industrialization of Building (A) | 4.672 | Elements of Urban Evolution |
| 4.227 | The Design Process in Architecture (A) | 4.52 | Seminar in Industrialization of Building (A) | 4.673 | Seminar in Urban Communal Space (A) |
| 4.23 | Analysis of Urban Design (A) | 4.541J | Legal Problems in Construction (A) | 4.681 | Introduction to Building in East Asia |
| 4.236J | Introduction to Environmental Design (A) | 4.542 | Legal Regulation of the Building Process (A) | 4.682 | Selected Topics in the Study of East Asian Architecture |
| 4.242 | 3D Computer Graphics (A) | | | | |
| 4.251 | Applications of Digital Video (A) | | | | |
| 4.26 | Built Form Observations | | | | |
| 4.262 | Building Design Techniques | | | | |
| 4.27 | Analysis of Precedent | | | | |
| 4.271 | Advanced Topics in Environmental Precedent (A) | | | | |
| 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) | | | | |

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| 4.691- | Special Studies in the | 4.884 | Messages and Means II (A) | 4.987 | Film, Video and Space (A) |
| 4.693 | History, Theory and Criticism of Art (A) | 4.886 | Approaches to Visual Communication (A) | 4.988 | Film, Video and Performance (A) |
| 4.696- | Special Studies in the | 4.889 | Special Projects in Graphic Communication (A) | 4.989 | Independent Projects in Motion Picture Production (A) |
| 4.699 | History, Theory and Criticism of Architecture and Urban Form (A) | 4.895- | Special Problems in | 4.991 | Introduction to the History of Film |
| 4.742J | Shaping the Urban Environment | 4.899 | Environmental Art (A) | 4.992 | Introduction to Film Criticism and Theory |
| 4.743J | Neighborhood Planning (A) | 4.901 | Creative Seeing | 4.995 | Special Topics in the Theory of Media (A) |
| 4.744J | Site Planning | 4.903 | Total Exposure | 4.997 | Special Topics in Film/Video Distribution (A) |
| 4.745J | Problem Setting in Environmental Programming (A) | 4.906 | Graduate Seminar in Photography, Photo-Graphics and Graphics (A) | 4.999 | Special Topics in Film History and Criticism (A) |
| 4.747J | Theory of City Form (A) | 4.908 | Special Projects in Visual Arts | | |
| 4.748J | Environmental Programming (A) | 4.909 | Special Projects in Visual Arts (A) | | |
| 4.751 | Urbanization in Developing Countries: People, Dwellings, Land (A) | 4.921 | Creative Photography I: Regular Workshop | | |
| 4.753J | Urban Settlements in Developing Countries (A) | 4.922 | Color Creative Photography I | | |
| 4.761J | The Finite Earth: Agendas for a More Just, Sustainable and Participatory Society | 4.931 | Creative Photography II: An Historical Approach | | |
| 4.771 | Behavior in the Built Environment (A) | 4.932 | Creative Photography II: A Personal Approach | | |
| 4.772 | User Needs Programming (A) | 4.933 | Creative Photography II: The Projected Image | | |
| 4.797- | Special Problems in | 4.938 | Special Projects in Photography | | |
| 4.799 | Architecture and Social Change (A) | 4.941 | Advanced Photography (A) | | |
| 4.801 | Art and the Environment | 4.945 | Advanced Photography Seminar: Visiting Artists (A) | | |
| 4.802 | Visual Form and Expression | 4.949 | Special Advanced Projects in Photography (A) | | |
| 4.821 | Visual Design Projects I | 4.961 | Introduction to Video | | |
| 4.822 | Visual Design Projects II | 4.963 | Video Studio Production | | |
| 4.823 | Form and Design I | 4.965 | Video Processing, Color and Special Effects | | |
| 4.824 | Form and Design II | 4.968 | Special Project in Cable TV | | |
| 4.825 | Form and Color | 4.969 | Special Problems in Video (A) | | |
| 4.826 | Form and Color Workshop | 4.971 | Introduction to Moviemaking | | |
| 4.828 | Special Problems in Visual Design | 4.972 | Experiments in Film Imagery | | |
| 4.831 | Environmental Art | 4.973 | Intermediate Motion Picture Production | | |
| 4.838 | Special Problems in Environmental Art | 4.978 | Independent Projects in Film/Video Production | | |
| 4.841 | Environmental Light and Color I (A) | 4.981 | Advanced Production: Autobiographical and Biographical Filmmaking | | |
| 4.842 | Environmental Light and Color II (A) | 4.982 | Advanced Production: Problems in Editing (A) | | |
| 4.845 | Advanced Visual Design (A) | 4.983 | Visiting Artists Workshop | | |
| 4.846 | Advanced Visual Design (A) | 4.984 | Design Project in Film/Video Technology (A) | | |
| 4.861 | Life Drawing and Still Life | 4.985 | Film/Video and Its Technology I (A) | | |
| 4.862 | Advanced Figure Drawing | 4.986 | Film/Video and Its Technology II (A) | | |
| 4.865 | Painting | | | | |
| 4.867 | Plastic Composition | | | | |
| 4.868 | Special Problems in Graphic Communication | | | | |
| 4.871 | Photo-Graphics | | | | |
| 4.872 | Experimental Color Imaging | | | | |
| 4.873 | Messages and Means I | | | | |
| 4.875 | Typographics | | | | |
| 4.878 | Special Problems in Graphic Design | | | | |

Department of Urban Studies and Planning

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Department of Urban Studies and Planning

The Department of Urban Studies and Planning offers several degree and non-degree programs: Bachelor of Science in Urban Studies; Master of City Planning; Doctorate in Urban Studies and Planning; joint programs with the Departments of Architecture, Civil Engineering, Political Science, and Economics; a Special Program in Urban and Regional Studies (for mid-career professionals from developing areas); the Community Fellows Program (for mid-career professionals from minority communities in the United States); and special student status for part-time mid-career professionals interested in continuing education.

City and regional planners in the United States and other parts of the world are involved in a variety of activities aimed at shaping the pattern of human settlements and providing housing, public services, employment opportunities, and other crucial support systems that comprise a decent living environment. Planning encompasses not only a concern for the structure and imageability of the built environment, but also a desire to harness the social, economic, political, and technological forces that give meaning to the everyday lives of men and women in residential, work, and recreational settings. For planners operating at the neighborhood, metropolitan, state, or national level, in the public or the private sector, the tasks are the same: to help define goals and objectives, to formulate and implement programs and policies responsive to individual and group needs, and to work with and for various communities in allocating both economic and natural resources most efficiently and most equitably.

Planners are often described as "generalists-with-a-specialty." Specialties have been thought of in functional terms (such as housing, transportation, land use, and health care) or in terms of the geographic levels at which decision making takes place (neighborhood planning, town planning, regional planning, and planning for international development). Sub-specialties 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, and futurist.

The Department of Urban Studies and Planning seeks to train professionals and scholars who as practitioners, managers, advisors, or policy analysts will be able to deal with the processes of urban and regional development, environmental planning and design, and public policy analysis and implementation. The Department is committed to educating planners who can advocate the interests of underrepresented constituencies.

A focus on practice and the development of practice-related skills is central to the Department, particularly to students in the professional degree (M.C.P.) program. One means of acquiring these practice-related skills and of integrating them with classroom knowledge is through the Department's fieldwork and internship programs. Through fieldwork, students can acquire competence by witnessing others in action and by participating in and bringing field experiences back into the academic setting for reflection and discussion. Students may work as staff members to community organizations or government agencies, or as interns under the direction of faculty members involved in field-based projects for "outside" clients. Academic credit is awarded according to the time committed. In some cases stipends are related to fieldwork or internship programs.

During the month of January, the Department of Urban Studies and Planning offers a series of "mini-subjects" in specialized fields not covered by the regular curriculum. The Institute-wide **January Independent Activities Period** provides a unique opportunity to experiment with innovative approaches to teaching and flexible learning environments. In many instances, student-organized activities initiated during the Independent Activities period have subsequently been incorporated into the basic academic program.

Opportunities for concentration and specialization available to students are included in the descriptions of the degree programs that follow.

Undergraduate Study

Bachelor of Science in Urban Studies Course XI

The Department of Urban Studies and Planning offers an interdisciplinary, preprofessional program in applied social science, which provides knowledge of 1) urban systems and processes of managing public systems, 2) alternative approaches to improving urban and environmental conditions, and 3) analytical skills for evaluating the public policies and programs that shape these conditions. Fieldwork, internships, and participation in faculty research projects provide work experience and communication skills for employment in urban and environmental planning and related fields. The program prepares students to do graduate work in urban planning, public policy analysis, environmental design, law, and the social sciences.

The core of the program includes a set of restricted electives and specialized subjects that give basic knowledge of planning, urban and environmental systems and of the disciplines applied and integrated. Students take one introductory subject, four restricted electives and then specialize by adding at least 48 units of focused, advanced study. The senior colloquium and senior project complete their study in the fourth year.

Bachelor of Science Course XI-Option 2

This option, in cooperation with Civil Engineering, is designed for students who want to combine the skills of the two fields. Such programs concentrate, for example, on environmental engineering, transportation systems related to land development, or constructed facilities and environmental planning. Other combinations are possible.

The program is administered by a committee of faculty representing the two departments. Applications are made directly to this committee through either department. The committee advises students on the choice of courses to meet their study objectives.

This is a combined degree. The diploma names only the Department of Urban Studies and Planning, but a letter provided upon graduation by the Combined Program Committee confirms the student's participation in the program.

Bachelor of Science Course XI Option 3: Urban and Regional Planning in Developing Countries

This option provides training in urban studies and planning in the setting of developing countries. It is designed particularly for those students who come from developing countries or who are preparing to work in such places. Electives are available from a larger set than the restricted electives. They are chosen in conference with the student's advisor and are intended to develop a basic competence in analysis and planning in some specific areas. The major problem-area foci available are housing, transportation, and urban policy, but arrangements can be made to combine work in other departments such as Architecture, Civil Engineering, Economics, or Political Science.

Five-Year S.B.-M.C.P. Option

Undergraduate urban studies majors may apply for admission to the Department's Master in City Planning (M.C.P.) Program at the end of their junior year. Students accepted into the five-year program are exempted from the undergraduate thesis requirement and receive both the Bachelor of Science and the Master in City Planning at the end of five years. Admission is limited to those undergraduates who have demonstrated exceptional professional promise. More information on the five-year program may be obtained from the Director of the Undergraduate Urban Studies Program or the Chairman of the M.C.P. Committee.

Graduate Study

The Department of Urban Studies and Planning offers graduate work leading to the Master in City Planning and the Doctor of Philosophy. The Course is open to students with varying backgrounds. Urban studies, architecture, political science, civil engineering, economics, sociology, law, management, and public administration all offer suitable preparation. Applicants from other fields are also accepted. Undergraduate preparation for urban studies and planning usually differs from that required for scientific degrees at M.I.T. Further information concerning academic programs in the Department, admissions, financial aid, etc. may be obtained from the Graduate Admissions Coordinator, Room 7-338, M.I.T., Cambridge, Massachusetts 02139, (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 will 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.

An original thesis project is required of each M.C.P. student. By the end of the first semester, each student selects an area of specialization. This specialization is the focus of the student's work during the remaining three semesters of the program.

Environmental Design involves conceptualizing and guiding changes in the spatial environment. Work in this area at M.I.T. involves acquiring knowledge about the interactions between people and the settings they inhabit; understanding the historical evolution of current forms of settlement; improving methods for analyzing, programming, designing, and implementing environmental change; anticipating and coping with the impacts of changes in the form and functioning of human settlements; and developing processes for regulating and managing environments over time.

Environmental Planning and Policy emphasizes the study of the legal, institutional, and economic tools by which society conserves and manages its environmental resources. Substantive areas of concern include energy facility siting, pollution control, land use, growth management, and coastal zone management. Students examine the interactions between built and natural systems, techniques for describing and evaluating changes in environmental quality, approaches to environmental policy analysis, and mechanisms for assessing the choices posed by the environmental impacts of new technology.

Neighborhood and Community Development integrates economic, social, and political theories of development with planning methods. Emphasis is on community planning, including the location and organization of community services and facilities; the impact of housing, capital, and labor markets on the operation of the local economy; strategies for intervening in neighborhood income and employment structures; analysis of current and alternative policies towards neighborhoods; and the development of new techniques for defining community needs, assessing alternative policies, and implementing planned change.

Regional Economic Development involves the study of economic growth and locational change. Emphasis is on the production and distribution of goods and services; job creation and employment processes; development finance, trade, migration, and capital flows; techniques for analyzing regional development; and the evaluation of domestic, foreign, and international regional economic policies. Currently, special attention is paid to domestic issues and the application of regional input-output techniques.

The study of **Planning for Developing Countries** applies the theories and the techniques of regional and urban planning to developing countries. Emphasis is on national and subnational area planning in the context of national development policy; political and social aspects of development; and policy issues posed by alternative urban and rural development strategies. Research topics include criteria for infrastructure investment; housing policy; and rural development. Social science applications are central to this work.

Housing, Real Estate, and Land Development focuses on the management of urban growth, and on the design, location, and financing of housing. Emphasis is on public policies that affect housing conditions and private development, incentives in the development sector, land use regulations, and assessments of housing needs. Real estate development, construction, and the operation of financial institutions are related fields of interest.

Teaching and research in **Transportation Planning** takes place in several departments at M.I.T. 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.

Course work 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 interests.

Fieldwork and Internships

Students in the M.C.P. Program are encouraged to integrate fieldwork and internships with academic course work. The Department provides a variety of individual and group field placements involving varying degrees of faculty participation and supervision. Academic credit is awarded for field experience, although some students decide against requesting credit, and choose instead to participate in the work-study financial aid program. The Department also sponsors a variety of seminars in which students have an opportunity to reflect on their field experiences.

The HUD Intern Program is a special Federally funded program for minority M.C.P. students. The HUD Program and the Office of Education's Public Service Intern Program provide tuition and fieldwork placements in public and non-profit 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.

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.

Doctor of Philosophy

Advanced students, especially those seeking research or teaching careers in planning, applied public policy, 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.

Subject to the approval of a faculty advisor and the doctoral committee of the Department, a Ph.D. candidate engages in a program of study which provides a broad background in urban studies and advanced work in a major and minor area of specialization. These areas may be in any sub-field related to urban studies, planning, or applied public policy in which the Department of Urban Studies and Planning together with other M.I.T. departments offers strong support.

Interested and qualified students can undertake joint doctoral programs with the Departments of Political Science and Economics. Doctoral students in urban studies may be associated with the research program of the M.I.T.-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. They are permitted to enroll in a maximum of two subjects per term. (Special student status is not available to any individual for more than two terms.) 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.

Subjects in Urban Studies and Planning

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 academic year. This is done because it is important for the Fellow's primary support system to remain intact. Fellows spend a good portion of the year working on a research-development project of their own choosing that will be implemented after the fellowship year. Fellows are encouraged to utilize the vast resources of M.I.T. in order to successfully achieve their project objectives. Project work is guided by a mentor, either an M.I.T. 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 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, M.I.T., Cambridge, Massachusetts 02139. Applications will be accepted until March 31.

Special Program for Urban and Regional Studies of Developing Areas

SPURS provides an opportunity for a small number of unusually qualified people to carry out a non-degree program of study and research for one academic year. The work of this group of Fellows is focused on the problems of urban and regional change within the broad context of national development. The major aim of the Program is to enable individuals who will be shaping policy in developing nations in future years to enhance their capacity to deal with these problems.

The Program is designed to serve mature individuals who are now occupying or are likely to occupy significant positions in private or public organizations in such varied fields as architecture, engineering, sociology, economics, government, and business, or in any field in which there is a concern with problems of urban and regional development. Preference is given to applicants from developing countries; however, some participants come from Western Europe or the United States. The principal criteria for admission include exceptional ability, experience, and position of an individual. All applicants must have a thorough command of English, i.e., achieve a TOEFL score of at least 500.

Application forms may be obtained from: Director, SPURS, M.I.T., Room 10-400, Cambridge, Massachusetts 02139, USA. Completed applications should be submitted by mid-March. Applicants will be notified of acceptances shortly thereafter. Late applications also will be considered.

(A) following the name of the subject indicates that it is an approved subject for a graduate degree and is given primarily for graduate students.

- 11.001 Introduction to Urban and Environmental Planning and Development
- 11.002 Introduction to Public Policy Analysis and Governmental Action
- 11.003 Senior Colloquium
- 11.004 Models and the Metropolis
- 11.005 Urban Social Structure and Process
- 11.006J Politics, Planning and Urban Policy
- 11.007J Politics and Public Policy
- 11.008J Urban Economics
- 11.009 Technology and the City
- 11.010 Community Sociology
- 11.011 Laboratory in Research Methods
- 11.013J American Urban History
- 11.014J American Urban History
- 11.018 The Writer and the City
- 11.019J Modern Social Movements and Mass Phenomena in Historical Perspective
- 11.121 Introduction to Environmental Issues
- 11.122 Environmental Policy and Regulation
- 11.123 Environmental Quality Assessment
- 11.131 The Urban Neighborhood
- 11.132J Shaping the Urban Environment
- 11.133 Introduction to Design
- 11.141 Urban and Regional Planning in Developing Countries
- 11.142 Introduction to Community Development
- 11.144 Urban and Regional Economic Issues in Developing Countries
- 11.146 The Political Economy of Urban Poverty
- 11.163 Institutions and Communities
- 11.165 Law and Public Policy
- 11.166 Legal Institutions and Social Change
- 11.167 Seminar on Legal Institutions
- 11.172 Models in the Policy Process I
- 11.173 Models in the Policy Process II

| | | | | | |
|---------|---|---------|--|---------|---|
| 11.185J | Design with Microclimate | 11.312J | Environmental Programming (A) | 11.468 | The Implementation of Metropolitan Planning in Developing Countries |
| 11.U.R. | Undergraduate Research | 11.313J | Urban Settlements in Developing Countries (A) | 11.481 | Regional Economic Theory and Techniques |
| 11.191 | Undergraduate Tutorial in Urban Studies | 11.315 | Environmental Design II | 11.482 | Applications of Regional Economic Theory |
| 11.192 | Undergraduate Tutorial in Urban Studies | 11.316J | Environmental Design III (Total Studio) (A) | 11.483 | Workshop in Regional Economic Planning in Developing Countries (A) |
| 11.193 | Preparation for Undergraduate Thesis | 11.330 | Theory of City Form (A) | 11.484 | Regional Resource Allocation and Project Analysis |
| 11.194 | Special Topics in Urban Studies and Planning | 11.332 | City Design (A) | 11.485 | Rural Development: Theory and Practice in the Regional Context |
| 11.195 | Special Topics in Urban Studies and Planning | 11.334 | Environmental Ecology and Natural Resource Management | 11.487 | Practicum in Area Planning for Developing Countries (A) |
| 11.196 | Urban Fieldwork and Internships | 11.336J | Site Planning | 11.502 | Seminar in Program Design (A) |
| 11.197J | State and Local Government Internships | 11.360 | Community Growth and Land Use Planning | 11.510 | Seminar on Sociological Aspects of Policy Research |
| 11.200 | The Planning Process | 11.361 | Environmental Policy and Regulation (A) | 11.514 | Social Policy and the Metropolitan Community (A) |
| 11.210 | Economic Analysis for Planners | 11.362 | Land Use and Environmental Policy Implementation (A) | 11.521 | Policy Analysis of Social Service Systems (A) |
| 11.211 | Urban Economics: International Comparisons in Planning | 11.363 | Environmental Planning Practicum (A) | 11.523J | Evaluation of Public Programs (A) |
| 11.215 | Municipal Finance (A) | 11.364J | Urban Politics, Planning and Public Policy (A) | 11.526J | Urban Operations Research (A) |
| 11.218 | Project Management Techniques for Planning | 11.365J | Coastal Zone Management (A) | 11.527J | Comparative Topics in Administrative Practice (A) |
| 11.219 | Review of Mathematics for Urban Studies and Planning | 11.380J | Urban Transportation Planning (A) | 11.546 | Social Policy Studio (A) |
| 11.220 | Introduction to Statistical Concepts for Planning | 11.382J | Transportation Institutional Analysis and Policy (A) | 11.560 | Housing Issues and Policy |
| 11.221 | Multivariate Analysis for Planning | 11.384J | Transportation Policy and Planning in Developing Countries (A) | 11.562 | Housing Analysis and Public Policy (A) |
| 11.222 | Decision Analysis for Planning | 11.410J | Urban Economic Analysis I (A) | 11.571 | Issues in Criminal Justice (A) |
| 11.223 | Communication Techniques for Planning | 11.411J | Urban Economic Analysis II (A) | 11.572 | Planning for the Criminal Justice System (A) |
| 11.224 | Urban and Environmental Impact Assessment | 11.413 | Social Aspects of Development (A) | 11.581 | Fundamentals of Community Health Planning (A) |
| 11.225 | Analysis of Neighborhood and Regional Change | 11.417 | Planning in Socialist Countries (A) | 11.900 | Doctoral Proseminars (A) |
| 11.226 | Cost-Benefit Analysis for Planning | 11.420J | Neighborhood Planning (A) | 11.901 | Research Seminar: Topics in Urban Studies and Planning (A) |
| 11.227 | Formal Models for Public Policy Analysis | 11.431 | Financial Analysis in Urban Planning | 11.902 | Research Seminar: Topics in Urban Studies and Planning (A) |
| 11.228 | Survey Research Methods | 11.432 | Urban Land Development (A) | 11.911 | Reading Seminar in Urban Studies and Planning (A) |
| 11.229 | Case Study and Field Research Methods | 11.435 | Employment and Economic Development Policy and Planning I (A) | 11.912 | Reading Seminar in Urban Studies and Planning (A) |
| 11.230 | Institutional Analysis | 11.436 | Employment and Economic Development Policy and Planning II (A) | 11.921 | Statistical Research Methods for Urban Studies and Planning |
| 11.235 | Issues and Strategies in Public Management (A) | 11.441 | Issues and Strategies in Community Development | 11.932 | Preparation for Thesis (A) |
| 11.236 | Practicum in Public Management | 11.442 | Seminar in Community Development | 11.941- | Special Studies in Urban Studies and Planning (A) |
| 11.240 | Images of Cities | 11.445 | Community Development in Urban Neighborhoods | 11.948 | Urban Fieldwork and Internships (A) |
| 11.252 | Legal Regulation of the Use and Development of Land | 11.461 | Urban and Regional Growth Issues in Developing Countries (A) | 11.981 | Graduate Tutorial |
| 11.301J | Introduction to Environmental Design | 11.462 | Housing Problems, Goals and Policies in Developing Countries | 11.982 | Graduate Tutorial |
| 11.310 | Psychological Perspectives on Urban Life and Urban Form | | | 11.983 | Doctoral Seminar (A) |
| 11.311J | Problem Setting in Environmental Programming (A) | | | | |

School of Engineering



Never has the challenge of engineering been more exhilarating, the opportunities of engineering been more exciting than they are today, a time when resource limitations and environmental constraints are in conflict with the desire of society for an improved quality of life. Never has the role of the engineer been more exacting.

Engineering is concerned with developing and using scientific knowledge and technology to meet the needs of a complex society in ways that are sensitive to the constraints imposed by that society.

Shaping the physical and chemical behavior of materials into efficient systems providing energy, transport, communications, food, security, and the other needs of society is clearly the central activity of engineering, and that activity must be carried out within a social context, always subject to physical, economic, political, and legal bounds, and to the cultural value structure of the society.

Such concerns have created a large demand for engineering graduates, not only to enter the professional practice of engineering, but to bring the strengths of the engineering curricula to other fields by entry into law, medicine, management, and government science.

The School of Engineering at M.I.T. recognizes today's educational challenges and is responding to them by continuing to offer unique educational opportunities for advancement of the science and technology base of engineering. The School is also expanding its involvement in the application of engineering science and technology to the development of new technological solutions; in the identification of the relevance of such solutions in meeting society's needs; in the determination of their impacts on the social and natural environment; and in the steps required to translate meaningful solutions into reality.

In all of these activities the School of Engineering has continued to operate on the basis that its principal objective is to educate men and women so that they can become leaders in industry, government, and educational institutions. Hence their education at M.I.T. is viewed as being only one step in a life-long process of continual education and growth. The various curricula within the School are designed to emphasize underlying principles and their use in engineering, and to develop in students a versatility of mind and an ability to learn anew. In this same spirit, individual subjects and departmental programs are constantly under review and revision to reflect advances in knowledge and new issues in its application.

The School of Engineering is organized into eight departments: I Civil Engineering, II Mechanical Engineering, III Materials Science and Engineering, VI Electrical Engineering and Computer Science, X Chemical Engineering, XIII Ocean Engineering, XVI Aeronautics and Astronautics, and XXII Nuclear Engineering.

While the various departments do provide a convenient basis for administration of the School, it should be noted that they increasingly share common interests in terms of the problem areas to which their particular scientific disciplines and technologies are applied. This sharing of interests is illustrated in the following table which lists some of the broad applications areas in which the School of Engineering's faculty and students are currently involved, and shows the departments which are most closely involved in them.

The School of Engineering offers formal graduate degree programs in both the departmental areas and in a number of interdepartmental areas including: Bio-medical Engineering, Environmental Studies, Instrumentation, Operations Research, Materials, Mineral Resources Engineering and Management, and Technology and Policy. In addition, numerous other interdepartmental opportunities exist at both the undergraduate and graduate levels. With the faculty and resources of all the departments available, the student is able to

develop a program that satisfies his or her own intellectual and professional objectives. The student interested in an interdepartmental program will find it helpful to study the departmental descriptions and also to read the specific sections covering interdepartmental opportunities that combine, in various manners and degree, disciplines from the Schools of Science, Management, Humanities and Social Science, and Architecture and Planning with those of the School of Engineering.

| Applications | Departments | Civil Engineering | Mechanical Engineering | Materials Science and Engineering | Electrical Engineering and Computer Science | Chemical Engineering | Ocean Engineering | Aeronautics and Astronautics | Nuclear Engineering |
|---------------------|--------------------|-------------------|------------------------|-----------------------------------|---|----------------------|-------------------|------------------------------|---------------------|
| Energy | | • | • | • | • | • | • | • | • |
| Transportation | | • | • | • | • | | • | • | |
| Communication | | | | • | • | | • | • | |
| Manufacturing | | | • | • | • | • | | • | |
| Construction | | • | | • | | | • | | • |
| Materials | | • | • | • | • | • | • | • | • |
| Environment | | • | • | • | • | • | • | • | • |
| Medicine | | | • | • | • | • | | • | • |
| Governance | | • | • | | • | | • | • | • |

Engineering Internship Program

The Engineering Internship Program, a new educational program available to students in the School of Engineering, combines traditional on-campus academic programs with off-campus work experience in industry and government. The program is motivated by the belief that work experience can be an important aspect of a sound engineering education. By giving students an opportunity to participate in the world of work through professional activities early in their careers, it is hoped that students can:

- 1 make more informed choices from among the various on-campus educational offerings, and
- 2 obtain a better understanding of career opportunities available to them after graduation.

Programs of combined work and study are not new to M.I.T., 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 new 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" work assignments that extend the learning experience into areas that are not available at M.I.T. 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 M.I.T. 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 M.I.T. 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 M.I.T. 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 M.I.T. to the company at the beginning of each assignment and his or her travel back to M.I.T. 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, M.I.T., 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 M.I.T.,

be a service subject to engineering students and other students, and/or

be germane to many engineering students, without being central to any one departmental program.

A list of current School-wide Electives follows. Please note that registration for these subjects takes place through one of the departmental numbers. Subject descriptions may be found in Chapter V of this catalogue.

Computer Models of Physical and Engineering Systems I U(2)

1.16, 2.101, 3.05, 10.11, 13.51, 16.008, 22.006

Dynamics of Physical and Social Systems U(1)

2.193, 3.146, 13.49, 15.851, 16.994, 22.005

Introduction to Technology and Law I U(1)

1.030, 2.998, 10.803, 13.97, 16.792, 22.85

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

Introduction to FORTRAN (I.A.P.)

No departmental numbers; registration through Information Processing Services. See I.A.P. *Guide*. A not-for-credit two-week introduction to FORTRAN programming, offered in cooperation with I.P.S.

Interdepartmental Centers, Projects, and Laboratories

In addition, there exist at M.I.T. 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 Chapter III of this catalogue.

Artificial Intelligence Laboratory

Biomedical Engineering Center for Clinical Instrumentation

Center for Advanced Engineering Study

Center for Materials Science and Engineering

Center for Policy Alternatives

Center for Sensory Aids Evaluation and Development

Center for Space Research

Center for Transportation Studies

Cryogenic Engineering Laboratory

Division for Study and Research in Education

Electric Power Systems Engineering Laboratory

Energy Laboratory

Francis Bitter National Magnet Laboratory

Fuels Research Laboratory

Gas Turbine and Power Dynamics Laboratory

Degree Programs in Engineering

Harvard-M.I.T. Division of
Health Sciences and Technology

Heat Transfer Laboratory

Information Processing Center

Innovation Center

Laboratory for Computer Science

Laboratory for Information
and Decision Systems

Laboratory for Manufacturing
and Productivity

Laboratory for Nuclear Science

Lincoln Laboratory

Man-Vehicle Laboratory

M.I.T. Sea Grant Program

Nuclear Reactor Laboratory

Operations Research Center

Ralph M. Parsons Laboratory for
Water Resources and
Hydrodynamics

Rehabilitation Engineering Center

Research Laboratory of Electronics

Sloan Automotive Laboratory

Technology Adaptation Program

Technology and Policy Program

Urban Systems Laboratory

Through its departments and various interdepartmental groups the School of Engineering offers a wide variety of educational programs. Although students are classified as graduate students or undergraduate students, large numbers of the latter often enroll in some graduate subjects, and both groups are strongly encouraged to participate in a variety of research, engineering applications, and public service projects. Together, these activities and interactions provide a rich educational experience.

Degrees are awarded by the departments of the School and in several interdepartmental fields. At the undergraduate level several departments also offer so-called "undesignated" degrees which lead to the Bachelor of Science without departmental designation. The curricula for these programs offer students opportunities to pursue programs of studies which are broader than could be accommodated within a normal four-year departmental program.

Most undergraduate departmental degrees are accredited by the Engineers' Council for Professional Development. However, given their more general nature, the School of Engineering has not sought accreditation for any undesignated degrees. Holders of an accredited degree can generally take examinations for professional registration with fewer years of experience than holders of unaccredited or non-engineering degrees. Also, an accredited degree may be required for certain jobs. As the situation varies markedly from field to field, students should discuss this question with their faculty counselor 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 counselors.

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.

Robert Channing Seamans, Jr.
Dean of the School of Engineering

Office of the Dean

Robert Channing Seamans, Jr., Sc.D.
Henry R. Luce Professor of Environment and Public Policy
Dean

Kent Forrest Hansen, Sc.D.
Professor of Nuclear Engineering
Associate Dean

Frederick James Quivey, M.B.A.
Assistant Dean for Administration

John Ronald Martuccelli, S.M.
Director, Engineering Internship Program

School Professors Without Departmental Affiliation

J. Herbert Hollomon, Sc.D.
Japan Steel Industry Professor of Engineering
Director, Center for Policy Alternatives

Thomas Franklin Jones, Sc.D.
Professor of Engineering
Vice President for Research

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

Judah Leon Schwartz, Ph.D.
Professor of Engineering Science and Education

Myron Tribus, Ph.D.
Professor of Engineering
Director, Center for Advanced Engineering Study

Lawrence L. Bucciarelli, Ph.D.
Associate Professor of Engineering and Technology Studies

Benjamin Calhoun Ball, Jr., S.M.
Adjunct Professor of Management

Professor Emeritus

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Ford Professor of Engineering, Emeritus

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

Professors

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Professor of Aeronautics and
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Eugene Edzards Covert, Sc.D.
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Charles Stark Draper, Sc.D.
Institute Professor, Emeritus
Professor of Aeronautics and
Astronautics, Emeritus
Senior Lecturer

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Astronautics

Shaoul Ezekiel, Sc.D.
Professor of Aeronautics and
Astronautics and Electrical
Engineering

Morton Finston, Ph.D.
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Acting Dean for Student
Affairs

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Karl Uno Ingard, Ph.D.
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Marten Teodor Landahl, Tekn.D.
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Yao Tzu Li, Sc.D.
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Jean Francois Louis, Ph.D.
Professor of Aeronautics and
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Associate Director, Energy
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James Wah Mar, Sc.D.
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Winston Roscoe Markey, Sc.D.
Professor of Aeronautics and
Astronautics

John Francis McCarthy, Jr., Ph.D.
Professor of Aeronautics and
Astronautics
(Absent)

James Elliot McCune, Ph.D.
Professor of Aeronautics and
Astronautics

Flene Harcourt Miller, M.A.
H. N. Slater Professor of Flight
Transportation

Theodore Hsueh-Huang Pian, Sc.D.
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Robert Warren Simpson, Ph.D.
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Astronautics

Harold Yehuda Wachman, Ph.D.
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Henry Philip Whitaker, S.M.
Professor of Aeronautics and
Astronautics

Sheila Evans Widnall, Sc.D.
Professor of Aeronautics and
Astronautics
Chairman of the Faculty

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Professor of Aeronautics and
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Laurence Retman Young, Sc.D.
Professor of Aeronautics and
Astronautics

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John Vincent Harrington, Sc.D.
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and Astronautics and Electrical
Engineering

Senior Lecturers

Raymond Lewis Bisplinghoff,
Dr.Sci.Tech.
Charles Oswald Cary
William R. Hawthorne, Sc.D.
Donald John Jordan, B.S.
John Regnier Wiley, S.B.

Lecturers

Philip Nathaniel Bowditch, S.B.
Philip Kenyon Chapman, Sc.D.
John Jacob Deyst, Jr., Sc.D.
Antonio Luis Elias, Ph.D.
Donald Charles Fraser, Sc.D.
Betsy Gidwitz, Ph.D.
Arthur Grossman, B.S.
Albert Lafayette Hopkins, Jr., Ph.D.
John Hovorka, Sc.D.
James Thomas Kneafsey, Ph.D.
Henry Herbert Kolm, Ph.D.
Stephen James Madden, Jr., Ph.D.
Rudrapatna V. Ramnath, Ph.D.
John Stanley Sinkiewicz, B.S.
John Pascal Vinti, Sc.D.
Joseph Yamron, S.B.

Technical Instructors

Allan Ralph Shaw
E. Donald Weiner

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Senior Research Associate

Howard Theodore Hermann, M.D.

Principal Research Engineers

Charles Waldo Haldeman, Sc.D.
Nawal Koshore Taneja, Ph.D.

Principal Research Scientist

Charles McMaster Oman, Ph.D.

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Alan Harry Epstein, Ph.D.
Ralph Joseph Markson, Ph.D.
Alan Natapoff, Ph.D.

Postdoctoral Associates

Lars Hakan Gustavsson, Tekn.Dr.
Marcos Rosenbaum, Licentiate
George Peter Succì, Ph.D.
Choon Sooi Tan, Ph.D.

Postdoctoral Fellows

Pinchas Bar-Yoseph, D.Sc.
Otmar Leo Bock, M.D.

Visiting Scientist

Alfred David Weiss, M.D.

Research Affiliates

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Lindesay Ines Ker Harkness, Ph.D.
Greg Leon Zacharias, Ph.D.

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Walter Wrigley, Sc.D.
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and Astronautics, Emeritus

Department of Aeronautics and Astronautics

The objectives of the Department of Aeronautics and Astronautics are to provide broad training in the philosophy, approach, and disciplines of Aerospace Engineering, and to conduct research at the forefronts of a wide range of technologies critical to the future development of aerospace technology.

The aerospace community is unusual in its emphasis on advanced technology, and in its responsibility for large complex vehicles and systems which demand uniform excellence in engineering and management. To retain its position of leadership, it must seek continually to advance basic understanding of a wide range of physical phenomena, to conceive new devices and systems based on this understanding, and to carry them through the development process to practical use. It encompasses a wide range of talent, from basic researchers to managers of organizations employing thousands of engineers. The M.I.T. Department of Aeronautics and Astronautics is equally unusual in its commitment to providing training for and access to this broad range of opportunities in aerospace engineering. Its success in this endeavor is indicated by the large numbers of its alumni who are senior managers in government and in major aerospace firms, or in the forefront of basic research in the engineering sciences. The extensive involvement of its faculty with government and industry is a further measure of the Department's central role in the aerospace community.

The aerospace vehicle — be it a helicopter, commercial transport, satellite, or space shuttle — provides a focus for many aspects of aerospace engineering with which the Department deals. Throughout its teaching and research activities, the vehicles and the transportation systems of which they are major elements are used for motivation and coordination of the instruction and research. The faculty is also alert to the possibilities for application of aerospace-derived technologies to non-aerospace uses, resulting in a myriad of couplings to the scientific and engineering research communities.

At the undergraduate level, the Department seeks to provide a broad introduction to aerospace engineering, together with thorough basic training in all of the disciplines critical to aerospace. The departmental program comprises: 1) Unified Engineering, an Introductory course taught cooperatively by a number of senior faculty members, covering all of the basic disciplines in an interrelated format as well as experimental and systems approaches; 2) a series of Restricted Electives and access to other Electives providing greater depth in each disciplinary area; and 3) the Experimental Projects Laboratory, in which each student conceives and executes an individual experiment. In addition, undergraduates are encouraged to become involved in the research activities of the Department through the Undergraduate Research Opportunities Program. Research opportunities are outlined under Graduate Study.

The graduate teaching and research activities of the Department are strongly interwoven, since the graduate subjects evolve from the research and professional interests of the faculty and in turn serve to introduce students to the areas of active research. Teaching activities are informally organized into five Divisions of Instruction: Mechanics and Physics of Fluids; Structures, Materials, and Aeroelasticity; Propulsion and Energy Conversion; Instrumentation, Guidance, and Control; and Aeronautical and Astronautical Systems. Research is conducted in the Departmental Laboratories including the Aerophysics and Fluid Dynamics Laboratories, the VTOL Technology Laboratory, the Aeroelastic and Structures Research Laboratory, the Technology Laboratory for Advanced Composites, the Gas Turbine and Plasma Dynamics Laboratory, the Man-Vehicle Laboratory, the Laser Systems Laboratory, the Flight Transportation Laboratory, and the Space Systems Laboratory. In addition to its departmental activities, the Department maintains close interaction with the Charles Stark Draper Laboratory. Each of these is described briefly in the section on Graduate Study.

Undergraduate 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.

The undergraduate course of study is based on a core of two 24-unit subjects in Unified Engineering. 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. Students are assigned desks in a Common Room reserved for the subject and used for recitations and design sessions. The Common Room serves as a work-study room for students throughout the week.

Unified Engineering is usually taken in the sophomore year; it fulfills the prerequisites for a variety of Restricted Electives and other Electives which deal more intensively with subjects in the five areas of: mechanics and physics of fluids; instrumentation, guidance, and control; propulsion and energy conversion; structures, materials, and aeroelasticity; and aeronautical and astronautical systems. Alternatively, a student may take Unified Engineering in

the junior year, and complete the Departmental requirements, which include one Restricted Elective selected from each of the five above areas.

Each student has the opportunity in the Undergraduate Projects Laboratory 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 are required. This subject satisfies the Institute Laboratory Requirement.

Any one of several programs leads to the degree of Bachelor of Science in Aeronautics and Astronautics. All programs leading to degrees in Aeronautics and Astronautics are accredited by the Engineers' Council for Professional Development (ECPD). If desired, the student may request an unspecified degree, Bachelor of Science. This degree is not so accredited.

Program 1 Aeronautics and Astronautics. Program 1 is appropriate for students desiring a broad exposure to aerospace engineering in the normal four years of residence at M.I.T. The required subjects may be supplemented with additional restricted electives or other undergraduate or graduate courses according to individual interests.

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.

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.

Graduate Study

A student interested in the program should apply to 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 M.I.T. 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 M.I.T. usually is necessary.

Engineering Internship Program Course XVI-C

This program reflects the participation of the Department of Aeronautics and Astronautics in the Engineering Internship Program (E.I.P.) 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 M.I.T. See additional discussion of this program in the School of Engineering section of this catalogue.

Interested students apply for participation in E.I.P. during the spring term of their sophomore year. Companies select students for work assignments based on interviews at M.I.T. 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.

The advantage of this Program to the student is a continuing series of work experiences interleaved with study. This stimulates interest in the academic subjects and gives the student a professional perspective on his or her education. The curriculum requirements for Course XVI-C are the same as for Course XVI with 16.801 (twice) used as 12 units of elective. At the completion of the Program there is no obligation on the part of the student or the company for further employment. For further information, please see additional discussion of the program in the School of Engineering section of this catalogue, or the Department E.I.P. Coordinator.

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, M.I.T., Cambridge, Massachusetts 02139, (617) 253-2279.

Advanced 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 M.I.T. Degrees are awarded at the Master's, Engineer's, and doctoral levels.

Divisions of Instruction and Research Laboratories

The graduate subject offerings of the Department are informally organized into five Divisions: Mechanics and Physics of Fluids; Structures, Materials, and Aeroelasticity; Instrumentation, Guidance, and Control; Propulsion and Energy Conversion; 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 at the Charles Stark Draper Laboratory, or in one or more of the following departmental laboratories: the Aerophysics Laboratory, the Fluid Dynamics Research Laboratory, the VTOL Technology Laboratory, Aeroelastic and Structures Research Laboratory, Technology Laboratory for Advanced Composites, the Man-Vehicle Laboratory, Laser Systems Laboratory, Gas Turbine and Plasma Dynamics Laboratory, the Flight Transportation Laboratory, and the Space Systems Laboratory.

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. Gaps in preparation can be filled early in the graduate program, but additional time in residence should be expected if many undergraduate courses are required.

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 Master's candidate customarily emphasizes a single professional field; however, excessive specialization is not encouraged. Under the guidance of a faculty advisor with related interests, students select individual programs without restriction as to departments. There is no language requirement for the Master of Science.

Master of Science in Technology and Policy

Students interested in applying their aeronautical engineering background to problems of policy and socioeconomic assessment of technology may apply for the Interdepartmental Master of Science Program in Technology and Policy. This program combines subjects in advanced technology with subjects in economics, systems analysis, political science, and law. It engages the student in significant project work integrating technology and policy. Well-qualified students may complete this program in one calendar year. General requirements and application procedures are described in Chapter V of this catalogue.

Engineer in Aeronautics and Astronautics

This degree program is limited to those possessing demonstrable capability for excellence in engineering, including a capacity for pursuing rigorous advanced training in the disciplines upon which engineering is based. Judgment and skill needed to apply technology to the synthesis of complex operational systems must be demonstrated.

Requirements for admission to candidacy for the Engineer in Aeronautics and Astronautics are more rigorous than for the Master of Science in Aeronautics and Astronautics. A specific description of requirements is available in a pamphlet which may be requested from the Department graduate office.

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-M.I.T. program in Medical Engineering and Medical Physics is for students wishing a more intensive exposure to the medical sciences as preparation for a career of research focused on clinical problems. For a further description of these programs, please see Chapter V, Interdepartmental Study and Research. Most biomedical engineering in the Department of Aeronautics and Astronautics is conducted in the Man-Vehicle Laboratory. Further information is contained in the brochure "Biomedical Engineering at M.I.T. and Harvard," available from the Biomedical Engineering Committee, Room 37-219, M.I.T.

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 that 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 Department of Aeronautics and Astronautics, Civil Engineering, Economics, and the Center for Transportation Studies (See Chapter V, Interdepartmental Graduate Study). A special interdepartmental program may be established for the doctoral student (or participation in the Operations Research Center Program may be considered.)

Fellowships, Research and Teaching Assistantships

Financial assistance for graduate study may be in the form of fellowships or research or teaching assistantships. There are several endowed and departmental fellowships which are granted to students of exceptional promise. Among the endowed fellowships are: 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, M.I.T., Cambridge, Massachusetts 02139, (617) 253-2260.

Innovation Program

The Department has initiated and provides logistic support for the M.I.T. Innovation Program which is organized by the School of Engineering with the support of the Sloan School of Management. The primary goals are to develop an atmosphere conducive to inventiveness and to provide the facilities and organization necessary to carry out the development of promising ideas. The complete process of bringing a new concept or device from the idea stage, through development and testing, including marketing and the legal aspects of patents and licensing, is undertaken. Students at any level and from any department may participate.

Subjects in Aeronautics and Astronautics

(A) following the name of the subject indicates that it is an approved subject for a graduate degree and is given primarily for graduate students.

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|---------|---|---------|--|---------|---|
| 16.U.R. | Undergraduate Research | 16.32 | Principles of Optimal Control (A) | 16.671J | Invention |
| 16.001 | Unified Engineering I | 16.34 | Automatic Control of Flight Vehicles (A) | 16.672 | Entrepreneurship |
| 16.002 | Unified Engineering II | 16.351J | Quantitative Physiology: Sensory and Motor Systems | 16.675 | Invention Development Laboratory |
| 16.003 | Unified Engineering III | 16.352J | Sensory-Neural Systems (A) | 16.676 | Internship in New Enterprise Development |
| 16.004 | Unified Engineering IV | 16.353 | Seminar in Sensorimotor Processes (A) | 16.701 | Principles of Systematic Policy Analysis |
| 16.008 | Computer Models of Physical and Engineering Systems I | 16.354J | Design and Evaluation of Human/Engineering Systems (A) | 16.703 | Introduction to Aerospace Management |
| 16.01J | Molecular Theory of Materials | 16.355J | Man-Machine Systems (A) | 16.704J | Seminar in Air Transportation Analysis and Planning |
| 16.02 | Aerodynamics | 16.37 | Statistical Problems in Automatic Control (A) | 16.711 | Introduction to Probability and Statistics |
| 16.025 | Introduction to Numerical Aerodynamics (A) | 16.371 | Estimation and Control of Stochastic Processes (A) | 16.712 | Air Transportation Forecasting Methods (A) |
| 16.035 | Fluid Mechanics (A) | 16.381J | Optics and Optical Electronics | 16.72 | Air Traffic Control (A) |
| 16.041 | Aerodynamics — Viscous Fluids (A) | 16.382 | Lasers and Optics for Applications (A) | 16.73 | Airline Management (A) |
| 16.042 | Aerodynamic Heating (A) | 16.383 | Topics in Laser Instrumentation (A) | 16.74 | Air Transportation Economics (A) |
| 16.044J | Turbulence and Random Processes in Fluid Mechanics (A) | 16.39 | Algorithms for Function Minimization and Optimal Control (A) | 16.751 | Flight Transportation (A) |
| 16.051 | Gas Dynamics (A) | 16.40 | Principles of Flight Guidance | 16.752J | International Air Transportation |
| 16.052 | Real Gas Dynamics (A) | 16.41 | Space Dynamics and Gyroscopic Instruments (A) | 16.76J | Urban Operations Research |
| 16.060 | Surface and Gas-Surface Problems in Aerospace Engineering (A) | 16.42 | Inertial Navigation (A) | 16.77 | Flight Transportation Operations Analysis (A) |
| 16.07 | Aerodynamics of Wings and Bodies (A) | 16.43 | Strapped-Down Inertial Systems (A) | 16.781J | Planning and Design of Airport Systems (A) |
| 16.081J | Principles of Acoustics (A) | 16.46 | Astronautical Navigation (A) | 16.782J | Airport Operation and Management (A) |
| 16.082J | Flow Noise (A) | 16.491 | Selected Topics in Celestial Mechanics (A) | 16.792J | Introduction to Technology and Law I |
| 16.09 | Nonlinear Wave Propagation (A) | 16.492 | Selected Topics in Celestial Mechanics (A) | 16.793 | The Law/Technology Interface (Law, Technology and Public Policy) |
| 16.105 | Applied Aerodynamics | 16.53 | Rocket Propulsion | 16.80 | Industrial Practice |
| 16.15 | Advanced Flight Vehicle Stability and Control (A) | 16.54 | Aircraft Engines and Gas Turbines | 16.801 | Engineering Internship |
| 16.20 | Structural Mechanics | 16.541 | Aircraft Turbine Engines (A) | 16.802 | Advanced Engineering Internship |
| 16.21 | Plates, Stability and Thermoelasticity (A) | 16.542 | Advanced Computational Methods in Internal Flows (A) | 16.811J | Introduction to Systems Analysis |
| 16.22 | Shell Structures (A) | 16.543 | Fluid Mechanics of Turbomachinery (A) | 16.821 | A Management View of Engineering Seminar |
| 16.24 | Plasticity, Viscoelasticity and Creep (A) | 16.55 | Ionized Gases | 16.83 | Automotive Vehicles |
| 16.251 | Structural Design for Longevity (A) | 16.551 | MHD Power Generation (A) | 16.84 | Flight Vehicle Engineering |
| 16.252 | Structural Response to Severe Transient Loads (A) | 16.56 | Noise Control Engineering (A) | 16.85 | Space Systems Engineering |
| 16.261J | Structural Mechanics in Nuclear Power Technology (A) | 16.59J | Introduction to Plasma Kinetic Theory (A) | 16.851 | Satellite Engineering (A) |
| 16.27 | Finite Element Method (A) | 16.60 | Advanced Special Project (A) | 16.86 | Advanced Systems Engineering (A) |
| 16.28 | Advanced Finite Element Method (A) | 16.601 | Advanced Special Subject (A) | 16.87 | VTOL Aircraft (A) |
| 16.29 | Design with Filamentary Composite Materials (A) | 16.602 | Advanced Special Subject | 16.88 | Aerodynamics, Structural Dynamics, and Aeroelasticity of Wind Turbines and Rotorcraft (A) |
| 16.30 | Principles of Automatic Control | 16.605 | Special Projects | 16.891 | Technology and History: China and the West |
| 16.31 | Principles of Instrumentation and Control (A) | 16.606 | Selected Topics in Aeronautics and Astronautics | 16.91 | Structural Dynamics (A) |
| | | 16.62 | Experimental Projects | 16.92 | Advanced Aeroelasticity (A) |
| | | 16.64 | Flight Measurement Laboratory | 16.94 | Advanced Structural Dynamics (A) |
| | | 16.65 | Experimental Techniques in Aerodynamics (A) | 16.991 | Aeronautics and Astronautics Seminar |
| | | | | 16.992 | Seminar |
| | | | | 16.993 | Management in Engineering |
| | | | | 16.994 | Dynamics of Physical and Social Systems |

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Head of the Department

Jack Benny Howard, Ph.D.
Professor of Chemical Engineering
Executive Officer of the
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Professor of Chemical and Fuel
Engineering

Clark Kenneth Colton, Ph.D.
Professor of Chemical Engineering

Lawrence Boyd Evans, Ph.D.
Professor of Chemical Engineering

John Ploger Longwell, Sc.D.
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Edward Wilson Merrill, Sc.D.
Carbon P. Dubbs Professor of
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Robert Clark Reid, Sc.D.
Professor of Chemical Engineering

Adel Fares Sarofim, Sc.D.
Professor of Chemical Engineering

Charles Nelson Satterfield, Sc.D.
Professor of Chemical Engineering

Kenneth Alan Smith, Sc.D.
Joseph R. Mares Professor of
Chemical Engineering

Johnson Edward Vivian, Sc.D.
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Director of the School of Chemical
Engineering Practice

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

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Robert Edward Cohen, Ph.D.
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Christos Georgakis, Ph.D.
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Michael Modell, Sc.D.
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Preetinder Singh Virk, Sc.D.
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William Murray Deen, Ph.D.
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Michael Patrick Manning, Sc.D.
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(Visiting)
Charles Michael Mohr, Sc.D.
William Caabu Rousseau, M.S.
(Visiting)

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(Visiting)
Malcolm Thomas Jacques, Ph.D.
Edmund Gale Lowrie, M.D.
(Visiting)
James Hall Porter, Sc.D.
(Visiting)
Barry Alan Solomon, Ph.D.
(Visiting)
Warren Myron Zapol, M.D.
(Visiting)

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Stanley Robert Mitchell

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Prem Krishna Gupta, Ph.D.
Paul M. Mathias, Ph.D.
Saranga Raghavan, Ph.D.

Postdoctoral Associate

Michael Phillip Bohrer, Ph.D.

Visiting Engineers

Guillermo Calleja, Ph.D.
Amitava Mitra, M.Sc.
Ignacio Rossi, Chem.E.

Visiting Scientists

Federico Beretta, Ph.D.
Karl-Heinz Reichert, Ph.D.
Edwin W. Salzman, M.D.
Michael Bernard Stemberman, 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

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, the provision of adequate food supplies, the recreation of proper ecological balances, the advancement of medical/engineering science, and the economic production of material goods. In order to participate meaningfully in these activities, the engineer must have a thorough grounding in chemistry, mathematics, and physics. At M.I.T., the Department of Chemical Engineering achieves this objective in two undergraduate programs. One is Course X, leading to the Bachelor of Science in Chemical Engineering. This program is accredited by the Engineers' Council for Professional Development and the American Institute of Chemical Engineers. The other program is 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 an 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 counselor.

Graduate Study

Bachelor of Science in Chemical Engineering Course X

Students in the regular Course X take a group of specified core subjects in chemistry and chemical engineering including some laboratory work, together with additional restricted electives in chemistry and/or biology and chemical engineering. Additional opportunities for experimental research with considerable flexibility in scheduling are provided in 10.91 Experimental Research Problem. Students with a strong interest in a professional minor may satisfy this interest by use of the scheduled free elective time.

A chemical engineering elective available for freshmen is 10.10 Process Synthesis. It may be used to satisfy the restricted electives 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 will achieve their objectives. Students are assigned a member of the Department faculty as an advisor.

Five-Year Programs

In addition to offering separate programs leading to the Bachelor of Science and Master of Science in Chemical Engineering, the Department offers a program leading to the simultaneous award of both degrees at the end of five years. A detailed description of this program is available from the Graduate Registration Officer.

For chemical engineering students interested in nuclear applications, the Departments of Chemical Engineering and Nuclear Engineering offer a five-year program leading to the joint Bachelor of Science in Chemical Engineering and Master of Science in Nuclear Engineering. Such programs are approved on an individual basis between the registration officers of the two departments.

Inquiries

Additional information concerning undergraduate academic and research programs, admissions, financial aid, etc. may be obtained by writing to Professor Jack B. Howard, Executive Officer, Department of Chemical Engineering, Room 66-350, M.I.T., Cambridge, Massachusetts 02139, (617) 253-4574.

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. Current fields of graduate study are: applied chemistry, biochemical engineering, biomedical engineering, environmental engineering, chemical engineering systems, engineering operations (process engineering), fuel and fossil energy engineering, and materials engineering and polymers.

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.

Advanced Degrees

The following advanced degrees are offered in chemical engineering: Master of Science in Chemical Engineering; Master of Science in Chemical Engineering Practice; Chemical Engineer; Environmental Engineer; Materials Engineer; Doctor of Science or Doctor of Philosophy.

Master of Science in Chemical Engineering

Programs for the Master of Science in Chemical Engineering are usually arranged as a continuation of undergraduate professional training, but on a more mature basis.

Master of Science in Chemical Engineering Practice

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 are usually not admitted to the Practice School until they have spent at least one term at the Institute.

There are two field stations in the program: one at two chemical plants of the General Electric Company near Albany, New York and one at the Oak Ridge National Laboratory in Oak Ridge, Tennessee. At each field station, student groups operate under the full-time direction of two members of the Institute staff. Quantitative aspects of chemical engineering are studied in the Practice School. Plant investigations are carried out on special phases of unit operations and on problems of industrial chemistry. Oral and written presentation of plans, results, and recommendations for action are stressed.

Master of Science in Technology and Policy

Students interested in applying their chemical engineering background to problems of policy and socioeconomic assessment of technology may apply for the interdepartmental Master of Science Program in Technology and Policy. This program combines subjects in advanced technology in the particular field of the student's choosing with subjects in economics, systems analysis, political science, and law. It engages the student in significant project work integrating technology and policy. Well-qualified students may complete this program in one calendar year. General requirements and application procedures are described in Chapter V of this catalogue.

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. 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 will prepare 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.

Subjects in Chemical Engineering

Joint M.I.T.-W.H.O.I. 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 M.I.T., students enrolled in this course follow a program similar to that of other students in this Department. The program is described in more detail under the section on M.I.T.'s Joint Program in Oceanographic Engineering with the Woods Hole Oceanographic Institution.

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 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.

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 Jack B. Howard, Executive Officer, Department of Chemical Engineering, Room 66-350, M.I.T., Cambridge, Massachusetts 02139, (617) 253-4574, or Professor Glenn C. Williams, Graduate Registration Officer, Department of Chemical Engineering, Room 66-368, (617) 253-4587.

(A) following the name of the subject indicates that it is an approved subject for a graduate degree and is given primarily for graduate students.

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| 10.U.R. | Undergraduate Research |
| 10.10 | Process Synthesis |
| 10.11 | Computer Models of Physical and Engineering Systems I |
| 10.13 | Mass and Energy Processing |
| 10.14 | Chemical Engineering Thermodynamics |
| 10.17 | Air Pollution Fundamentals |
| 10.18 | Industrial Chemistry |
| 10.19 | Experimental Methods in Combustion and Heat Transfer |
| 10.21 | Structures and Properties of Matter |
| 10.23 | Measurement of Environmental Pollutants |
| 10.24 | Survey of Analytical Chemistry |
| 10.25 | Industrial Chemistry (A) |
| 10.26 | Chemical Engineering Laboratory |
| 10.301 | Heat, Mass and Momentum Transfer |
| 10.302 | Fluid Mechanics and Transport Processes |
| 10.311 | Continuum Mechanics |
| 10.312 | Transport Phenomena |
| 10.32 | Separation Processes |
| 10.33 | Analytical Treatment of Chemical Engineering Processes (A) |
| 10.34 | Numerical Solution of Problems in Chemical Engineering (A) |
| 10.35 | Chemical Process Dynamics and Control (A) |
| 10.351 | Advances in Process Control (A) |
| 10.36 | Process Design |
| 10.37 | Chemical Kinetics and Reactor Design |
| 10.371 | Chemical Reactor Analysis (A) |
| 10.38 | Analysis and Simulation of Chemical Processing Systems (A) |
| 10.39 | Energy Technology (A) |
| 10.40 | Chemical Engineering Thermodynamics (A) |
| 10.41 | Distillation (A) |
| 10.42 | Advanced Thermodynamics (A) |

| | | | |
|---------|---|---------|--|
| 10.47 | Ion Exchange (A) | 10.79J | Nuclear Chemical Engineering (A) |
| 10.48J | Gas-Solid Reactions (A) | 10.801 | Entrepreneurship |
| 10.49J | Biomedical Transport Phenomena (A) | 10.802J | Invention |
| 10.50 | Heat and Mass Transfer (A) | 10.803 | Introduction to Technology and Law I |
| 10.51 | Macromolecular Hydrodynamics (A) | 10.805J | Technology, Law, and the Working Environment |
| 10.52 | Mechanics of Fluids (A) | 10.806 | Management in Engineering |
| 10.53 | Chemical Engineering Design (A) | 10.807J | The Maximum Entropy Formalism |
| 10.54 | Advanced Topics in Mass Transfer (A) | 10.82 | School of Chemical Engineering Practice — Industrial Station (A) |
| 10.55 | Advanced Topics in Heat Transfer (A) | 10.83 | School of Chemical Engineering Practice — Industrial Station (A) |
| 10.56 | Chemical Engineering in Medicine (A) | 10.84 | School of Chemical Engineering Practice — Industrial Station (A) |
| 10.57J | Thermo-Mechanical Processing of Polymers (A) | 10.85 | School of Chemical Engineering Practice — Industrial Station (A) |
| 10.58J | Artificial Internal Organs (A) | 10.86 | School of Chemical Engineering Practice — Oak Ridge Station (A) |
| 10.59 | Properties of Gases and Liquids (A) | 10.87 | School of Chemical Engineering Practice — Oak Ridge Station (A) |
| 10.60 | Heterogeneous Catalysis and Catalytic Processes (A) | 10.88 | School of Chemical Engineering Practice — Oak Ridge Station (A) |
| 10.61 | Surface and Colloid Chemistry (A) | 10.89 | School of Chemical Engineering Practice — Oak Ridge Station (A) |
| 10.611 | Physics and Chemistry of Surfaces (A) | 10.90 | Experimental Research Problem (A) |
| 10.612 | Advanced Topics in Surface and Colloid Chemistry (A) | 10.91 | Experimental Research Problem |
| 10.613J | Solid State Surface Science (A) | 10.93 | Teaching Experience in Chemical Engineering (A) |
| 10.621 | Electrochemistry | 10.94 | Special Problems in Chemical Engineering |
| 10.63 | Adsorption and Catalysis (A) | 10.95 | Special Problems in Chemical Engineering (A) |
| 10.641 | Structure and Properties of Polymers (A) | 10.96 | Selected Topics in Chemical Engineering (A) |
| 10.642 | Molecular and Phenomenological Interpretation of Polymer Viscoelasticity (A) | 10.991 | Seminar in Chemical Engineering (A) |
| 10.65 | Chemical Reaction Engineering (A) | 10.992 | Seminar in Chemical Engineering (A) |
| 10.66 | Polymer Rheology Laboratory (A) | | |
| 10.67 | Polymer Science Laboratory (A) | | |
| 10.681 | Physical Chemistry of Polymers (A) | | |
| 10.691 | Synthetic Chemistry of Polymers (A) | | |
| 10.694 | Polymer Chemical Engineering | | |
| 10.70 | Principles of Combustion (A) | | |
| 10.72 | Seminar in Air Pollution Control (A) | | |
| 10.73 | Seminar in Fuel Conversion and Utilization (A) | | |
| 10.74 | Radiative Transfer (A) | | |
| 10.76 | Oral Technical Presentation | | |
| 10.771 | Seminar in Wastewater Treatment Processes (A) | | |
| 10.772 | Seminar in Wastewater Treatment Processes (A) | | |
| 10.78 | The Structure of the Chemical Processing Industries: Function and Economics (A) | | |

Department of Civil Engineering

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Professor of Civil Engineering
Head of the Department

Professors

John Melvin Biggs, S.M.
Professor of Civil Engineering

Jerome Joseph Connor, Jr., Sc.D.
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Director of Research, M.I.T. Sea Grant Program

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Professor of Civil Engineering

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

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Ann Fetter Friedlaender, Ph.D.
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Ford Professor of Engineering

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(Visiting)

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Edmund K. Turner Professor of Civil Engineering

Robert Daniel Logcher, Sc.D.
Professor of Civil Engineering
(Absent)

Marvin Lee Manheim, Ph.D.
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David Hunter Marks, Ph.D.
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Frederick Jerome McGarry, S.M.
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Chiang Chung Mei, Ph.D.
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Director, Technology Adaptation Program

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Daniel Roos, Ph.D.
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Director, Center for Transportation Studies

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James Martin Becker, Ph.D.
Class of 1922 Associate Professor

Moshe Emanuel Ben-Akiva, Ph.D.
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Rafael Luis Bras, Sc.D.
Associate Professor of Civil Engineering
Gilbert W. Winslow Career Development Professor

Oral Buyukozturk, Ph.D.
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Herbert Heinrich Einstein, Sc.D.
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Ralph A. Gakenheimer, Ph.D.
Associate Professor of Urban Studies and Planning and Civil Engineering
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Ole Secher Madsen, Sc.D.
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Keith Densmore Stolzenbach, Ph.D.
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Alonzo Rhenals, C.E.

Research Affiliate

Donald M. Anderson, Ph.D.

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Robert Joseph Hansen, Sc.D.
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Myle Joseph Holley, Jr., S.M.
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Emeritus

Eugene Mirabelli, S.B.
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Engineering,
Emeritus

William Edward Stanley, C.E.
Professor of Sanitary Engineering,
Emeritus

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

Civil Engineering is the principal instrument for focusing humanity's scientific and technological skills on the creation of constructed facilities which advance a society toward the attainment of such basic objectives as economic development, environmental protection, and social well-being.

The essence of the profession, as we view it, is to bring about a symbiosis of the constructed facility with the natural environment on the one hand, and with the social environment on the other. Creating this accommodation between humans and the environment requires recognition and formulation of very complex problems when the objectives are multiple; when human and institutional, as well as technical, constraints are operative; and when both our understanding and the available information are imperfect. It requires problem solution in a manner which reveals an array of technically feasible, economically justifiable, and socially desirable alternatives, and it demands that we involve the affected public in the process of final choice. It calls for design which incorporates the best technology. It includes ensuring that the physical process of construction is sensitive to social and environmental constraints and that management and operation of the completed facility can be responsive to changing objectives over time.

This broad scope of civil engineering activities, embracing planning, analysis, design, construction, and management, requires an equally diverse set of practitioners — those with the breadth of perspective to assess needs and to evaluate impacts, and the specialists within the disciplines who design the system and make it work.

The undergraduate program of the Department of Civil Engineering is designed to balance the problem-formulation and problem-solving needs for a broad range of careers. The core of the program is designed to provide, first, an overall appreciation for the issues and structure of civil engineering problems and for the skills required to achieve solutions, and, second, the fundamental methods for formulating, solving, and evaluating problems of physical behavior and of complex system performance. The program then promotes the study of an applications area in some depth, as much for the self-discipline and self-confidence to be gained from thoroughness of understanding as for the particular knowledge itself.

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

It is our belief that the education of civil engineers for future leadership positions should provide not only the latest technology but also 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 broadened curriculum and the encouragement of interactions with other departments at M.I.T. and neighboring universities.

Undergraduate Study

The Department of Civil Engineering contains three functional Divisions: Constructed Facilities, Transportation Systems, and Water Resources and Environmental Engineering. These Divisions have responsibility for graduate admissions, research and teaching assistant awards and assignments, fellowship and traineeship assignments, and the administration of those research and academic programs which are functionally oriented.

The quality of these functional efforts critically depends upon inputs from the contributing disciplines. Therefore, we have created three disciplinary Groups, orthogonal to the Divisions, having responsibility for activities which are discipline oriented, and for the nurturing of our disciplinary capability.

Prospective graduate students must indicate their choice of Divisional affiliation when applying for admission. Because of the broad spectrum of career opportunities open within each functional area, students may pursue graduate studies in one of these three areas from an analytically oriented undergraduate base in such fields as urban planning, science, or management, as well as from other branches of engineering.

In preparing civil engineering students to solve problems in the several functional areas of civil engineering — Constructed Facilities, Transportation, Water Resources — they must be shown not only how to deal with the pragmatic engineering constraints of time and cost, but also must be provided with a firm base of knowledge in the supportive disciplinary areas.

In years past civil engineering education was based on the classical physical sciences — applied earth science, mathematics, chemistry, and biology — in preparation for understanding physical behavior and for the design of facilities. With the advent of the digital computer, which gave birth to the systems sciences, the planning and analysis of large-scale systems became possible, and the engineer found it necessary to be familiar with applied probability and statistics, decision analysis, optimization, mathematical programming, simulation, and computer systems. More recently has come the need to appreciate the interactions of our facilities and systems with the people and institutions they are designed to serve. For this we draw upon the social and management sciences.

To meet the current needs of civil engineering students we have organized our Department by dividing the supporting disciplines into three groupings — Physical Systems, Systems Methodology, and Social and Management Systems. Each member of the faculty of the Department has specialized training in one or more of these disciplines, in addition to an overriding interest in a particular functional application. Each group is responsible for the establishment and maintenance of the requisite disciplinary capability and for guiding and assisting in program formulation those students whose educational interests are not met through the degree programs of the functional Divisions.

The Department of Civil Engineering offers three undergraduate curricula for students seeking a strong base for careers in civil engineering or related fields. The first curriculum, 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 and third curricula, which lead to the Bachelor of Science without designation, are designed for students having a well-defined educational goal, the attainment of which requires a specially formulated program of study.

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 five-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, and also give an appreciation for the role of related disciplines. This program (including the internship option below) is accredited by the Engineers' Council for Professional Development.

Graduate Study

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 Course I — Internship Option. The Engineering Internship Program is described in detail in the School of Engineering section of this catalogue.

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 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.

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 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 student 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. The programs leading to this degree are not accredited by the Engineers' Council for Professional Development. This may be a consideration for students, who at some future time may seek professional registration.

Two options are available. Option 1 is intended for 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. It is also intended for students who wish to pursue interdisciplinary studies in the mineral resources area, particularly in mining engineering. Option 2 is designed for students whose interest is in civil engineering and urban planning. Programs under Option 2 must be approved by a joint committee made up of faculty members from the Departments of Civil Engineering, and Urban Studies and Planning.

The Department of Civil Engineering grants the following advanced degrees: Master of Science; Master of Science in Civil Engineering; Civil Engineer; Environmental Engineer; Doctor of Science; and Doctor of Philosophy. For the Institute's general requirements for the various degrees, see Chapter IV of this catalogue. Detailed information regarding the requirements of the department for these degrees may be obtained from the Civil Engineering Academic Programs Office, Room 1-281.

Fields of Advanced Study

Integrated programs of advanced study are available in the following areas: geotechnical engineering, structural engineering and mechanics, construction engineering and project management, transportation systems, hydrodynamics and coastal engineering, hydrology and water resource systems, water quality control and the aquatic environment, and environmental engineering. Major fields available for doctoral theses are included in the Civil Engineering list in Chapter IV. Fields other than those listed must be approved by the Department Registration Officer and the Dean of the Graduate School.

Special Programs and Facilities

Entrance Requirements for Graduate Study

Applicants do not need to have an undergraduate degree in civil engineering.

Numerous opportunities for graduate education in civil engineering exist for students with backgrounds in other branches of engineering, science, and certain social sciences. These arise through the growth of interdepartmental research and degree programs which are bringing people of diverse backgrounds together in search of solutions to the major problems of our society. Graduate students and faculty now in the Department have, for example, backgrounds 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 chapter of *Courses and Degree Programs*. Students may make up deficiencies in prerequisites while pursuing a program of graduate study.

Graduate Assistantships

The research of the Department is an integral part of the study program, and approximately 100 graduate students each year receive appointments as Research Assistants. A limited number of Teaching Assistantships are available for advanced graduate students. In addition to financial support, these appointments provide valuable educational experience and, in the case of Research Assistantships, thesis opportunities.

Educational and research facilities and special programs within the Department are described below.

Interdisciplinary Programs

As new problem areas emerge, they increasingly fail to fall within the traditional interest area of a single academic department at M.I.T. 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, and economics, 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. 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, and mineral resources engineering and management.

In short, each student's educational and research program may be arranged to reflect his or her personal and professional goals, whether they are intensive or extensive in nature.

Master of Science in Technology and Policy

Students interested in applying their civil engineering background to problems of policy and socioeconomic assessment of technology may apply for the interdepartmental Master of Science Program in Technology and Policy. This program combines subjects in advanced technology in the particular field of the student's choosing with subjects in economics, systems analysis, political science, and law. It engages the student in significant project work integrating technology and policy. Well-qualified students may complete this program in one calendar year. General requirements and application procedures are described in Chapter V.

Center for Transportation Studies

The Center for Transportation Studies coordinates transportation research and teaching at M.I.T. Participating departments include: Aeronautics and Astronautics, Civil Engineering, Economics, Mechanical Engineering, Management, Ocean Engineering, Political Science, and Urban Studies. 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 has as its goal the fostering of interdisciplinary cooperation, which is so essential in transportation study. The solution of transportation problems demands understanding of technological options and their social, economic, and political ramifications. The Center for Transportation Studies provides the framework for exchange in this broadly based field of study. The research program of the Center includes projects in such diverse areas as innovative transportation planning, railroad network

planning, urban transportation, transportation demand models, the Federal role in transportation planning, railroad regulation and technical change, and transportation in developing countries. The Center is currently directed by Professor Daniel Roos, a faculty member of the Department of Civil Engineering. A fuller description of the Center is provided in Chapter V.

Master of Science in Transportation

The new interdepartmental degree of Master of Science in Transportation is now offered by departments in cooperation with the Center for Transportation Studies. Civil Engineering students interested in transportation now have the choice of pursuing a Master's within the department, or structuring their program under the requirements for the new interdepartmental degree. Requirements for the Master of Science in Transportation are described in Chapter V of this catalogue.

Joint M.I.T.-W.H.O.I. 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 M.I.T., students enrolled in this course follow a program similar to that of other students in this Department. The program is described in more detail under the section on M.I.T.'s Joint Program in Oceanographic Engineering with the Woods Hole Oceanographic Institution.

Mining and Mineral Resources Research Institute

The M.M.R.R.I. coordinates academic and research activities in the mineral resources field. In addition to the Department of Civil Engineering, the Departments of Mechanical Engineering, Materials Science and Engineering, Earth and Planetary Sciences, Ocean Engineering, Economics, Management, and Political Science are involved, as is the Energy Laboratory. A consortium consisting of several other universities in Massachusetts and M.I.T. ensures statewide interaction. Finding mineral resources, extracting and processing them economically and in an environmentally acceptable manner, are some of the major problems facing us today; this problem area includes reducing our need for mineral resources and substituting one for the other. The M.M.R.R.I. makes use of M.I.T.'s strength in integrating many different disciplines toward the solution of these problems. Joint academic subjects and seminars and particularly the undergraduate and graduate interdisciplinary programs of study in Mineral Resources Engineering and Management represent the academic side of the M.M.R.R.I., while on the research side interdepartmental efforts are organized and individual projects coordinated. The M.R.E.M. programs are described in detail in Chapter V of this catalogue.

Laboratories

The **Ralph M. Parsons Laboratory for Water Resources and Hydrodynamics** is a major unit for research in the water environment, containing more than 40,000 square feet of classrooms, laboratories, shops, computer facilities, and offices.

Experimental equipment is available for the study of wave deformation and breakwaters, sediment transport, waste heat disposal, turbulence, surface runoff, and other phenomena of importance in water resources engineering. Laboratory facilities are also available for the study of aquatic biological and chemical interactions related to water quality. A van with portable facilities is provided for field observations.

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 **Structures Laboratory** is an educational facility for the study of the behavior of structural elements and structural systems.

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, M.I.T., Cambridge, Massachusetts 02139, or by calling (617) 253-7106 or 253-7176.

Subjects in Civil Engineering

(A) following the name of the subject indicates that it is an approved subject for a graduate degree and is given primarily for graduate students.

| | | | | | |
|--------|---|--------|--|--------|--|
| 1.U.R. | Research in Civil Engineering | 1.151 | Introduction to Probability, Statistics and Regression (A) | 1.254J | Transportation Policy and Planning in Developing Countries (A) |
| 1.00 | Information Systems | 1.153 | Random Processes in Civil Engineering (A) | 1.255 | Transportation Policy Analysis (A) |
| 1.01J | Ethics and Technocrats | 1.154 | Assessment of System Behavior (A) | 1.257 | Innovative Urban Transportation Systems (A) |
| 1.014J | Engineering Aspects of Economic Analysis | 1.158 | Studies in Advanced Systems Methodology (A) | 1.258 | Public Transportation (A) |
| 1.02J | Materials of Construction | 1.159 | Judgment, Prediction, and Risk in Engineering Planning (A) | 1.26 | Case Study in Transportation Planning |
| 1.030 | Introduction to Technology and Law I | 1.16 | Computer Models of Physical and Engineering Systems I | 1.261 | Transportation Workshop (A) |
| 1.04 | Introduction to Structural Engineering | 1.161 | Numerical Modeling of Physical Systems (A) | 1.27 | Studies in Transportation Engineering (A) |
| 1.05 | Fluid Dynamics | 1.181 | Ethical Issues in Professional Work (A) | 1.271 | Research Seminar in Transportation |
| 1.06 | Soil Mechanics | 1.185 | Multi-Criteria Project Evaluation (A) | 1.281J | Transportation Economics (A) |
| 1.07 | Analysis of Uncertainty | 1.20 | Introduction to Urban Transportation | 1.282 | Structure and Operational Characteristics of Transportation Services (A) |
| 1.08 | Introduction to Engineering Geology | 1.200 | Introduction to Inter-City Transportation | 1.283J | Urban Economic Analysis I (A) |
| 1.09 | Fundamentals of Ecology | 1.201J | Basic Concepts in the Analysis of Transportation Systems (A) | 1.284J | Topics in Transportation Economics (A) |
| 1.102 | Transportation Systems Laboratory Projects | 1.202J | Transportation Demand and Activity Analysis (A) | 1.285J | Issues in Transportation Management (A) |
| 1.103 | Geotechnical Engineering Laboratory | 1.203 | Transportation Supply Models (A) | 1.286 | Freight Transportation (A) |
| 1.104 | Materials of Construction Laboratory | 1.204 | Transportation Systems Design (A) | 1.290J | Transportation Performance and Technology (A) |
| 1.105J | Structural Engineering Laboratory | 1.205 | Advanced Travel Demand Modeling (A) | 1.298 | Research in Transportation |
| 1.106 | Laboratory Projects in Aquatic Systems: Physical Aspects | 1.206 | Transportation and Urban Activity Modeling (A) | 1.299 | Teaching in Transportation |
| 1.107 | Laboratory Projects in Aquatic Systems: Chemical and Biological Aspects | 1.208 | Topics in the Analysis of Transportation Systems (A) | 1.311 | Theoretical Soil Mechanics (A) |
| 1.11J | Introduction to Systems Analysis | 1.21 | Field Experience in Transportation | 1.322 | Soil Behavior (A) |
| 1.12 | Civil Engineering | 1.211 | Analysis of Transportation Systems | 1.331 | Soil Dynamics (A) |
| 1.13 | Behavior of Physical Systems | 1.215 | Traffic Engineering and Control | 1.34 | Risk and Decisions in Geotechnical Engineering (A) |
| 1.143 | Mathematical Optimization Techniques (A) | 1.231J | Planning and Design of Airport Systems (A) | 1.361 | Advanced Soil Mechanics and Engineering (A) |
| 1.146J | Engineering Systems Analysis (A) | 1.232J | Airport Operation and Management (A) | 1.362 | Earth Structures (A) |
| 1.15 | Systems Analysis for Planning and Design | 1.233J | Seminar in Air Transportation Analysis and Planning | 1.364 | Foundation Engineering (A) |
| | | 1.242 | Highway Technology (A) | 1.366 | Geotechnical Engineering (A) |
| | | 1.251J | Transportation Institutional Analysis and Policy (A) | 1.37 | Geotechnical Measurements and Exploration (A) |
| | | 1.252J | Urban Transportation Planning (A) | 1.38 | Engineering Geology (A) |
| | | | | 1.381 | Rock Mechanics I (A) |
| | | | | 1.382 | Rock Mechanics II (A) |

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|--------|--|--------|--|--------|---|
| 1.383 | Underground Construction (A) | 1.571 | Advanced Structural Analysis I (A) | 1.761 | Aquatic Chemistry (A) |
| 1.384J | Introduction to Mining and Mineral Technology | 1.572 | Advanced Structural Analysis II (A) | 1.77 | Water Quality Control (A) |
| 1.39 | Studies in Geotechnical Engineering (A) | 1.573 | Advanced Structural Analysis III (A) | 1.78 | Water Quality Management (A) |
| 1.41 | Introduction to Project Management | 1.581 | Structural Reliability (A) | 1.79 | Aquatic Ecology (A) |
| 1.42 | The Construction of Buildings (A) | 1.586 | Structural Dynamics (A) | 1.80 | Problems in Aquatic Biology and Chemistry (A) |
| 1.431 | Project and Company Organizations (A) | 1.587 | Safety of Structures and Foundations Under Dynamic Loads (A) | 1.811J | Environmental Law: Pollution Control (A) |
| 1.432 | Project Control (A) | 1.588 | Earthquake Engineering (A) | 1.812J | Regulation of Health and the Environment: Selected Topics (A) |
| 1.441 | Modeling of Construction Processes I (A) | 1.589 | Studies in Structural Engineering (A) | 1.85 | Introduction to Water and Wastewater Treatment Engineering |
| 1.442 | Modeling of Construction Processes II (A) | 1.59J | Fracture of Structural Materials (A) | 1.86 | Element Cycles in the Environment |
| 1.451 | Construction Labor Economics and Labor Relations (A) | 1.592 | Properties and Selection of Construction Materials (A) | 1.898 | Research in Water Resources and the Water Environment |
| 1.46 | Analysis in Real Estate Development (A) | 1.593J | Mechanical Behavior of Plastics (A) | 1.899 | Teaching in Water Resources and the Water Environment |
| 1.471J | Legal Problems in Construction (A) | 1.594J | Composite Materials (A) | 1.90 | Projects in Systems Engineering (A) |
| 1.481 | Seminar in Construction Engineering and Management | 1.598 | Research in Constructed Facilities | 1.91 | Civil Engineering Internship |
| 1.482 | Engineering Risk-Benefit Analysis | 1.599 | Teaching in Constructed Facilities | 1.92 | Advanced Civil Engineering Internship |
| 1.50 | Engineering of Constructed Facilities | 1.60 | Introduction to Water Resources Engineering and Management of Water Related Projects | 1.961- | Special Graduate Studies in Civil Engineering (A) |
| 1.502 | Structural Analysis and Design | 1.61 | Free Surface Hydraulics | 1.965 | Graduate Studies in Civil Engineering (A) |
| 1.503 | Engineering Mechanics | 1.62 | Principles of Hydrodynamics (A) | 1.969 | Graduate Studies in Civil Engineering (A) |
| 1.511J | Basic Building Construction | 1.63 | Transport and Mixing in Turbulent Flows (A) | 1.991- | Special Undergraduate Studies in Civil Engineering |
| 1.512J | Design of Building Systems | 1.64 | Problems in Water Resources and Environmental Engineering (A) | 1.992 | Studies in Civil Engineering |
| 1.541 | Behavior and Design of Concrete Structures (A) | 1.66 | Sediment Transport and Coastal Processes (A) | 1.999 | Undergraduate Studies in Civil Engineering |
| 1.542 | Behavior and Design of Steel Structures (A) | 1.67 | Physics of Natural Water Bodies (A) | | |
| 1.551 | Planning and Design of Structural Systems (A) | 1.681 | Introduction to Coastal Engineering (A) | | |
| 1.552 | Structural Loads (A) | 1.69 | Wave Hydrodynamics in Coastal Engineering (A) | | |
| 1.553J | Analysis and Design of Offshore Structures (A) | 1.691 | Wave Hydrodynamics in Oceanographic Engineering (A) | | |
| 1.562 | Finite Element Methods (A) | 1.692 | Oceanographic Systems I | | |
| 1.565J | Structural Mechanics in Nuclear Power Technology (A) | 1.697J | Oceanographic Systems II | | |
| | | 1.698J | Special Projects in Oceanographic Engineering (A) | | |
| | | 1.699J | Introduction to Hydrology | | |
| | | 1.71 | Dynamic Hydrology (A) | | |
| | | 1.711 | Hydrologic Analysis and Synthesis (A) | | |
| | | 1.712 | Groundwater Hydrology (A) | | |
| | | 1.72 | Groundwater Resources Evaluation and Modeling (A) | | |
| | | 1.721 | Subsurface Water Quality (A) | | |
| | | 1.723 | Water Resources Systems I (A) | | |
| | | 1.731 | Water Resource Systems II (A) | | |
| | | 1.732 | Public Expenditure Theory (A) | | |
| | | 1.74 | Limnology and Wetland Ecology (A) | | |
| | | 1.75 | | | |

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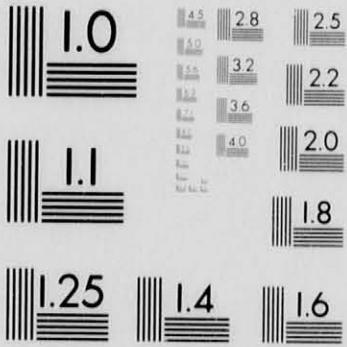
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MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS
STANDARD REFERENCE MATERIAL 1010a
(ANSI and ISO TEST CHART No. 2)

M. I. T. ANNUAL CATALOGUES AND BULLETINS

1979/80

03
OF
11

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Henry Joseph Zimmermann, S.M.

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James T. O'Connor, V.M.D.
Alan Runck, Ph.D.
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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 electronic digital computers, their associated communication and switching networks, and software systems. Electrical engineers have developed conceptual models for detection, communication, and control, and have applied them not only to physical systems but also to such fields as economics, management, physiology, and linguistics. In addition, they have developed complex instrumentation systems for observation and measurement which are used extensively in all branches of the physical and biological sciences and engineering. Much of this work in turn has drawn upon progress made in understanding and exploiting the fundamental electric and magnetic properties of materials in a variety of novel devices for processing energy, signals, and information.

In a field of rapidly changing technology no one can describe the systems and devices of even 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 fields of electrical science and engineering or 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 in a variety of fields. Each student's program is developed through personal discussion with and guidance from his or her faculty counselor.

The Department offers four undergraduate programs: two in Course VI (Program 1: Electrical Science and Engineering, and Program 3: Computer Science and Engineering), and the two cooperative versions of these programs in Course VI-A. The two Course VI-A programs combine study with industrial engineering practice.¹

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.

¹

All of these programs are accredited by the Engineers' Council for Professional Development.

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.

**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.

Inquiries

Additional information concerning undergraduate academic programs may be obtained from Professor L. A. Gould, Room 38-476, M.I.T., Cambridge, Massachusetts 02139, (617) 253-7312.

**Bachelor of Science in Electrical Engineering or in Computer Science and Engineering
Course VI-A**

The VI-A Program combines industrial and research experience with academic work through a series of organized cooperative Work Assignments interwoven with the regular course of study at M.I.T. Although students may stop at the Bachelor's degree, the Program encourages the simultaneous completion of the Bachelor's and Master's degrees 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 Work Assignments serves as the basis for this thesis. As the VI-A Program ensures a continuing liaison between the participating companies and the professorial staff of the Department, students receive job assignments more professionally rewarding than typical summer jobs. In addition to receiving academic credit for these Work Assignments, students are paid nominal wages which help to defray educational expenses.

Additional information concerning the VI-A Program may be obtained from John A. Tucker, VI-A Office, Room 38-473, M.I.T., Cambridge, Massachusetts 02139, (617) 253-4644.

Engineering Internship Program

Sophomore students in good standing in the Department may apply for admission to the School-wide Engineering Internship Program. A general description of this program is provided in the School of Engineering section of this catalogue. Like the Department's VI-A Program, the Internship Program provides a way to combine industrial experience with the Course VI academic program.

Electrical Engineering and Computer Science students who are accepted for the Engineering Internship Program register for the usual program of study in either Program 1 or Program 3. They receive academic credit for their two undergraduate work assignments.

Participants in the Program are encouraged to apply for admission to the graduate school. If they are accepted to and enter the graduate school, they will complete their work experience with a seven-month assignment at their internship company, for which they receive graduate academic credit. In many cases they also will be able to satisfy the thesis requirements for both the S.B. and 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, M.I.T., Cambridge, Massachusetts 02139, (617) 253-5994.

Graduate Study

The program of graduate education in the Department of Electrical Engineering and Computer Science has three aspects. First, a variety of classroom subjects in physics, mathematics, and fundamental fields of electrical engineering and computer science is offered to permit students to develop strong theoretical backgrounds. Second, more specialized classroom and laboratory subjects and a wide variety of colloquia and seminars introduce the student to 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; communication and probabilistic systems; operations research; bioelectrical engineering; high-voltage radiation engineering; stroboscopic photography and underwater sound.

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 Laboratory for Insulation Research, the Operations Research Center, and the Stroboscopic Light and Pulsed Sonar Laboratory. Detailed descriptions of many of these laboratories may be found in Chapter V, under Interdepartmental Organizations and Research Facilities.

Joint M.I.T.-W.H.O.I. Program Course VI-W

A joint program with the Woods Hole Oceanographic Institution is intended for students whose primary career objective is oceanographic engineering. Students divide their academic and research efforts between the campuses of the two institutions. While in residence at M.I.T., students enrolled in this course follow a program similar to that of other students in this Department. The program is described in more detail under the section on M.I.T.'s Joint Program in Oceanographic Engineering with the Woods Hole Oceanographic Institution.

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.

All regular graduate students who intend to enter a doctoral program are required to complete a written examination in January of their first year of graduate study. This examination, designed to explore student undergraduate preparation in principal areas of interest, is intended primarily to help students evaluate their preparation and to help faculty members counsel them with respect to their graduate programs. Special examinations are arranged if the regular examination is inappropriate.

Master of Science in Electrical Engineering and Computer Science

This program provides an opportunity for gaining greater depth in a particular area of specialization than is possible at the Bachelor of Science level. 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 may take as many as four classroom subjects per term. The subjects are wholly elective and are not restricted to those given by the Department. The program of study must be well balanced, emphasizing one or more of the theoretical or experimental aspects of electrical engineering or computer science. A thesis is required.

Electrical Engineer¹

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 Department also requires that the program include at least eight approved graduate "A" subjects.

Doctor of Philosophy and Doctor of Science

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.

The General Examination for the Doctoral program consists of the written examination taken during the first graduate year and two oral examinations. One oral examination is normally taken in the third term of graduate study and the other in the fifth term. A thesis examination is held when the doctoral thesis research is completed.

A Minor Program is required by the Department and must have departmental approval.

Fellowships and Research and Teaching Assistantships

Studies toward an advanced degree may be supported by personal funds, by an award such as the National Science Foundation Fellowship which the student brings with him or her to M.I.T., by a fellowship or traineeship awarded by M.I.T., 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 M.I.T.*, 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, M.I.T., Cambridge, Massachusetts 02139, (617) 253-4605.

¹ This degree may be awarded for work in either Electrical Engineering or Computer Science.

Subjects in Electrical Engineering and Computer Science

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|--|--------|---|--------|--|
| (A) following the name of the subject indicates that it is an approved subject for a graduate degree and is given primarily for graduate students. | 6.161 | Modern Optics Project Laboratory | 6.453 | Optical Detection and Communication (A) |
| | 6.162 | Image Transmission Systems Project Laboratory | 6.454 | Advanced Topics in Optical Communication Research (A) |
| | 6.163 | Strobe Project Laboratory | 6.455J | Marine Data Systems (A) |
| 6.002 | 6.164 | Electron Optical Design | 6.501 | Sound, Speech, Hearing |
| 6.003 | 6.170 | Introduction to Software Engineering | 6.523J | Computers and Patient Care |
| 6.012 | 6.171 | Artificial Intelligence Project Laboratory | 6.524J | General Physiology |
| 6.013 | 6.176 | Computer Performance Measurement Laboratory | 6.532J | Sensory-Neural Systems (A) |
| 6.014 | 6.182 | Psychoacoustics Project Laboratory | 6.541J | Speech Communication (A) |
| 6.015 | 6.230 | Linear System Theory (A) | 6.542J | Laboratory on the Physiology, Acoustics and Perception of Speech (A) |
| 6.018 | 6.232 | Optimal Control (A) | 6.543 | Natural Language Processing (A) |
| 6.021J | 6.251J | Introduction to Mathematical Programming (A) | 6.551 | Signal Processing by the Auditory System: Physiology (A) |
| 6.022J | 6.252J | Nonlinear Programming and Discrete-Time Optimal Control (A) | 6.552 | Signal Processing by the Auditory System: Perception (A) |
| 6.023J | 6.253 | Algebraic System Theory (A) | 6.561 | Fields, Forces and Flows: Background for Physiology (A) |
| 6.030 | 6.254 | Qualitative Theory of Dynamical Systems (A) | 6.562J | Ultrasound: Physics, Biophysics and Technology (A) |
| 6.031 | 6.255 | Advanced Optimal Control Theory (A) | 6.564J | Medical Engineering Measurements Laboratory |
| 6.032 | 6.262 | Advanced Markov Models and their Applications (A) | 6.565J | Medical Engineering Measurements Laboratory |
| 6.033 | 6.263 | Data-Communication Networks (A) | 6.601 | Fields, Forces and Motion |
| 6.034 | 6.271 | Introduction to Operations Research (A) | 6.611 | Introduction to Optical Electronics |
| 6.035 | 6.272 | Introduction to Operations Research (A) | 6.631J | Optics and Optical Electronics (A) |
| 6.036J | 6.281J | Urban Operations Research (A) | 6.632 | Advanced Electromagnetic Theory (A) |
| 6.041 | 6.291 | Seminar in Systems and Control Research (A) | 6.633 | Electrodynamics of Waves, Media and Interactions (A) |
| 6.045J | 6.301 | Solid State Circuits | 6.635 | Topics in Electrodynamics (A) |
| 6.046 | 6.302 | Feedback Systems | 6.638 | Electrical and Optical Processes in Gases (A) |
| 6.071 | 6.311 | Telephony | 6.641 | Microwave Circuits (A) |
| 6.074 | 6.312 | Acoustics | 6.642 | Antennas (A) |
| 6.082 | 6.331 | Advanced Circuit Techniques (A) | 6.651J | Introduction to Plasma Physics (A) |
| 6.088 | 6.333 | Electronic Circuits (A) | 6.652 | Special Topics in Plasma Research (A) |
| 6.100 | 6.334 | Power Electronics (A) | 6.661 | Receivers, Antennas, and Signals (A) |
| 6.101 | 6.341 | Digital Processing of Signals (A) | 6.663J | Techniques of Radar Astronomy (A) |
| 6.111 | 6.342 | Advanced Topics in Digital Signal Processing (A) | 6.664J | Radio Interferometry (A) |
| 6.112 | 6.343 | Digital Speech Processing (A) | 6.686 | Advanced Electrical Energy Processing Laboratory (A) |
| 6.114 | 6.361 | Image Processing (A) | 6.720 | Semiconductor Devices |
| 6.121 | 6.371 | Introduction to VLSI Systems (A) | 6.725 | Solar Energy Systems |
| 6.131 | 6.431 | Applied Probability | 6.731J | Physics of Solids I (A except VIII) |
| 6.141 | 6.432 | Stochastic Processes and Applications (A) | 6.732J | Physics of Solids II (A) |
| 6.151J | 6.435 | System Identification (A) | 6.734J | Application of Group Theory to the Physics of Solids (A) |
| | 6.441 | Transmission of Information (A) | | |
| | 6.451 | Principles of Communication (A) | | |
| | 6.452 | Stochastic Filtering and Detection (A) | | |

| | | | |
|--------|------------------------------------|--------|-----------------------------------|
| 6.741J | Theory of Solids I (A) | 6.875J | Cryptography and |
| 6.742J | Theory of Solids II (A) | | Cryptanalysis (A) |
| 6.743 | Conduction Processes in Solids (A) | 6.880 | Perspectives on Computers |
| 6.751 | Quantum Electronics (A) | | and Society (A) |
| 6.752 | Quantum Theory of | 6.891- | Special Topics in the Computer |
| | Magnetism (A) | 6.899 | Sciences (A) |
| 6.753 | Microwave Magnetics (A) | 6.901 | Inventions and Patents |
| 6.754 | Signal Processing with Coherent | 6.910 | Special Studies in Electrical |
| | Wave States in Crystals (A) | | Engineering and Computer |
| 6.761J | Electronic Materials (A) | | Science |
| 6.762 | Dielectric and Optical Materials | 6.911- | Special Subjects in Electrical |
| | and Devices (A) | 6.919 | Engineering and Computer Science |
| 6.770 | Microelectronics Project | 6.921 | Industrial Practice |
| | Laboratory | 6.922 | Advanced Industrial Practice |
| 6.771 | Physics of Semiconductor | 6.925 | Engineering Internship |
| | Devices (A) | 6.929 | Undergraduate Thesis Presentation |
| 6.772 | Semiconductor Devices and | 6.930 | Management in Engineering |
| | Processes | 6.931 | Development of Inventions |
| 6.773 | Topics in Semiconductor | | and Creative Ideas (A) |
| | Device Research (A) | 6.932J | The Technology and Politics of |
| 6.780J | Materials for Advanced | | Nuclear Weapons and Arms Control |
| | Energy Systems | | (A) |
| 6.791 | Special Topics in the Solid | 6.935J | Invention |
| | State and Its Application (A) | 6.936 | Entrepreneurship |
| 6.792 | Special Topics in the Solid | 6.951 | Graduate Industrial Practice |
| | State and Its Application (A) | 6.955 | Advanced Engineering Internship |
| 6.830 | Introduction to Program | 6.961 | Introduction to Research in |
| | Semantics (A) | | Electrical Engineering and |
| 6.831 | Programming Language | | Computer Science |
| | Processors (A) | 6.962- | Special Studies in Electrical |
| 6.835 | Theory of Concurrent | 6.969 | Engineering and Computer Science |
| | Systems (A) | 6.971- | Special Subjects in Electrical |
| 6.837 | Data Base Management | 6.979 | Engineering and Computer |
| | Systems (A) | | Science (A) |
| 6.840J | Theory of Computation (A) | 6.980 | Teaching Electrical Engineering |
| 6.845 | Topics in Computer Systems | | and Computer Science |
| | Research (A) | 6.981- | Teaching Electrical Engineering |
| 6.847 | Data Flow Computer | 6.989 | and Computer Science |
| | Architecture (A) | 6.991- | Research in Electrical |
| 6.851J | Algorithms (A) | 6.999 | Engineering and Computer Science |
| 6.853 | Computation by Automata (A) | 6.U.R. | Undergraduate Research in |
| 6.854J | Advanced Algorithms (A) | | Electrical Engineering and |
| 6.860 | Introduction to Artificial | | Computer Science |
| | Intelligence (A) | 6. ThU | Undergraduate Thesis |
| 6.863 | Natural Language and the Computer | 6. ThG | Graduate Thesis (A) |
| | Representation of Knowledge (A) | | |
| 6.865 | Introduction to Machine | | |
| | Vision and Manipulation (A) | | |
| 6.868 | Topics in Artificial | | |
| | Intelligence (A) | | |
| 6.871 | Knowledge-Based Applications | | |
| | Systems (A) | | |

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Professor of Metallurgy, Emeritus

Department of Materials Science and Engineering

The Department of Materials Science and Engineering is concerned with the extraction, production, and use of engineering materials; with how they can be produced economically in the shapes required and with the properties demanded by modern applications. The performance of all machines and structures is limited by the properties of the materials from which they are made; thus materials engineering is at the heart of all engineering. Almost all of the properties of importance to an engineer are structure-sensitive; that is, they can be modified in significant ways by changing the chemical composition, the arrangement of the atoms or molecules in crystalline or amorphous configurations, or the size, shape, and orientation of the crystals or other macroscopic units of a solid. To understand how the useful properties of a material can be modified, it is necessary to understand the relationships between structure and properties and how the structure can be changed and controlled by the various chemical, thermal, or mechanical treatments to which a material is subjected during manufacture and in use. All materials are used in a gaseous or fluid environment which is to some degree hostile. The environment may affect the performance of the material and, when it does, the effect is usually detrimental. The losses due to surface chemical attack of building materials and to the corrosion of metals are enormous. Thus, surface reactions and surface protection are important areas of study. The study of the structure, the control of the structure, and the relationships between the structure and the properties of a material in a gaseous or fluid environment are the essential components of materials science. It is physics and chemistry applied to real materials.

Some materials have been used as structural materials for centuries. Gradually, the properties have been improved by trial and error methods using empirical knowledge. Materials science in its modern form is a very young discipline within the range of applied sciences. It is no more than 50 years old, and more important scientific developments have occurred in the last three decades than in the preceding 300 years. At first the materials scientist concentrated on trying to understand the empirical ideas about materials which had evolved over the centuries, but this stage was quickly replaced by one in which it became possible successfully to apply solid-state science to real materials. To do this, much relevant science had to be developed in parallel with the rapid improvement in our understanding of engineering materials, and these parallel developments continue at an accelerating pace. In recent years most of the major improvements in materials have resulted from the applications of scientific knowledge. The days when the materials engineer had only empiricism and intuition as guides are nearly over. In addition to marked improvements in the properties of traditional engineering materials, whole classes of new materials, such as semiconductors and modern magnet materials, have developed out of the great surge in activity in materials science.

All recent achievements in materials have depended as much on developments in materials engineering as they have on materials science. When developing processes for extracting and processing materials, and when designing materials for specific applications, the modern materials engineer must have a proper concern for economic, social, and environmental factors. Materials technology is only one, although an essential, component of a total materials system. Students wishing to specialize in materials engineering are provided with many opportunities to obtain an understanding of the economic and social components of materials systems in association with the technological aspects of materials design.

The links between materials engineering and materials science are very strong, and the two activities are interwoven in the Department of Materials Science and Engineering. There are some subjects which it is necessary for all students of materials to know—most important are thermodynamics, and certain aspects of solid mechanics, physics, and chemistry. Suitable core subjects in these areas are provided at the undergraduate and 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.

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

Undergraduate Study¹

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 (for example, 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, metals, or polymers.

Materials engineers and materials scientists, whether generalists or specialists in a particular class of material, are of vital importance to modern industry. The design and operation of propulsion units such as gas turbines and rocket motors, energy producers such as nuclear reactors, energy converters such as magnetohydrodynamic generators, semiconductor or superconductor devices and machines, laser communication systems, or any one of dozens of other developments of modern engineering are critically dependent upon the availability of materials with the requisite blend of properties. Scientists and engineers with the knowledge and skills to carry out imaginative research on new materials, on the development of new methods of producing and processing materials, or the design of materials for specific applications are in great demand by industry and government. They find challenging opportunities in a variety of positions in operations, development, and research in the basic materials-producing industries, in consumer and construction industries, and in the space and electronics industries.

Bachelor of Science in Materials Science and Engineering Course III

The undergraduate program caters to the diverse needs of students who intend to pursue graduate work, to those who are more inclined toward engineering application, and to those who prefer solid-state science. The decision to concentrate on either the science or the engineering of materials may be reached by students as late as the sophomore year or even during the junior year.

The teaching facilities, some of which are located in the Center for Materials Science and Engineering, include an electron-optics laboratory with X-ray and electron diffraction equipment; electron microscopes and micro-analyzers; 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 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.

¹ The degree programs in Course III and Course III-B are accredited by the Engineers' Council for Professional Development. The degree programs in Course III-A are not accredited by the Engineers' Council for Professional Development.

Graduate Study

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 the 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.

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 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.

The Department offers the following graduate degrees: Doctor of Philosophy, Doctor of Science, and Master of Science in Ceramics, Materials Engineering, Materials Science, Metallurgy, or Polymerics; also the degrees of Materials Engineer and Metallurgical Engineer.

Programs of advanced study and research in the Department are organized in five fields. It is useful to think of them in a 3x2 matrix.

The three fields in the columns are concerned with the integrated science and engineering of a single class of material. The two rows are fields which deal with either the science or the engineering of all materials. Thus, the coverage of each of the graduate fields is:

| | | | |
|-----------|-------------|-------------|-------------|
| | Ceramics | Metallurgy | Polymerics |
| Materials | Science | Science | Science |
| Materials | Engineering | Engineering | Engineering |

Ceramics The field of ceramics is concerned with the science and engineering involved in the manufacturing, processing, and utilization of a wide range of inorganic materials which include oxides, nitrides, carbides, silicates, and more complex compounds; some, such as refractory alumina, are crystalline and others, such as soda glass, are used in the amorphous form. Ceramic materials are essential to many diverse industries. In recent years a large research and development effort has resulted in important extensions of the useful properties of traditional ceramics and has led to the development of many exciting new materials.

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.

Materials Science The field of materials science has evolved as an independent discipline only in the last few decades. It is the science concerned with the discovery, analysis, and understanding of the nature of materials. The objectives are to provide coherent descriptions or models of the structure of materials and to explain how this structure relates to composition, properties, and behavior.

Metallurgy This well-established discipline encompasses the study of metallic materials, elemental, alloy, and composite. It includes the 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 in the same depth. Suitable programs are likely to be individualistic, and may be constructed in a number of ways from the subjects listed below.

Polymeric Polymeric materials are working substances of modern technology, similar to metals and ceramics as essential components of engineering systems and processes. The program covers structure-property relationships, improvement of properties by control and modification of structure and composition, processing techniques and applications of polymers. Numerous opportunities exist to concentrate on specific areas of polymer technology: physical properties; mechanical behavior; chemical synthesis and modification; surface characteristics; environmental interactions; combinations with other substances are a few examples. Each student pursues a particular program of study and research consistent with individual interests.

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.

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.

Master of Science in Technology and Policy

Students interested in applying their materials science and engineering background to problems of policy and socioeconomic assessment of technology may apply for the interdepartmental Master of Science Program in Technology and Policy. This program combines subjects in advanced technology in the particular field of the student's choosing with subjects in economics, systems analysis, political science, and law. It engages the student in significant project work integrating technology and policy. Well-qualified students may complete this program in one calendar year. General requirements and application procedures are described in Chapter V of this catalogue.

Mineral Resources Engineering and Management

Students in the Department with interests in the scientific, technical, and policy aspects of mineral resources will find programs of study and research in the areas of metallurgy, ceramics, and materials engineering. These activities are also coordinated with the interdisciplinary program at M.I.T. in Mineral Resources Engineering and Management. Students seeking information on opportunities for careers in areas related to minerals resources, or who wish to speak with faculty who have related programs, may obtain information from the Mining and Minerals Resources Research Institute of M.I.T., Room 4-140.

Simultaneous Award of Two Master of Science Degrees for Students from Other Departments

Graduate students from other departments 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 general 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 co-supervisor 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 M.I.T.-W.H.O.I. 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 M.I.T., students enrolled in this Course follow a program similar to that of other students in this Department. The program is described in more detail under the section on M.I.T.'s Joint Program in Oceanographic Engineering with the Woods Hole Oceanographic Institution.

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.

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, and financial aid, may be obtained by writing to the Chairman of the Departmental Committee on Graduate Students, Room 8-303, M.I.T., Cambridge, Massachusetts 02139, (617) 253-3329.

Subjects in Materials Science and Engineering

| | | | | | |
|--|--|--------|--|--------|---|
| (A) following the name of the subject indicates that it is an approved subject for a graduate degree and is given primarily for graduate students. | | 3.16 | Applied Surface Chemistry | 3.59 | Research Proposals—Planning for Discovery (A) |
| | | 3.17J | Understanding the Discovery Process—An Historical Approach | 3.60 | Thermal and Tensor Properties of Crystalline Ceramics (A) |
| | | 3.18 | Materials Processing | 3.601 | Electrical, Optical and Magnetic Properties of Ceramics (A) |
| | | 3.19 | Techniques of Metal Sculpture | 3.603 | Advanced Topics in Mechanical Properties of Ceramics (A) |
| 3.U.R. | Undergraduate Research | 3.20 | Thermodynamics of Materials (A) | 3.604 | Problems in Nonstoichiometry (A) |
| 3.00 | Thermodynamics of Materials | 3.21 | Kinetic Processes in Materials (A) | 3.61 | Glass Structure and Properties (A) |
| 3.01 | Physical Chemistry of Materials | 3.22J | Solid State Surface Science | 3.611 | Polyphase Ceramics (A) |
| 3.02 | Phase Transformations and Structure Development | 3.23 | Physics and Chemistry of Materials | 3.63 | Ceramic Processes I (A) |
| 3.03 | Chemical Metallurgy | 3.25J | Physics of Deformation and Fracture of Solids I (A) | 3.633 | Applications of Ceramic Processing II (A) |
| 3.04 | Special Problems in Materials Science and Engineering | 3.26J | Physics of Deformation and Fracture of Solids II (A) | 3.64 | Special Problems in Ceramics (A) |
| 3.05 | Computer Models of Physical and Engineering Systems I | 3.27 | Diffraction and Structure (A) | 3.65 | Ceramics Seminar (A) |
| 3.06 | Engineering of Glasses and Polymers | 3.271 | Structure of Materials (A) | 3.691- | Teaching Materials Science and Engineering |
| 3.061J | Introduction to Polymer Science and Engineering | 3.281 | Statistical Thermodynamics, Kinetics and Phase Transformations of Materials I (A) | 3.699 | Special Problems in Metallurgy (A) |
| 3.07 | Introduction to Ceramics | 3.282 | Statistical Thermodynamics, Kinetics and Phase Transformations of Materials II (A) | 3.70 | Materials for Ocean Engineering |
| 3.08 | Economics of Engineering Materials | | | 3.701J | Physical Metallurgy Principles for Engineers (A) |
| 3.081 | Materials Laboratory I | 3.29 | Structure-Properties Relationships in Materials (A) | 3.71J | Nuclear Fuels (A) |
| 3.082 | Materials Laboratory II | 3.30 | Electron Microscopy: Image Interpretation (A) | 3.72J | Radiation Effects in Crystalline Solids (A) |
| 3.083J | Semiconductor Devices Project Laboratory | 3.31 | Phase Transformations (A) | 3.721J | Special Problems in Advanced Computer Applications (A) |
| 3.091 | Introduction to Solid-State Chemistry | 3.32 | Introduction to Electron Optics and Electron Microscopy (A) | 3.73 | Materials for Advanced Energy Systems |
| 3.092 | Perspectives in Materials Science | 3.33 | Defects in Crystals (A) | 3.74J | Radiation Effects to Reactor Structural Materials (A) |
| 3.093 | Magnetics | 3.34 | Advanced Physical Metallurgy (A) | 3.75J | Electronic Materials (A) |
| 3.094 | Materials Technology | 3.35 | Solidification Processing (A) | 3.77 | Laboratory Measurement and Control |
| 3.095J | Introduction to Mining and Mineral Technology | 3.36J | Welding Engineering (A) | 3.80J | Comparative Ancient Technologies Art, Materials and Culture |
| 3.10 | Chemical Physics of Materials | 3.37 | Deformation Processing (A) | 3.81J | Structural Mechanics in Nuclear Power Technology (A) |
| 3.101J | Biomedical Materials | 3.38 | Behavior of Metals at Elevated Temperatures (A) | 3.82J | Fracture of Structural Materials (A) |
| 3.11 | Mechanics of Materials I | 3.39 | Mechanical Behavior of Materials (A) | 3.90J | Mechanical Behavior of Plastics (A) |
| 3.12 | Mechanics of Materials II | 3.50 | Physical Chemistry of Melts (A) | 3.91J | Composite Materials (A) |
| 3.13 | Crystallography | 3.51 | Process Metallurgy (A) | 3.92J | Materials Science of Polymers (A) |
| 3.14 | Physical Metallurgy | 3.52 | Dynamic Behavior of Metallurgical Systems (A) | 3.93 | Industrial Practice |
| 3.141 | Engineering Materials | 3.53 | Electrochemical Processing of Materials (A) | 3.931 | Industrial Practice (A) |
| 3.142J | Introduction to Electron Microscopy | 3.54 | Corrosion—The Environmental Degradation of Materials (A) | 3.932 | Polymer Processing (A) |
| 3.143J | Materials of Construction | 3.541 | Oxidation and Corrosion of Materials at Elevated Temperatures (A) | 3.94 | Environmental Properties of Polymers (A) |
| 3.144J | Deformation and Failure of Engineering Alloys in Service | 3.55 | Macroscopic Transport in Materials Processing (A) | 3.95 | Electrical and Optical Properties of Polymers (A) |
| 3.145J | Introduction to Systems Analysis | 3.551J | Gas-Solid Reactions (A) | 3.96 | Special Problems in Polymer Science and Engineering (A) |
| 3.146 | Dynamics of Physical and Social Systems | 3.56J | Engineering Systems Analysis (A) | | |
| 3.15 | Electrical, Optical and Magnetic Materials and Devices | 3.561 | Materials Systems Analysis (A) | | |
| | | 3.575J | Technology, Law, and the Working Environment | | |
| | | 3.58 | Seminar on Problems in Materials Policy | | |
| | | 3.581J | Resources Management (A) | | |

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Department of Mechanical Engineering

Engineering is a creative profession concerned with the efficient combining of material, human, and economic resources to satisfy the perceived needs of society. Mechanical engineering is one of the broadest and most versatile of the engineering professions, dealing generally with systems and devices for the conversion of energy and for the control of motions, forces, and material flows, including living systems.

Engineering is always concerned with change as it utilizes basic scientific knowledge, human and material resources, and systems-type information to improve the standard of living, the quality of life, and the physical environment, and to provide such vital services as energy, food, manufactured goods, health care, transportation, and communication. As the priorities of society change, mechanical engineers will always find rewarding and challenging areas where their broad skills can be brought to bear.

The educational program in mechanical engineering prepares students for professional practice in an era of rapidly advancing technology. It combines a strong base in the engineering sciences (mechanics and materials, fluid and thermal sciences, and systems and control) with project-based laboratory and design experience. It is intended 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.

Environmental Engineering The Department's environmental engineering activities have three broad goals: to reduce environmental hazards; to restore degraded environments; to conserve limited material and energetic resources. Mechanical engineers are devising methods for reducing the levels and effects of pollution (such as noise, chemicals, and heat) emitted from automobile and aircraft engines, power plants, incinerators, and waste treatment plants. Wherever possible, they seek methods which convert these liabilities into resources; for example, by recycling metals, by exploiting the agricultural/ aquacultural potentials of sewage and thermal wastes, by purifying wastewaters, and by desalinating saltwater.

The Department also offers a broad selection of fundamental courses and research opportunities dealing with the physical, chemical, and biological processes involved in pollution, as well as with the ecological processes affected by pollution.

Thus, Mechanical Engineering provides ample engineering and scientific experiences for students preparing for careers as environmental engineers or scientists.

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 on 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 and materials science or engineering materials involving not only the more conventional metals and alloys but also ceramics, composite materials, fibers, polymers, and biological matter.

Research Laboratories and Programs

Manufacturing and Materials

Processing Mechanical engineers have a continuing and growing interest in the production of equipment, components, and materials. 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.

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.

Transportation The growing need for better transportation services, coupled with increasing emphasis on safety, environmental protection, and energy conservation will create many new and satisfying opportunities for mechanical engineering graduates to contribute to this important field.

Mechanical engineering encompasses most of the basic technologies of transportation, including structures (vehicles, guideways, and terminals), power and propulsion, and automation and control.

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.

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. Notable new activities include the Laboratory for Manufacturing and Productivity and the Mining and Minerals Resources Research Institute.

The **Laboratory for Manufacturing and Productivity** was established in 1977 to provide a new focus for research and education in manufacturing and productivity, an area of growing importance to society. The purpose of the Laboratory is to address the technical problems and the related social and economic issues associated with the field by providing major conceptual developments for technical needs and human issues, by advancing the knowledge base for manufacturing, and by developing human expertise. The Laboratory seeks to establish a rational foundation for productivity increase by providing innovative methods and devices, a systematic understanding of the complex interactions among the many facets of manufacturing, and an important, new talent base in manufacturing. The Laboratory also is committed to addressing the issues of the impact of technology on workers, the role of labor in a technology-based society, and the impact of new manufacturing technology on society.

Associated with the Laboratory is the M.I.T.-Industry Polymer Processing Program which is a cooperative effort between M.I.T. and industrial firms in polymer processing. Since its founding in 1973, the program has provided a new focus in polymer processing by becoming a major source of new ideas, innovations, scientific and technological development, and manpower.

Undergraduate Study

Mining and Minerals Resources Research Institute The use of the earth's depleted resources is demanding new approaches to extraction. Mechanical engineers are contributing significantly to the search for methods which will show high extraction efficiencies with low environmental impact and reduced energy use. Some of the directions being explored at present include improved methods of drilling and cutting; utilization of methane combined with more efficient mine ventilation; and new methods of coal gasification. Within M.I.T.'s interdepartmental Mining and Minerals Resources Research Institute program, the Department of Mechanical Engineering offers courses and thesis research opportunities ranging from study of the behavior of geologic materials to mining technology and, in particular, the innovative mechanization and automation of mining.

Among the other laboratories associated with the Department of Mechanical Engineering are: Acoustics and Vibrations Laboratory, Biomechanics and Human Rehabilitation Engineering Laboratory, Center for Transportation Studies, Chemical Dynamics Research Laboratory, Combustion and Propulsion Laboratory, Cryogenic Engineering Laboratory, Energy Laboratory, Fibers and Polymers laboratories, Fluid Mechanics Laboratory, Heat Transfer Laboratory, Man-Machine Systems Laboratory, Mechanical Behavior of Materials Laboratory, Laboratory for Medical Ultrasonics, Sloan Automotive Laboratory, Surface Laboratory, and the Vehicle Dynamics Laboratory. In addition, the Department has a number of general laboratories and shops used by faculty and students for work on topics not covered by these 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. Please see Chapter V of this catalogue for further description of interdepartmental laboratories and research facilities associated with the Department of Mechanical Engineering.

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 faced by the mechanical engineer. Beginning with mathematics, physics, and chemistry, students acquire adequate proficiency in the engineering sciences: dynamics, mechanics, and properties of materials; fluid dynamics; heat and mass transport; thermodynamics; systems analysis; and control. Further, students will 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 objective 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 specification of curricular requirements and in its subject offerings three categories of students it wishes to serve: 1) those who will base their professional careers as mechanical engineers on the bachelor's degree with no further formal study; 2) those who will proceed to formal graduate study in mechanical engineering or in an allied field; and 3) those for whom the undergraduate program will provide 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. This program is accredited by the Engineers' Council for Professional Development.

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 M.I.T.

To meet such needs, the Department offers the Bachelor of Science,¹ 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.

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. This program is accredited by the Engineers' Council for Professional Development.

Students in this program interested in graduate study are encouraged to apply for early graduate school admission under the combined Bachelor's and Master's program. Students in this Program may spend an additional seven months (one summer and one term) at the cooperating company and will 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 the School of Engineering section of this catalogue, or by contacting Professor Igor Paul, Room 3-451, M.I.T., Cambridge, Massachusetts 02139, (617) 253-4466.

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.

¹
The undesignated Bachelor of Science is not accredited by the Engineers' Council for Professional Development.

Graduate Study

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 will 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 will permit.

The fields of advanced study and research are listed in Chapter IV.

Graduate Core Subjects

The Department offers the following series of basic core subjects 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 subjects to the starting points of their more advanced and specialized branches. A selection of these subjects 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) |
| 2.865 | Manufacturing Processes and Surface Properties (A) |

Master of Science in Mechanical Engineering and Master of Science

The objective of the master's degree program is to develop professional competence in mechanical engineering beyond that achieved in the undergraduate program. Study for the master's degree usually requires about one year and brings the student into more advanced work than in the undergraduate program. The individually planned programs are well balanced, emphasizing one or more of the analytical, economic, design, or experimental aspects of the field. Some are deep in a specialization; others are broad in scope. All include a research experience culminating in a thesis.

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 subjects in advanced technology in the particular field of the student's choosing with subjects in economics, systems analysis, political science, and law. It engages the student in significant project work integrating technology and policy. Well-qualified students may complete this program in one calendar year. General requirements and application procedures are described in Chapter V.

Master of Science in Textile Technology

The Department offerings in fiber science and in textile processing technology provide the basis for a Master of Science in Textile Technology. This program is designed to train textile engineers and technologists in application of engineering sciences to structural design of fibrous materials and systems and to analysis and synthesis of textile processes. Graduates of the program qualify for employment in research and development, engineering, or production activities of the fiber, textile, or textile machinery segments of the industry. Candidates for the M.S. in Textile Technology should have training equivalent to that offered by the Institute in mechanical engineering, chemical engineering, or chemistry. In some cases, graduates from textile colleges may be accepted in the program, but they should expect to spend at least two years fulfilling the M.S. degree requirements.

Mechanical Engineer

For those who desire preparation for engineering practice at a professional level beyond the Master of Science, the Mechanical Engineer is offered. The degree requires approximately one year of study beyond the Master of Science. The program is centered around the application of engineering principles to advanced development problems and includes an applications-oriented thesis. The general requirements for the degree are given in Chapter IV; 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.

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 M.I.T.-W.H.O.I. 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 M.I.T., students enrolled in this Course follow a program similar to that of other students in this Department. The program is described in more detail under the section on M.I.T.'s Joint Program in Oceanographic Engineering with the Woods Hole Oceanographic Institution.

Doctor of Philosophy and Doctor of Science

The objective of the doctoral degree is to prepare the student for doing creative work at the forefront of the mechanical engineering field and for careers in advanced engineering, research, or teaching. It usually requires two or three years' work beyond the master's degree. The course work includes a major area in depth and a minor area. Demonstration of successful English writing ability, or the successful completion of remedial training, is part of the program. The thesis research, which requires at least the equivalent of one year's full-time work, must contribute significantly to knowledge in the major field and may be of an analytical, experimental, or design nature.

Subjects in Mechanical Engineering

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 may alternatively elect an interdepartmental doctoral program in biomedical engineering (administered by the Committee on Biomedical Engineering) which is described in the section on the Harvard-M.I.T. Division of Health Sciences and Technology at the end of this chapter.

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 to the Graduate Registration Officer. Consideration for awards is not given before students have been assured of admission to the Graduate School.

Inquiries

Additional information concerning academic and research programs, admissions, financial aid, etc. may be obtained by writing to: Professor David Gordon Wilson, Undergraduate Officer, Room 3-154, M.I.T., Cambridge, Massachusetts 02139, (617) 253-2305; and Professor Warren M. Rohsenow, Graduate Officer, Room 3-156, (617) 253-2208.

(A) following the name of the subject indicates that it is an approved subject for a graduate degree and is given primarily for graduate students.

| | |
|--------|---|
| 2.U.R. | Undergraduate Research in Mechanical Engineering |
| 2.01 | Mechanics of Solids |
| 2.015 | Mechanics of Solids |
| 2.02 | Introduction to System Dynamics |
| 2.023 | Dynamic Systems |
| 2.03J | Dynamics |
| 2.032 | Dynamics (A) |
| 2.06J | Mechanical Vibration |
| 2.060J | Principles of Acoustics (A) |
| 2.061 | Random Vibration (A) |
| 2.062 | Wave Propagation (A) |
| 2.063J | Sound and Structural Vibration (A) |
| 2.065J | Flow Noise (A) |
| 2.066 | Studies in Engineering Acoustics (A) |
| 2.071J | Introduction to Structural Mechanics |
| 2.072 | Mechanics of Continuous Media (A) |
| 2.073 | Solid Mechanics—Plasticity and Inelastic Deformation (A) |
| 2.074 | Mechanics of Porous/Geological Materials (A) |
| 2.083 | Applied Elasticity (A) |
| 2.084J | Structural Mechanics in Nuclear Power Technology (A) |
| 2.092 | Methods of Engineering Analysis (A) |
| 2.093 | Computer Methods in Dynamics (A) |
| 2.094 | Theory and Practice of Continuum Mechanics |
| 2.10 | Elementary Programming and Machine Computation |
| 2.101 | Computer Models of Physical and Engineering Systems I |
| 2.120J | Transportation Performance and Technology (A) |
| 2.131J | Environmental Ecology I |
| 2.132J | Environmental Ecology II |
| 2.14 | Control System Principles |
| 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) |
| 2.153 | Nonlinear Control Systems (A) |
| 2.154 | Dynamics and Control of Rotating Machine Systems (A) |
| 2.155 | Dynamics and Control of Thermofluid Processes and Systems (A) |

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|--------|---|--------|---|--------|---|
| 2.157 | Computer Aided Design (A) | 2.58 | Radiation Heat Transfer (A) | 2.924 | Structural Mechanics of Fiber Assemblies (A) |
| 2.161 | Computer Controlled Experimentation (A) | 2.601J | Thermal Power Systems (A) | 2.925 | Textile Fibers: Structure and Chemical Modification (A) |
| 2.171 | Analysis and Design of Actuation Devices and Computer Control Systems (A) | 2.615 | Advanced Internal Combustion Engines (A) | 2.941J | Invention |
| 2.173 | Instrumentation for Measurement, Analysis and Control (A) | 2.621 | Gas-Turbine Design (A) | 2.942 | Entrepreneurship |
| 2.18J | Man-Machine Systems (A) | 2.63 | Energy Production from Renewable Resources (A) | 2.95 | Innovation and Industrial Development |
| 2.181J | Design and Evaluation of Human/Engineering Systems (A) | 2.649 | Low Temperature Refrigeration (A) | 2.951 | Engineering Internship |
| 2.19J | Introduction to Systems Analysis | 2.671 | Measurement and Instrumentation | 2.96 | Management in Engineering |
| 2.192J | Engineering Systems Analysis (A) | 2.672 | Project Laboratory | 2.97 | Independent Activities |
| 2.193 | Dynamics of Physical and Social Systems | 2.70 | Introduction to Design | 2.981J | Project Proseminar in Technology and Policy I (A) |
| 2.20 | Fluid Mechanics | 2.701 | Drafting for Engineers | 2.982J | Project Proseminar in Technology and Policy II (A) |
| 2.21 | Applications in Fluid Mechanics | 2.73 | Design Projects | 2.995 | Special Topics in Mechanical Engineering |
| 2.25 | Advanced Fluid Mechanics (A) | 2.731 | Advanced Engineering Design (A) | 2.996 | Advanced Topics in Mechanical Engineering (A) |
| 2.271 | Compressible Fluid Mechanics (A) | 2.74 | Advanced Mechanical Design | 2.998 | Introduction to Technology and Law I |
| 2.272 | Viscous and Turbulent Flows (A) | 2.741 | Fundamentals of Mining Technology (A) | 2.999 | Engineer's Degree Thesis Proposal Preparation (A) |
| 2.275 | Turbomachinery Design (A) | 2.742J | Introduction to Mining and Mineral Technology | | |
| 2.277 | Biomedical Fluid Mechanics (A) | 2.75 | Physiology of Human Movement (A) | | |
| 2.281 | Reacting Gas Dynamics (A) | 2.76J | Ultrasound: Physics, Biophysics and Technology | | |
| 2.282 | Combustion (A) | 2.761J | Principles of Medical Imaging (A) | | |
| 2.283 | Fluid Physics of Pollution (A) | 2.77 | Research in Biological Effects and Applications of Ultrasound and Other Non-Ionizing Radiations (A) | | |
| 2.284 | Water Purification (A) | 2.78 | Seminar on Rehabilitation Engineering Research and Practice | | |
| 2.30 | Mechanical Behavior of Solids | 2.791J | Quantitative Physiology: Cells and Tissues | | |
| 2.301 | Advanced Mechanical Behavior of Materials (A) | 2.792J | Quantitative Physiology: Organ Transport Systems | | |
| 2.31 | Materials for Mechanical Engineers | 2.793J | Quantitative Physiology: Sensory and Motor Systems | | |
| 2.332J | Physics of Deformation and Fracture of Solids I (A) | 2.86 | Manufacturing Processes Laboratory | | |
| 2.333J | Physics of Deformation and Fracture of Solids II (A) | 2.863 | Elements of Manufacturing | | |
| 2.34J | Deformation and Failure of Engineering Alloys in Service | 2.865 | Manufacturing Processes and Surface Properties (A) | | |
| 2.40 | Thermodynamics | 2.866 | Manufacturing Systems, Materials, Tools and Processes (A) | | |
| 2.404J | Molecular Theory of Materials | 2.867J | Thermo-Mechanical Processing of Polymers (A) | | |
| 2.41J | Thermodynamics of Power Systems | 2.900J | Biomedical Materials | | |
| 2.451J | General Thermodynamics I (A) | 2.901J | Introduction to Polymer Science and Engineering | | |
| 2.452J | General Thermodynamics II (A) | 2.907 | Science and Engineering of Biological Membranes and Structural Tissue (A) | | |
| 2.453J | The Maximum Entropy Formalism | 2.915 | Clothing Comfort and Utility | | |
| 2.46 | Thermodynamics and Statistical Mechanics of Rate Processes (A) | 2.921 | Polymer Deformation and Fracture (A) | | |
| 2.47J | Quantum Foundations of Mechanics and Thermodynamics (A) | 2.922 | Fiber Processing Mechanics (A) | | |
| 2.51 | Heat and Mass Transfer | | | | |
| 2.54 | Heat Transfer | | | | |
| 2.55 | Advanced Heat Transfer (A) | | | | |
| 2.56 | Conduction Heat Transfer (A) | | | | |
| 2.57J | Two-Phase Flow and Boiling Heat Transfer (A) | | | | |

Department of Nuclear Engineering

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Professor of Nuclear Engineering
Head of the Department

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Professor of Nuclear Engineering

Sow-Hsin Chen, Ph.D.
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Thomas Henderson Dupree, Ph.D.
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David Davton Lanning, Ph.D.
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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
Senior Lecturer

Department of Nuclear Engineering

The Department of Nuclear Engineering provides undergraduate and graduate education for students interested in developing the peaceful applications of nuclear reactions, plasma physics, and related aspects of radiation. In keeping with M.I.T.'s traditional role in other branches of knowledge, the Department aims to educate the individuals who will make the key scientific and engineering advances in these fields. 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, however, the totality of its interests is best described as the engineering physics of low-energy charged particles, neutrons, and radiation. Included is a strong involvement in the broader problems of providing energy in socially acceptable ways and of energy policy alternatives in general.

Fission reactors are used to produce heat and electricity, to propel submarines and ships, and to transmute elements and to produce radioisotopes. The most important development now occurring in the fission field is the rapid growth in the number and capacity of electric generating stations using nuclear fission reactors as heat sources. National and world demands for all forms of energy are expanding dramatically, such that the doubling time for the entire US electric utility industry is about 10 years. The supply and utilization of these increasing amounts of energy with minimal environmental impact has become one of society's major technological problems.

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.

In the Department's programs in these fields, attention is focused on the technology of the fission reaction and plasma phenomena and on aspects of applied mathematics, physical science, and engineering which contribute importantly to the efficient development of these fields — for example, low-energy nuclear physics, plasma physics, nuclear materials, numerical methods and high-flux heat transfer. The Department follows a broad interdisciplinary approach, making use of important segments of physics, chemistry, applied mathematics, and metallurgy, and drawing on the techniques of chemical, civil, electrical, and mechanical engineering where relevant to the solution of nuclear engineering problems. The programs aim to teach the basic principles of nuclear technology and applied plasma and radiation physics, and to show students how other fields of undergraduate specialization may be applied to problems in nuclear technology.

To fulfill society's growing expectations for increased electric and thermal energy production, not only must new generating technologies be developed, but generating plants must be designed and operated so as to produce energy safely, reliably, economically, and with acceptable environmental impact. Most thermal-electric generating technologies involve similar requirements and methods of design and analysis, for structural integrity under conditions of high temperatures and pressures, for reliability of components and systems, and for economic and environmental impact evaluation. Consequently the Department is involved in active programs with applications across the entire field of energy production in the areas of structural mechanics, reliability analysis, safety and licensing, environmental impact of power production, and engineering economics.

Undergraduates and graduate students in other departments at M.I.T. who wish to learn how their major professional field may be utilized in nuclear developments will find certain subjects or groups of subjects offered by the Department of Nuclear Engineering to be of interest. Programs of study focused on nuclear power plant engineering are of special interest to students of chemical, electrical, or mechanical engineering. Programs focused on applied plasma or radiation physics are valuable for students in physics or electrical engineering. Students in chemical engineering or metallurgy and materials science will find the program in nuclear materials engineering of particular interest. An interdepartmental program on structural mechanics in nuclear power technology has been established for students in civil, mechanical, materials science, ocean, and aeronautical, as well as nuclear, engineering.

Undergraduate Study

Bachelor of Science in Nuclear Engineering

The undergraduate programs in Nuclear Engineering are designed to prepare students for careers in the nuclear power industry, or for graduate study in nuclear engineering and related disciplines. The field is very broad and hence the program is arranged to provide the student with considerable flexibility, while meeting the intellectual demands of career preparation.

The Department offers two undergraduate programs leading to a Bachelor of Science in Nuclear Engineering. The first, Course XXII, is structured for completion in four years. The second, Course XXII-A, is part of a five-year Engineering Internship Program leading to both a Bachelor of Science and a Master of Science in Nuclear Engineering. Course XXII-A combines study with industrial engineering practice.

The curriculum for both programs is designed to serve the interests of those who wish to specialize early in their program, as well as students preferring to obtain a broadly based background. Students are encouraged to select subjects from several departments at the Institute in order to perceive the many aspects of science and engineering in a meaningful perspective. Students are permitted to use graduate subjects for their elective if they wish advanced training in some aspect of the field. A bachelor's degree thesis is required of all undergraduates in Nuclear Engineering.

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. 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.

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.

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.

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. 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 objective of the master's program is to give the student as good a general knowledge of aspects of nuclear engineering as can be gained in one year of full-time graduate study. This will provide a good foundation either for productive work in the nuclear field or for more advanced graduate study. Most master's candidates specialize in one of four alternative fields: fission reactor technology, applied plasma physics, applied radiation physics, or nuclear materials engineering.

Students with adequate undergraduate preparation normally need one full year to complete the requirements for the Master of Science. Additional information concerning the requirements for the Master of Science in Nuclear Engineering are given in an information circular which may be obtained from the Department of Nuclear Engineering.

Master of Science in Technology and Policy

Students interested in applying their nuclear engineering background to problems of policy and socioeconomic assessment of technology may apply for the interdepartmental Master of Science Program in Technology and Policy. This program combines subjects in advanced technology in the particular field of the student's choosing with subjects in economics, systems analysis, political science, and law. It engages the student in significant project work integrating technology and policy. Well-qualified students may complete this program in one calendar year. General requirements and application procedures are described in Chapter V.

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.

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. degree 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.

Subjects in Nuclear Engineering

Doctor of Philosophy and Doctor of Science

The program of study leading to these degrees aims to give a comprehensive knowledge of nuclear engineering, to develop competence in advanced engineering research, and to develop perspective in assessing the role of nuclear science and technology in our society.

The alternative fields in which doctoral candidates may elect to study and for which they are examined are: fission reactor physics, fission reactor engineering, applied plasma physics, applied radiation physics, nuclear materials engineering, or nuclear fuel management.

Research Facilities

The Department's educational program is supported by a number of outstanding experimental facilities for advanced research in nuclear engineering. The M.I.T. Nuclear Reactor Laboratory, one of the finest university research reactors in the world, provides first-hand experience in the design, performance, and operation of nuclear reactors, and serves as a source of radiations for use in laboratory instruction on radiation detection and measurement methods. Extensive experimental facilities are available for the production, confinement, and study of highly ionized plasmas. The Department has played a major role in the design and operation of the new fusion device ALCATOR, a major plasma physics installation which is expected to function for many years as the plasma equivalent of the M.I.T. Research Reactor.

The Department has a well-equipped nuclear instrumentation laboratory, a 14 MeV neutron source, two subcritical natural-uranium reactors (one moderated by water, the other by graphite), its own liquid helium refrigeration unit, laboratory space, shop facilities, its own PDP-8 digital computer, the use of M.I.T.'s IBM 370/168, and a Tektronix Plot-50 Graphic System.

Inquiries

Additional information concerning academic and research programs, admissions, financial aids, assistantships, etc. may be obtained by writing to the Department of Nuclear Engineering, Room 24-102, M.I.T., Cambridge, Massachusetts 02139, (617) 253-3801.

(A) following the name of the subject indicates that it is an approved subject for a graduate degree and is given primarily for graduate students.

- 22.U.R. Undergraduate Research Opportunities Program
 - 22.001 Seminar in Nuclear Engineering
 - 22.002 Management in Engineering
 - 22.003J In Pursuit of Arms Control: Analysis of the Past and Choices for the Future
 - 22.005 Dynamics of Physical and Social Systems
 - 22.006 Computer Models of Physical and Engineering Systems I
 - 22.02 Introduction to Applied Nuclear Physics
 - 22.021 Nuclear Reactor Physics
 - 22.03 Engineering Design of Nuclear Power Reactor Systems
 - 22.031 Engineering Analysis of Nuclear Reactors
 - 22.033 Nuclear Systems Design Project
 - 22.04 Radiation Effects and Uses
 - 22.069 Undergraduate Plasma Laboratory
 - 22.07 Basic Plasma Physics
 - 22.08 Energy
 - 22.09 Introductory Nuclear Measurements Laboratory
 - 22.091 Special Topics in Nuclear Engineering
 - 22.092 Engineering Internship
 - 22.111 Nuclear Physics for Engineers I (A)
 - 22.112 Nuclear Physics for Engineers II (A)
 - 22.211 Nuclear Reactor Physics I (A)
 - 22.212 Nuclear Reactor Physics II (A)
 - 22.213 Nuclear Reactor Physics III (A)
 - 22.22 Nuclear Reactor Dynamics (A)
 - 22.29 Nuclear Measurements Laboratory (A)
 - 22.311 Engineering Principles for Nuclear Engineers
-

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|---------|--|---------|--|
| 22.312 | Engineering of Nuclear Reactors (A) | 22.69 | Plasma Laboratory (A) |
| 22.313 | Advanced Engineering of Nuclear Reactors (A) | 22.71J | Physical Metallurgy Principles for Engineers (A) |
| 22.314J | Structural Mechanics in Nuclear Power Technology (A) | 22.72J | Nuclear Fuels (A) |
| 22.32 | Nuclear Power Reactors (A) | 22.73J | Radiation Effects in Crystalline Solids (A) |
| 22.33 | Nuclear Reactor Design (A) | 22.75J | Radiation Effects to Reactor Structural Materials (A) |
| 22.34 | Economics of Nuclear Power (A) | 22.76J | Nuclear Chemical Engineering (A) |
| 22.35 | Nuclear Fuel Management (A) | 22.80 | National Socio-Technological Problems and Responses (A) |
| 22.36J | Two-Phase Flow and Boiling Heat Transfer (A) | 22.81 | Energy Assessment (A) |
| 22.37 | Environmental Impact of Electric Power Production (A) | 22.83J | The Finite Earth: Agendas for a More Just, Sustainable and Participatory Society |
| 22.38 | Reliability Analysis Methods (A) | 22.85 | Introduction to Technology and Law I |
| 22.39 | Nuclear Reactor Operations and Safety (A) | 22.86 | Entrepreneurship |
| 22.41 | Numerical Methods of Radiation Transport (A) | 22.89 | Basic Electronics |
| 22.42 | Numerical Methods of Reactor Analysis (A) | 22.901- | Special Problems in |
| 22.43 | Numerical Methods in Reactor Engineering Analysis (A) | 22.904 | Nuclear Engineering (A) |
| 22.51 | Radiation Interactions and Applications (A) | 22.911 | Seminar in Nuclear Engineering |
| 22.55J | Biological and Medical Applications of Radiation and Radioisotopes I (A) | 22.912 | Seminar in Nuclear Engineering |
| 22.56J | Principles of Medical Imaging (A) | 22.913 | Graduate Seminar in Energy Assessment |
| 22.571J | General Thermodynamics I (A) | 22.914 | Graduate Seminar in Energy Assessment |
| 22.572J | General Thermodynamics II (A) | 22.915 | Seminar in Reactor Safety |
| 22.58J | Quantum Foundations of Mechanics and Thermodynamics (A) | 22.92 | Advanced Engineering Internship |
| 22.610 | Controlled Fusion Power (A) | | |
| 22.611J | Introduction to Plasma Physics (A) | | |
| 22.612 | Plasmas and Controlled Fusion (A) | | |
| 22.615 | MHD Theory of Magnetic Fusion Systems (A) | | |
| 22.621 | Thermonuclear Reactor Design (A) | | |
| 22.622 | Special Topics in Thermonuclear Reactor Design (A) | | |
| 22.63 | Engineering Principles for Fusion Reactors | | |
| 22.64J | Plasma Kinetic Theory (A) | | |
| 22.65J | Advanced Topics in Plasma Kinetic Theory (A) | | |
| 22.66 | Transport Phenomena in Toroidal Systems (A) | | |
| 22.67 | Plasma Diagnostics (A) | | |
| 22.68J | Introduction to Plasma Kinetic Theory (A) | | |

Department of Ocean Engineering

Ira Dyer, Ph.D.
Professor of Ocean Engineering
Head of the Department
(Absent, fall)

Professors

Martin Aaron Abkowitz, Ph.D.
Professor of Ocean Engineering

Alexander Douglas Carmichael,
Ph.D.
Professor of Power Engineering

Ernst Gabriel Frankel,
Mar. Mech.E.
Professor of Marine Systems

Justin Elliot Kerwin, Ph.D.
Professor of Naval Architecture

Patrick Leehey, Ph.D.
Professor of Naval Architecture
and Applied Mechanics

Philip Mandel, B.S.
Professor of Naval Architecture
(Absent)

Koichi Masubuchi, D.Eng.
Professor of Ocean Engineering
and Materials Science

Jerome H. Milgram, Ph.D.
Professor of Naval Architecture

John Nicholas Newman, Sc.D.
Professor of Naval Architecture

John Henry Sweeney III, Nav.E.
Professor of Naval Architecture
Professor of Naval Science
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Kiyohida Terai, D.Eng.
Professor of Ocean Engineering
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Associate Professors

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David Valentine Burke, Jr., Ph.D.
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Chryssostomos Chryssostomidis,
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John Kim Vandiver, Ph.D.
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Ronald Wai-Chun Yeung, Ph.D.
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Assistant Professors

Francis Noblesse, Ph.D.
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Henry L. Doherty Professor in
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Assistant Professor of Marine
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Henry L. Doherty Professor in
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Michael Stefanos Triantafyllou, Sc.D.
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Engineering

Robert James Van Houten, Ph.D.
Assistant Professor of Ocean
Engineering

Paul Christos Xirouchakis, Ph.D.
Assistant Professor of Ocean
Engineering

Adjunct Professor

Clark Graham, Ph.D.
Adjunct Professor of Naval
Architecture

Senior Lecturers

Dean Alden Horn, Nav.E.
Harry A. Jackson, B.S. (Visiting)
William Wallace Murray, Ph.D.
(Visiting)
William S. Pellini, B.S. (Visiting)
Willard Franklin Searle, Jr.,
Nav.E. (Visiting)

Lecturers

William Avery Baker, S.B.
Damon Ellis Cummings, Ph.D.
(Visiting)
Keatinge Keays, Nav.E.
Wolfgang Reuter, S.M.
(Visiting)

Administrative Officer

Keatinge Keays, Nav.E.

Professors Emeriti

Evers Burtner, S.B.
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John Harvey Evans, B.Eng.
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Alfred Adolf Heinrich Kell,
Dr.Rer.Nat.
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Norman Judson Padeiford, Ph.D.,
LL.D.
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Emeritus

Shannon Curtis Powell, Dott.Ing.
Professor of Marine Engineering,
Emeritus

Department of Ocean Engineering

Since the earliest of times, the oceans have served societal needs. They have provided avenues of transportation, resources of food and minerals, and natural barriers of defense. These uses of the ocean are perhaps more important today than ever before as the world faces problems of growing populations and shrinking resources. Out of the need for increased utilization of the ocean has come a heightened sense of purpose. Simply stated, the task in ocean engineering is to use the oceans and to use them wisely.

The goal of the Department of Ocean Engineering is to provide an educational experience that ultimately will enable its students to conceive, initiate, carry through, and direct large-scale engineering projects for a variety of tasks related to the use of the oceans. The ocean engineer may be a designer of large, complex systems — ships, platforms, submersibles — that meet the rigorous demands of supporting life at sea for long periods of time. The ocean engineer may be involved in defense-related activities or in the search for petroleum or other minerals. Marine transportation and its relation to other modes of transportation is still another province of the ocean engineer. Also, ocean engineers can contribute vitally in the development of balanced public policy for using the oceans and protecting the ocean environment.

In whatever field the ocean engineer may choose to work, there appears to be no shortage of tasks and career avenues to challenge the full range of engineering knowledge, skills, and imagination.

Career Opportunities in Ocean Engineering

Students in the Department of Ocean Engineering may prepare for various jobs and career paths, including the following.

Careers in Ocean Engineering

Naval Architect
 Marine Power Engineer
 Ocean Systems Engineer
 Offshore Engineer
 Ocean Resources Engineer
 Oceanographic Engineer
 Sonar Engineer
 Coastal Zone Manager
 Government Planner and Regulator
 Environmental Engineer

In marine transportation, naval architecture is representative of applied ocean engineering skills. A naval architect may be involved in designing ships that range from sailing yachts to supertankers. For more than 85 years, M.I.T. 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 M.I.T. in 1912, is an integral and vital part of the Department of Ocean Engineering. Building upon this historical base of expertise in ship design, the Department's curriculum today offers studies in all systems that must operate in an ocean environment.

Marine transportation also encompasses broad questions of international trade. To answer such questions, the ocean engineer must be able to assess in an integrated fashion a wide range of technical, economic, and political considerations. Other aspects of marine transportation include designing deep-water ports, integrating harbor facilities with land-based transportation systems, and planning new uses of waterways to help solve urban transportation problems.

Oil and gas beneath the ocean floor are increasingly important to an energy-hungry world. An ocean engineer is concerned with all phases of discovering, producing, and delivering offshore petroleum resources. 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 will fall the task of developing technology for locating and recovering copper, nickel, and other valuable minerals that lie beneath the oceans. Much new technology will be required to explore the feasibility of ocean mining; more still will be 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.

Elements of Ocean Engineering

The education of an ocean engineer revolves around three central components. The first is a firm foundation in such basics as hydrodynamics, structural mechanics, vibratory phenomena, energy conversion, materials, and electronics. Second, the engineer needs broad exposure and practical experience in skills such as analysis and design. Third, the context of applications needs to be understood, and this can be approached by dealing with the societal functions typically served by ocean engineers.

The following list details some of the elements of these central components. 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 in ocean engineering.

Elements of Ocean Engineering

Basics of Ocean Engineering

Mechanics
 Thermodynamics
 Hydrodynamics
 Structural mechanics
 Soil mechanics
 Materials physics
 Dynamics
 Acoustics
 Electronics
 Economics
 Probabilistics
 Oceanographics (physical, geological, geophysical, biological, chemical)

Doing of Ocean Engineering

Measuring
 Surveying
 Analyzing
 Synthesizing
 Inventing
 Designing
 Constructing
 Operating
 Inspecting/regulating
 Decision making
 Managing
 Maintaining/repairing
 Salving

Functions Served by Ocean Engineering

Ocean transportation
 Offshore oil and gas extraction
 Offshore hard mineral extraction
 Ocean defense
 Maritime law enforcement
 Ocean environmental protection and enhancement
 Fish protein production (fishing, culturing)
 Coastal construction
 Marine recreation
 Ocean energy conversion

Undergraduate Study

Once a student has attained the engineering basics, individualized programs of study to meet particular interests are strongly encouraged. The Department's faculty has wide and continuing research and industrial experience. Departmental facilities, which include a variable pressure propeller tunnel, a ship model towing tank, a channel for oil-water interface studies, an acoustics and vibration laboratory, a marine data systems laboratory, a design laboratory, computer facilities, and a model shop, offer a variety of opportunities for laboratory experience.

The sections that follow describe the Department's undergraduate and graduate programs. Special requirements for the Graduate School and opportunities for financial aid are summarized in the section on graduate study.

Bachelor of Science in Ocean Engineering, in Naval Architecture and Marine Engineering, or without designation Course XIII

Course XIII is the basic program offered by the Department. For undergraduates, the four-year program relates to students interested in engineering aspects of ocean sciences, ocean exploration, and the utilization of the oceans for transportation, defense, and resources. The program leads to the Bachelor of Science in Ocean Engineering, in Naval Architecture and Marine Engineering, or without designation of field. A curriculum without designation of field permits pursuit of broader marine-related interests. Graduates are prepared for work in industry or government, or for further study in graduate school.

Versions of the Course XIII program leading to the Bachelor of Science in Ocean Engineering, or to the Bachelor of Science in Naval Architecture and Marine Engineering, are accredited by the Engineers' Council for Professional Development, while those leading to the Bachelor of Science without designation of field are not.

Bachelor of Science in Naval Architecture and Marine Engineering; and Master of Science in Shipping and Shipbuilding Management Course XIII-B

This five-year program, for students interested in the business and management phases of the marine industry, leads to the simultaneous award of the Bachelor of Science in Naval Architecture and Marine Engineering and the Master of Science in Shipping and Shipbuilding Management.

The program in Course XIII-B, leading to the Bachelor of Science in Naval Architecture and Marine Engineering, is accredited by the Engineers' Council for Professional Development.

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 M.I.T. sophomores in good standing may apply for entrance to the program. Alternating periods at the Institute and at cooperating establishments are arranged so that graduation is not delayed beyond the normal date.

The companies and laboratories participating in the internship program cover all important aspects of ocean engineering, including naval architecture and marine engineering. Assignments with these organizations provide opportunities to participate in activities such as construction, testing, design, development, research, and technical planning.

Versions of the Course XIII-C program leading to the Bachelor of Science in Ocean Engineering, or to the Bachelor of Science in Naval Architecture and Marine Engineering, are accredited by the Engineers' Council for Professional Development, while those leading to the Bachelor of Science without designation of field are not.

Graduate Study

Graduate study in the Department of Ocean Engineering can lead to the following degrees: Master of Science; Ocean Engineer; Doctor of Philosophy; and 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 are 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.

Ocean Engineering Naval Architecture and Marine Engineering Course XIII

Course XIII is the central Course of the Department, with major fields of study or specialization including:

- Applied mechanics
- Coastal zone development
- Environmental engineering
- Fluid mechanics
- Hydrodynamics
- Marine acoustics
- Marine data systems engineering
- Marine engineering
- Marine materials and fabrication
- Marine resource development
- Marine systems
- Naval engineering
- Ocean engineering and law
- Ocean transportation
- Offshore engineering
- Operations research
- Public policy and ocean use
- Seafloor engineering
- Ship and offshore rig dynamics
- Ship propulsion
- Ship systems
- Structural mechanics
- Technology and policy

While most of these fields may be studied and researched largely in the Department, interdepartmental programs described in Chapter V also serve students with interests in some of the foregoing. We draw your attention especially to the formal degree programs in Environmental Engineering, Mineral Resources Engineering and Management, Operations Research, and Technology and Policy.

Naval Construction and Engineering Course XIII-A

This Course provides appropriate academic background for naval officers who later actively participate in concept formulation, design, and construction of naval vessels. In addition to general engineering and science and a core program of subjects in ocean engineering, each student follows one of several specialized curricula in aspects of, or applicable to, naval construction and engineering.

The Course leads to the Ocean Engineer or Master of Science. For programs leading to the Ocean Engineer, a Master of Science may be awarded simultaneously upon recommendation of the Department or of some other department related to the student's specialty. For programs leading to the Master of Science, an additional Master of Science may be awarded simultaneously in a second field of specialization upon recommendation of the department represented by that field.

The Master of Science awarded by the Department to students who successfully complete the relevant portion of the Course XIII-A program is in Naval Architecture and Marine Engineering or in Ocean Engineering. A Master of Science awarded by another department in fulfillment of its requirements would be labeled in accordance with its program, for example Master of Science in Mechanical Engineering.

Admission to Course XIII-A requires that the Department's entrance requirements for graduate study be satisfied.

Shipping and Shipbuilding Management Course XIII-B

Course XIII-B is intended for students interested in the business and management phases of the marine industry. Students entering the program at the graduate level without the preparation comparable to an S.B. in Naval Architecture and Marine Engineering should expect to devote two years to completing requirements for the degree of Master of Science in Shipping and Shipbuilding Management. In addition to satisfaction of departmental requirements for the undergraduate curriculum in naval architecture and marine engineering, students select areas of concentration in management or operations. They study undergraduate and graduate subjects in the Department of Economics, the Sloan School of Management, and the Department of Ocean Engineering. They also may broaden their experience by electing advanced subjects offered by other departments at the Institute.

The Department also offers a doctoral program jointly with the Transportation Division of the Department of Civil Engineering. Marine transportation students registered in the Department of Ocean Engineering and working toward the doctorate must fulfill all the requirements of the Transportation Division doctoral program plus a dissertation relating to marine transportation.

Requirements for admission to the graduate program in shipping and shipbuilding management are the same as for other graduate study in the Department, with an added stipulation that scores in the Admissions Test for Graduate Schools of Business may be requested as part of the overall admissions process.

Joint M.I.T.-W.H.O.I. 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 M.I.T., students enrolled in this course follow a program similar to that of other students in the Department. The program is described in more detail under the section on M.I.T.'s Joint Program in Oceanographic Engineering with the Woods Hole Oceanographic Institution.

Entrance Requirements for Graduate Courses

Undergraduate preparation for admittance to graduate study in the Department of Ocean Engineering ideally should be equal in quality, quantity, and breadth of coverage to the Department's undergraduate curricula. An undergraduate degree in ocean engineering is not required.

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.

Assistantships and Graduate Scholarships

Many teaching and research assistantships are 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.

A limited number of M.I.T. fellowships and scholarships are available to graduate students in the Department of Ocean Engineering. In addition, some industrial fellowship aid is available. Fellowships are also awarded each year by the Society of Naval Architects and Marine Engineers.

Prospective students are invited to communicate with the Head of the Department regarding any of these educational and financial opportunities. Applications for the Society of Naval Architects and Marine Engineers Graduate Fellowships are made directly to that Society. Inquiries for the fall term should be made late in the preceding fall term.

Inquiries

Additional information concerning academic programs, research opportunities, admissions, financial aid, etc. may be obtained by writing to the Department of Ocean Engineering, Room 5-225, M.I.T., Cambridge, Massachusetts 02139, (617) 253-1994.

Subjects in Ocean Engineering

(A) following the name of the subject indicates that it is an approved subject for a graduate degree and is given primarily for graduate students.

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|---------|--|---------|---|---------|--|
| 13.U.R. | Undergraduate Research | 13.27 | Ocean Engineering Power Systems (A) | 13.80J | Mechanical Vibration |
| 13.001 | Introduction to Marine Applied Mechanics | 13.39 | Analysis of Techniques for Fabricating Structures (A) | 13.81J | Principles of Acoustics (A) |
| 13.002 | Marine Applied Mechanics | 13.411 | Principles of Naval Ship Design (A) | 13.82J | Sound and Structural Vibration (A) |
| 13.003J | Dynamics | 13.412 | Principles of Ship Design (A) | 13.84J | Flow Noise (A) |
| 13.004 | Linear Systems and Random Processes in Ocean Engineering | 13.431 | Methods of Naval Ship-System Design (A) | 13.85 | Fundamentals of Underwater Sound Applications (A) |
| 13.011 | Hydrostatics | 13.451 | Projects in Naval Ships Conversion Design (A) | 13.86 | Ocean and Seabed Acoustics (A) |
| 13.012 | Applied Hydrostatics | 13.461 | Projects in New Construction Naval Ship Design (A) | 13.901 | Ocean Engineering Laboratory I |
| 13.013J | Water, Air and Interface Vehicles | 13.462 | Projects in Ocean Engineering System Design (A) | 13.902 | Ocean Engineering Laboratory II |
| 13.014 | The Oceans | 13.48 | Offshore Engineering Design (A) | 13.903 | Advanced Ocean Engineering Laboratory (A) |
| 13.021 | Marine Hydrodynamics I (A) | 13.49 | Dynamics of Physical and Social Systems | 13.92 | Public Policy and Use of the Sea (A) |
| 13.022 | Marine Hydrodynamics II (A) | 13.50 | Computer Applications to Marine Problems | 13.94J | Ocean Engineering and Law Seminar (A) |
| 13.03 | Advanced Hydromechanics of Ship Design (A) | 13.51 | Computer Models of Physical and Engineering Systems I | 13.961J | Resources Management (A) |
| 13.04 | Hydrofoils and Propellers (A) | 13.52 | Management in Engineering | 13.962 | Legal Aspects of Ocean Resources and Systems Management (A) |
| 13.05 | Boundary Layers (A) | 13.61 | Network Scheduling, Routing and Planning (A) | 13.97 | Introduction to Technology and Law I |
| 13.07 | Free Surface Hydrodynamics (A) | 13.62J | Engineering Systems Analysis (A) | 13.98J | Coastal Zone Management (A) |
| 13.08 | Stability and Motion Control of Ocean Vehicles (A) | 13.63 | Reliability, Availability, and Maintainability of Systems (A) | 13.990 | Oceanographic Systems I |
| 13.09 | Potential Flows (A) | 13.631 | Port Planning and Development (A) | 13.991 | Oceanographic Systems II |
| 13.10J | Introduction to Structural Mechanics | 13.65 | Production Analysis (A) | 13.992 | Marine Navigation, Positioning and Data Telemetry (A) |
| 13.11 | Theory of Plates and Shells (A) | 13.66 | Marine Transportation Economics (A) | 13.994 | Buoy Engineering (A) |
| 13.111 | Structural Mechanics (A) | 13.67 | Marine Decision Making Under Uncertainty (A) | 13.997 | Principles of Oceanographic Instrument Systems I — Measurement Platforms (A) |
| 13.112J | Analysis and Design of Offshore Structures (A) | 13.68 | Management of Marine Systems (A) | 13.998 | Principles of Oceanographic Instrument Systems II — Sensors and Measurements (A) |
| 13.121 | Ship Structures (A) | 13.681J | Issues in Transportation Management (A) | 13.999J | Special Projects in Oceanographic Engineering (A) |
| 13.122 | Ship Structural Design (A) | 13.69 | International Shipping (A) | | |
| 13.123 | Advanced Analysis and Design of Ocean Engineering Structures (A) | 13.700- | Special Problems in Ocean Engineering | | |
| 13.131 | Plastic Analysis of Structures (A) | 13.709 | Special Problems in Ocean Engineering (A) | | |
| 13.132 | Advanced Structural Topics (A) | 13.719 | A Survey of Ocean Engineering Seminar in Ocean Engineering | | |
| 13.14J | Structural Mechanics in Nuclear Power Technology (A) | 13.73 | Marine Data Systems (A) | | |
| 13.15J | Materials for Ocean Engineering | 13.730- | Introduction to Random Processes in Ocean Engineering (A) | | |
| 13.16J | Fracture of Structural Materials (A) | 13.739 | Invention | | |
| 13.17J | Welding Engineering (A) | 13.74J | Engineering Internship | | |
| 13.21 | Ship Power and Propulsion (A) | 13.76 | Industrial Practice in Ocean Engineering | | |
| 13.25J | Thermodynamics of Power Systems | 13.77J | Advanced Engineering Internship | | |
| 13.26J | Thermal Power Systems (A) | 13.771 | Entrepreneurship | | |
| | | 13.772 | Applied Ocean Engineering | | |
| | | 13.774 | | | |
| | | 13.78 | | | |
| | | 13.79 | | | |

Joint Program in Oceanographic Engineering with the Woods Hole Oceanographic Institution

M.I.T. and the Woods Hole Oceanographic Institution (W.H.O.I.) on Cape Cod offer joint programs of graduate study and research for students with special interests in biological oceanography, chemical oceanography, marine geology, marine geophysics, oceanographic engineering, and physical oceanography. These graduate programs are administered by committees drawn from the faculty and staff of both institutions. Students accepted to the Joint Program have access to the extensive intellectual and physical resources available for advanced study at both Woods Hole and M.I.T.

The Woods Hole Oceanographic Institution operates three ocean-going research ships, and several inshore boats. A resident staff of more than 800 scientists, engineers, and support personnel conduct a wide range of ocean-related studies in biology, chemistry, physical oceanography, geology, geophysics, and oceanographic engineering from extensive laboratory facilities in Woods Hole. A marine facility is maintained by M.I.T. in Boston Harbor consisting of dock space and a small research vessel capable of coastal work. Subjects in various aspects of oceanography as well as a large number of subjects directly applicable to oceanography are offered by many M.I.T. departments. These include:

| | | | | | |
|--------|--|---------|---|---------|---|
| 1.030J | Introduction to Technology and Law | 1.692 | Wave Dynamics in Oceanographic Engineering (A) | 12.21 | Physics of the Ocean |
| 1.59J | Fracture of Structure Materials (A) | 1.697J | Oceanographic Systems I | 12.221- | Project Studies in Oceanography |
| 1.62 | Free Surface Hydraulics | 1.698J | Oceanographic Systems II | 12.229 | |
| 1.64 | Transport and Mixing in Turbulent Flows (A) | 1.699J | Special Projects in Oceanographic Engineering (A) | 12.32 | Mechanics of Sedimentary Processes (A) |
| 1.67 | Sediment Transport and Coastal Processes (A) | 1.75 | Limnology and Wetland Ecology (A) | 12.56 | Advanced Seminar in Plate Tectonics (A) |
| 1.681 | Physics of Natural Water Bodies (A) | 1.761 | Aquatic Chemistry (A) | 12.72 | Oceanic Petrology (A) |
| 1.69 | Introduction to Coastal Engineering (A) | 1.79 | Aquatic Ecology (A) | 12.73 | Introduction to Marine Geology (A) |
| 1.691 | Wave Dynamics in Coastal Engineering (A) | 1.80 | Problems in Aquatic Biology and Chemistry (A) | 12.74 | Marine Micropaleontology (A) |
| | | 2.065J | Flow Noise (A) | 12.75 | Marine Sediments (A) |
| | | 2.071J | Introduction to Structural Mechanics | 12.752 | Paleomagnetism (A) |
| | | 2.131J | Environmental Ecology I | 12.77 | Marine Geophysical Data Interpretation (A) |
| | | 2.132J | Environmental Ecology II | 12.774 | Plants, Animals, and Sediments |
| | | 2.283 | Fluid Physics of Pollution (A) | 12.80 | Marine Chemistry |
| | | 2.284 | Water Purification (A) | 12.81 | Waves and Tides (A) |
| | | 2.63 | Energy Production from Renewable Resources (A) | 12.82 | Marine Geochemistry of Sediments |
| | | 3.20 | Thermodynamics of Materials (A) | 12.83 | Marine Geochemistry (A) |
| | | 3.21 | Kinetic Processes in Materials (A) | 12.84 | Organic Geochemistry (A) |
| | | 3.35 | Solidification Processing (A) | 12.85 | Oceanographic Time Series (A) |
| | | 3.36J | Welding Engineering (A) | 12.86 | General Circulation of the Oceans (A) |
| | | 3.39 | Mechanical Behavior of Materials (A) | 13.021 | Marine Hydrodynamics I (A) |
| | | 3.54 | Corrosion — The Environmental Degradation of Materials (A) | 13.022 | Marine Hydrodynamics II (A) |
| | | 3.701J | Materials for Ocean Engineering | 13.07 | Free Surface Hydrodynamics (A) |
| | | 3.90J | Fracture of Structural Materials (A) | 13.08 | Stability and Motion Control of Ocean Vehicles (A) |
| | | 3.93 | Materials Science of Polymers (A) | 13.09 | Potential Flows (A) |
| | | 6.455J | Marine Data Systems (A) | 13.10J | Introduction to Structural Mechanics |
| | | 7.411- | Seminars in Biological | 13.15J | Materials for Ocean Engineering |
| | | 7.419 | Oceanography (A) | 13.16J | Fracture of Structural Materials (A) |
| | | 7.421- | Special Problems in Biological | 13.17J | Welding Engineering (A) |
| | | 7.429 | Oceanography | 13.27 | Ocean Engineering Power Systems (A) |
| | | 7.43 | Phytoplankton and Nutrient Cycling (A) | 13.48 | Offshore Engineering Design (A) |
| | | 7.44 | Ecology of Oceanic Zooplankton | 13.74J | Marine Data Systems (A) |
| | | 7.45 | Benthos and Fish (A) | 13.76 | Introduction to Random Processes in Ocean Engineering (A) |
| | | 7.46 | Topics in Physiology and Biochemistry of Marine Animals (A) | 13.84J | Flow Noise (A) |
| | | 7.491- | Research in Biological | 13.85 | Fundamentals of Underwater Sound Applications (A) |
| | | 7.497 | Oceanography (A) | 13.86 | Ocean and Seabed Acoustics (A) |
| | | 10.803 | Introduction to Technology and Law I | 13.92 | Public Policy and Use of the Sea (A) |
| | | 11.362 | Land Use and Environmental Policy Implementation (A) | 13.94J | Ocean Engineering and Law Seminar (A) |
| | | 11.365J | Coastal Zone Management (A) | 13.961J | Resources Management (A) |
| | | 12.003J | Environmental Ecology I | 13.962 | Legal Aspects of Ocean Resources and Systems Management (A) |
| | | 12.004J | Environmental Ecology II | | |
| | | 12.20J | Environmental Chemistry of the Ocean-Atmosphere System | | |

- 13.97J Introduction to Technology and Law I
- 13.98J Coastal Zone Management (A)
- 13.990J Oceanographic Systems I
- 13.991J Oceanographic Systems II
- 13.992 Marine Navigation, Positioning and Data Telemetry (A)
- 13.994 Buoy Engineering (A)
- 13.997 Principles of Oceanographic Instrument Systems I — Measurement Platforms (A)
- 13.998 Principles of Oceanographic Instrument Systems II — Sensors and Measurements (A)
- 13.999J Special Projects in Oceanographic Engineering (A)
- 15.228J Ocean Engineering and Law Seminar (A)
- 16.082J Flow Noise (A)
- 16.792 Introduction to Technology and Law I
- 17.865 International Organization, Legal and Political Response to Science and Technology (A)
- 19.05J Environmental Chemistry of the Ocean-Atmosphere System
- 19.10 Climate of the Past
- 19.65J Turbulence and Random Processes in Fluid Mechanics (A)
- 19.681 Dynamics of Large-Scale Circulation of Ocean and Atmosphere (A)
- 19.682 Dynamics of Large-Scale Circulation of Ocean and Atmosphere (A)
- 19.80 Surface and Internal Gravity Waves (A)
- 19.81 Introduction to Oceanic Models (A)
- 19.82 Introduction to Oceanic Models (A)
- 19.83 Physical Oceanography
- 19.841 Waves (A)
- 19.842 Mesoscale Ocean Dynamics (A)
- 19.851 Dynamics of Shallow Seas (A)
- 19.853 Turbulence and Friction in the Ocean
- 19.86 The General Circulation of the Oceans (A)
- 19.89 Special Problems in Oceanography (A)
- 19.891-19.899 Special Problems in Oceanography (A)
- 20.612 General Toxicology (A)
- 20.811 Biochemical Engineering (A)
- 22.85 Introduction to Technology and Law I

Subjects, seminars, and opportunities for research participation are offered at both institutions. Students live in either Cambridge or Woods Hole and transportation is provided for them to commute the 80 miles between institutions so they can take advantage of all available resources. Students have the opportunity to participate in oceanographic cruises during graduate studies. Depending upon individual study and research programs, students are encouraged to reside for at least one year at each place. Upon admission, students register in the appropriate M.I.T. department and are assigned academic advisors at each institution.

The Joint Program involves several departments at M.I.T. — Biology, Earth and Planetary Sciences, and Meteorology in the School of Science, and Chemical Engineering, Civil Engineering, Electrical Engineering and Computer Science, Materials Science and Engineering, Mechanical Engineering, and Ocean Engineering in the School of Engineering. Details concerning entrance requirements, examinations, financial aid, etc. may be found in the descriptions of each individual department and the description following the School of Science section.

Oceanographic Engineering

The Departments of Chemical Engineering, Civil Engineering, Electrical Engineering and Computer Science, Materials Science and Engineering, Mechanical Engineering, and Ocean Engineering offer joint programs in engineering with the Woods Hole Oceanographic Institution leading to the Engineer, the Doctor of Philosophy, or the Doctor of Science degree.

Students interested in oceanographic engineering, oceanography-related engineering problems, engineering in the ocean, or the control of the ocean and its resources can be served by the Joint Program in Oceanographic Engineering.

Inquiries

Application for admission to the Joint Program or for financial aid should be made on the M.I.T. Graduate Application Form which may be obtained from the Director of Admissions at M.I.T. or from the Education Office at W.H.O.I. Requests for further information may be addressed to the Dean of Graduate Studies, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts 02543; or to the appropriate Department Headquarters, Joint Program in Oceanography, M.I.T., Cambridge, Massachusetts 02139.

Center for Advanced Engineering Study (C.A.E.S.)

The M.I.T. Center for Advanced Engineering Study was established in order to provide ways for experienced professionals to attain and maintain the competence needed for continued leadership in an age of technological change. The Center adds a new dimension to the activities of M.I.T. by offering educational programs which are designed to enable experienced men and women from industry, government, and educational institutions to acquire the understanding and skills needed to open technical frontiers.

The Center provides both on-campus and off-campus programs.

Advanced Study Program

The Advanced Study Program is planned to enable engineers and scientists to work in depth in technological areas pertinent to their professions. It is thus possible to accommodate technical managers who wish to understand those developments that bear directly on their problems, men and women who seek competence in depth at technological frontiers, and those who desire to strengthen their technological base.

Fellows of the Program are affiliated with the Center for one or more terms. Each Fellow may be associated with a faculty member who acts as an advisor for the Program and helps to arrange activities divided among formal classroom study, tutorial or research study, and other M.I.T. opportunities best suited to the Fellow's needs and background.

Fellows may develop courses of study to meet their individual needs or may participate in specialized programs such as the Advanced Study Program in Air Transportation or Education for Public Management.

The entire offering of M.I.T. 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 M.I.T. is designed for individuals who have supplied and will 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 M.I.T. 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 M.I.T.

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.

Education for Public Management Program

The Education for Public Management Program is designed to give mature, experienced employees of governmental agencies intensive training and practice in the systematic analysis of public policy issues. The program is sponsored jointly by the Center for Advanced Engineering Study and the Department of Political Science. The program is organized around a set of specially developed subjects.

General Information about On-Campus Programs

The Programs coincide with the normal academic terms and academic year. Special weekly seminars are planned and conducted during the fall and spring terms especially for Fellows of the Advanced Study Programs and the Education for Public Management Program. Each year a few special subjects of broad interdisciplinary interest are also offered within the Center for participants in the Program.

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 M.I.T. Graduate School. Those who are accepted and who fulfill all the requirements of the Graduate School are eligible for advanced degrees. Grades will be recorded for all M.I.T. subjects which are taken for credit.

The tuition fee, payable to M.I.T. for any of the Programs described above, is \$4,250 for the fall or spring term, \$8,500 for the two-term school year, \$2,800 for the regular summer term, and \$1,500 for Calculus Revisited. A limited number of scholarships from the grant provided by the Alfred P. Sloan Foundation to establish the Center may be awarded to faculty participants from other colleges and universities to pay part of the tuition fees.

The personal and family costs incident to living in greater Boston for participation in the Program will 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 will be 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 M.I.T. subjects and other scholarly activities at the Institute.

Descriptive brochures and application forms are available from the Center for Advanced Engineering Study, Room 9-335, M.I.T., Cambridge, Massachusetts 02139. Applications for the fall term should be received before June 1; for the spring term before December 1; and for the summer term before May 1.

Self-Study Subject Development Program

The Self-Study Subject Development Program provides off-campus continuing education opportunities to practicing engineers, industrial scientists, and technical managers through the medium of self-study subjects. The principal elements of these subjects are a set of lectures on film or videotape, a textbook, and a study guide containing reading assignments, problem sets, quizzes, and solutions to the homework and quiz problems.

Subjects now available are:

Artificial Intelligence
Calculus "Revisited"
Building an Innovative Organization
Calculus
Colloid and Surface Chemistry
Computer Languages
Computer-Aided Manufacturing
Cooling of Electronic Equipment
Decision Analysis
Digital Signal Processing
Economics
Energy Auditing in Buildings
Engineering Economy
Friction, Wear, and Lubrication
Instrumentation
Integrated Optics
Introduction to Engineering Mechanics
Introduction to Experimentation
Introduction to Materials
Introduction to the Oscilloscope
Management of Technological Innovation
Mechanics of Polymer Processing
Microprocessors
Modern Control Theory
Nonlinear Vibrations
Operational Amplifiers and Active Filters
Probability and Random Processes
Probability: Distributions and Decision Rules
Quality Planning and Quality Control
Systems Behavior, Management, Modeling, and Performance

Systems Engineering and Systems Management, A Guide to Thermostatics and Thermodynamics Uncertain Exchange Rates

Information regarding the rental or purchase of these self-study subjects may be obtained by writing to the M.I.T. Center for Advanced Engineering Study, Dept. 99-A, Room 9-234, M.I.T., Cambridge, Massachusetts 02139.

The Seminar Office

The Seminar Office was created to meet the short-term continuing education needs of the professional engineer. The Office coordinates programs presenting recent technological advances and/or the social consequences of these advances, and holds meetings providing perspectives on timely scientific issues. Also presented are programs which discuss trends in the marketplace and their relationship to technological development.

Individual programs vary in length, lasting from one day to one month, and concentrate on technical applications rather than theory. Depending on whether the meeting is a workshop, seminar, or conference, the size of the group may range from 12-1,000 attendees.

Programs are offered throughout the academic year and may be held at M.I.T. or at other locations around the country as well as overseas. While most of the workshops and seminars are not announced outside of the United States, attendance is open to professionals worldwide, and continuing education conferences are usually international in scope.

For more information, please contact Lea Johnson at the Center for Advanced Engineering Study, Room 9-268, M.I.T., Cambridge, Massachusetts 02139.

School of Humanities and Social Science



The School of Humanities and Social Science reflects the great diversity of M.I.T. today. In a university whose activities are centered around science and technology, the School represents the main fields of the liberal arts and the social sciences. Strong graduate programs exist in Economics, Linguistics, Philosophy, Political Science, and Psychology. Both students and faculty participate extensively in the research activities of numerous centers, laboratories, and departments outside the School. There is an ambitious program of undergraduate education, whose range has been steadily broadening in recent years, and 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 M.I.T. 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 M.I.T. Because they admit relatively small numbers of students, teaching is conducted in a congenial atmosphere. The *esprit de corps* is strong and there is a marked emphasis on developing new and exciting fields of inquiry. Many students take advantage of the opportunity to develop close associations with such bodies as the Center for International Studies, the Center for Policy Alternatives, the Center for Advanced Engineering Study, the Energy Laboratory, the Research Laboratory of Electronics, and the Center for European Studies at Harvard. Some of the graduate programs stress the use of mathematical and computer-oriented skills, but many doctoral theses are concerned with non-quantitative social sci-

ence or humanistic topics. Moreover, graduate students are not entirely confined to the established doctoral programs. There is always room for the occasional highly motivated student to develop a special program of his or her own.

The research achievements of the School are perhaps best known to the world at large through the widely publicized achievements of certain distinguished members of the faculty. The chief emphasis of research in the School, however, as in the rest of the Institute, has been less on the activities of brilliant individuals than on teamwork. In the field of communications, for example, there are many interdisciplinary projects, some involving collaboration among linguistics, philosophy, and psychology, which all have a special interest in psycholinguistics, and others involving political science and various branches of engineering. The Department of Economics and the Sloan School of Management cooperate closely in a number of branches of applied economics. Studies of the labor market are conducted by economists, sociologists, and political scientists. A long-established concern with science and public policy involves people all over the Institute, and is particularly strong in Political Science. A growing interest among musicians in computers and acoustics leads them to work jointly with electrical engineers. As the engineering departments have become increasingly concerned with questions of applied social science, such as the management of energy and urban transportation problems, and the exploitation of the sea bed, new opportunities have emerged for such collaboration. It is to be expected that research in the humanities will also be greatly expanded, in response to increasing levels of research support by the Federal government and foundations.

Undergraduates benefit in a variety of ways from these advanced research and training programs. Students majoring in economics, philosophy, and political science, for example, take part in graduate seminars and may find part-time professional employment on faculty research projects. The Department of Humanities does not undertake graduate training, but does offer a number of undergraduate degree programs. Through Course XXI, students may major in one of the humanistic disciplines (history, literature, anthropology, music) or combine the study of any of these disciplines with a science or an engineering field in one of the unique dual degree programs (Course XXI-A and XXI-B, Program 1) offered by the Institute. 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 meet the purposes of the Institute Requirement in the Humanities, Arts, and Social Sciences. Teaching for the purposes of this requirement is shared with the School of Architecture and Planning, but the great bulk of subjects offered are provided by the School of Humanities and Social Science. The object of the requirement, most broadly stated, is to ensure that every undergraduate at M.I.T. is exposed to a wide range of cultural and intellectual influences. M.I.T. seeks to offer much the same range of subjects as a first-rate liberal arts college, plus the special offerings that are made possible by the existence of 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 M.I.T. and as student interests change. The arts have been expanding especially quickly, both in this School and in the School of Architecture and Planning. The requirement provides that every undergraduate must complete at least eight subjects in the humanities, arts, and social sciences. Three of these subjects are chosen from a list of over 100 subjects regarded as broadly humanistic in spirit; and in order to achieve some breadth of educational experience, these subjects are selected 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 to come to M.I.T. who are equally concerned with the sciences and technology on the one hand and with the humanities and social sciences on the other. The rules governing undergraduate majors in the humanities and social sciences are sufficiently flexible to provide for a wide range of special interests. We are persuaded that modern society has been unduly constricted intellectually by the educational tradition that has tended to segregate scientific and humanistic education. It is no longer possible to believe that science and technology can go on expanding the resources of the world indefinitely. All societies in the future will have to put far greater emphasis on the conservation and management of resources. This objective will require the combined resources of the natural and social sciences as well as the insights of the humanist. Undergraduate education at M.I.T. is moving increasingly in the directions already taken by research and placing growing emphasis on collaborative endeavors which bridge the sciences and humanities.

The School's commitment to this view finds expression in a substantial new Program in Science, Technology, and Society. This Program, which has both educational and research objectives, is concerned with the human consequences of scientific and technological advances. The Program is designed to be the interim, experimental phase in the development of a College of Science, Technology, and Society. The term "college" — first used at M.I.T. in 1977 by the Whitaker College of Health Sciences, Technology, and Management — has been chosen to reflect the multidisciplinary and integrative character of this new venture.

To stress this new development is not to imply that M.I.T. 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, and the humanities and for offerings concerned exclusively with the great works of literature or 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 M.I.T. undergraduate education something quite distinctive.

Harold John Hanham
Dean of the School of Humanities and Social Science

Office of the Dean

Harold John Hanham, Ph.D.
Professor of History and Political Science
Dean

Donald Laurence Morton Blackmer, Ph.D.
Professor of Political Science
Associate Dean
Director, Program in Science,
Technology, and Society

School Faculty and Staff Without Departmental Affiliation

Nicholas Herman, M.Div., M.B.A.
Instructor

Janet Horowitz Murray, Ph.D.
Research Associate

William Nash Locke, Ph.D.
Professor of Modern Languages, Emeritus
Director of Libraries, Emeritus

Program in Science, Technology, and Society

Donald Laurence Morton Blackmer, Ph.D.
Professor of Political Science
Associate Dean, School of Humanities
and Social Science
Director

Peter Buck, Ph.D.
Assistant Director
Lecturer in the History of Science

Professors

Loren R. Graham, Ph.D.
Professor of the History
of Science

Gerald Holton, Ph.D.
Visiting Professor

Carl Kaysen, Ph.D.
David W. Skinner Professor of Political Economy
(Absent, fall)

Kenneth Kenison, Ph.D.
Andrew W. Mellon Professor of Human
Development
(Absent)

Thomas Samuel Kuhn, Ph.D.
Professor of Philosophy and
History of Science

Leo Marx, Ph.D.
William R. Kenan Professor of American Cultural
History

Robert Swain Morison, M.D., D.Sc.
Visiting Professor of Science and Society

Merritt Roe Smith, Ph.D.
Professor of the History
of Technology

Leon Trilling, Ph.D.
Professor of Aeronautics
and Astronautics

Charles Weiner, Ph.D.
Professor of the History of Science
and Technology

Associate Professors

Louis Lawrence Bucciarelli, Ph.D.
Co-Director, Course XXI
Associate Professor of Engineering and Technology
Studies

Emma Rothschild, M.A.
Associate Professor of Technology,
Society and Rhetoric
Director of the Writing Program

Langdon Winner, Ph.D.
Associate Professor of Technology Studies and
Political Science

Joel Yellin, Ph.D.
Associate Professor of Social Science
Lecturer in Political Science

Assistant Professors

Kenneth Rogers Manning, Ph.D.
Assistant Professor of the History of Science

Michael D. Meyer, Ph.D.
Assistant Professor of
Civil Engineering

David Franklin Noble, Ph.D.
Assistant Professor of the
History of Technology

Charles Frederic Sabel, Ph.D.
Assistant Professor of Social Science

Sherry Roxanne Turkle, Ph.D.
Assistant Professor of Sociology

Research Associates

Frank Emspak, Ph.D.
Michael B. Folsom, Ph.D.

Fellows

Janet Corpus, Ph.D.
Evelyn Fox Keller, Ph.D.

Visiting Scientist

Clifford Grobstein, Ph.D.
(Summer 1979)

Assistant to the Director

Martha Lindell Taylor, B.A.

Professor Emeritus

Elting Elmore Morison, A.M.
Elizabeth and James Killian Class of 1926
Professor, Emeritus

Program in Science, Technology, and Society

Undergraduate Study

The rapid growth of science and technology in the 20th century has generated problems and conflicts which have a direct impact on people's lives and on the shape of society as a whole. Along with an awareness of these problems has come an increasing recognition that social, political, and ethical considerations in turn help determine the nature of scientific and technological development.

To provide a context in which these interactions can be systematically explored, M.I.T. in 1977 committed itself to the creation of a College of Science, Technology, and Society. The Program in Science, Technology, and Society was established at that time as the interim, developmental phase of the College.

This new Program reflects M.I.T.'s longstanding concern to give its students an understanding of the human ramifications of science and engineering. Many individuals and programs at the Institute have devoted themselves to the study of particular aspects of these questions. But until now, there has been no substantial program, with both educational and research objectives, focused centrally and directly on the ways in which scientific, technological, and social factors interact to shape modern life.

S.T.S. is intended to be a center where faculty and students from all parts of the Institute can come together to discuss these interactions, the study of which clearly transcends the boundaries of any single discipline. Because the Program draws its faculty from the social and natural sciences, engineering, and the humanities, it is able to combine varied approaches to the field. S.T.S. employs the techniques and perspectives of the humanities and social sciences to examine the history, sociology, and philosophy of science and technology. At the same time, the Program looks at

current social and political issues surrounding the growth and uses of scientific knowledge and technology. Through this combination of approaches, S.T.S. aims to understand the social, scientific, and technological forces which have given rise to the problems and possibilities confronting contemporary industrial societies.

By exploring both the range of social and cultural forms which have evolved in response to scientific and technological changes and the variety of scientific and technological means which have been fashioned to serve human needs and purposes, S.T.S. aims to help students think more realistically, creatively, and humanely about the important intellectual, moral, and social issues of our time.

There are several ways in which undergraduates can become involved in the Program. S.T.S. offers a wide range of undergraduate subjects intended to introduce students to the historical, social, and cultural contexts of science and engineering. The curriculum is organized around five general areas of inquiry: 1) the history of science; 2) the history of technology; 3) contemporary problems in science and technology; 4) science, technology, and the organization of industrial society; and 5) cultural dimensions of science and technology. Within each of these categories, students can choose both broad-based introductory subjects and more specialized advanced subjects.

Although at present there is no undergraduate major in Science, Technology, and Society, the Humanities Department, in collaboration with S.T.S. faculty members, offers a special version of the interdisciplinary major in Humanities and Science or Engineering for students interested in the social and cultural dimensions of science and technology. (For a detailed description of this option, please see Degree Program Requirements under the Department of Humanities.) Students majoring in other disciplines, such as political science or engineering, can also structure their programs to include a strong S.T.S. component. It is anticipated that S.T.S. will offer a degree program within the next few years. In addition, plans for the development of collaborative and dual degree programs between S.T.S. and other M.I.T. Schools and departments are now under way.

 Graduate Study

 Subjects in Science,
Technology, and Society

Summer Internships

The Program in Science, Technology, and Society and the Public Policy Program in the Department of Political Science jointly offer a special summer internship in Science and Technology Policy. This internship is designed for undergraduate students interested in issues of science and technology that are directly related to the development of public policies by public sector agencies, public interest lobbies, advisory committees, or other advocacy groups. In addition to participating in the activities of the Public Policy Program, interns will attend special seminars and lectures on science and technology topics.

S.T.S. offers several graduate level subjects jointly with other M.I.T. departments, but does not yet have a formal graduate program. Graduate students who wish to pursue questions relating to interactions among science, technology, and society are encouraged to consult with S.T.S. faculty members concerning the variety of arrangements which can be made to meet their needs and interests. Students can participate in research and reading seminars, become involved in faculty research projects, and, with departmental permission, structure a special concentration or minor in S.T.S. as part of their degree program. Individually tailored interdepartmental degree programs can also be arranged.

Research Assistantships

A few research assistantships are available each year to qualified graduate students for work under S.T.S. faculty supervision on projects supported by the Program.

Inquiries

Additional information on the Program may be obtained from the Director's office, Room 20D-213, M.I.T., Cambridge, Massachusetts 02139, (617) 253-4062.

(A) following the name of the subject indicates that it is an approved subject for a graduate degree and is given primarily for graduate students.

| | |
|-------------|---|
| STS 100J | Reading Seminar in Humanities, Science, and Technology I |
| STS 101J | Reading Seminar in Humanities, Science, and Technology II |
| STS 110 | Special Topics in Science, Technology, and Society |
| STS 111 | Special Topics in Science, Technology, and Society |
| STS 200 | Science from the Renaissance through the Enlightenment |
| STS 201 | History of 19th- and 20th-Century Science |
| STS 210 | American Science Since the 1930s |
| STS 211 | Russian Science and Society |
| STS 212 | Science and Society in Modern China |
| STS 220 | History of Modern Mathematics |
| STS 221J | Topics in the History of Physical Science |
| STS 230 | Emergence and Growth of New Research Fields: A Social History |
| STS 231J | Understanding the Discovery Process — An Historical Approach |
| STS 240 | The Work of the Scientist, and Its Sources |
| STS 241 | Biography in Science |
| STS 300 | History of Technology in America I: 1787-1876 |
| STS 301 | History of Technology in America II: 1876-Present |
| STS 302 | Culture and Technology in America: the 19th Century |
| STS 310J | Industrialization and Cultural Change in 19th-Century America |

| | | | |
|-------------|--|-------------|---|
| STS 320 | Arms, Power, and the Engineer | STS 600 | Technological Society and the Recovery of "The Natural" |
| STS 400 | Science, Technology, and Society: Problems of Innovation | STS 601J | Literature, Ideology, and Natural Experience in the United States |
| STS 401J | Value, Choice and Risk in Modern Technology | STS 602 | The Machine: Metaphor, Fact, and Theory |
| STS 410 | Ethical Issues in Science and Engineering | STS 610J | Writing about Work |
| STS 411J | Legal, Ethical, and Scientific Issues in the Regulation of Dangerous Industries | STS 630J | Seminar on Astronomy and Archaic Mythology |
| STS 412J | Ethics and Technocrats | | |
| STS 413J | Seminar in Public Interest Science | | |
| STS 414 | Medicine and its Critics: A Study of Medical Practices as a Paradigm for Expert- Client Relations | | |
| STS 420 | Computers and People | | |
| STS 421J | Computer Cultures, Computation, and the Individual (A) | | |
| STS 430 | Engineering Design in Social Context | | |
| STS 500 | Professions | | |
| STS 510J | Modern Social Theory (A) | | |
| STS 511J | Theories of Technological Society and Politics | | |
| STS 520 | Technology as a Social Process | | |
| STS 522 | Seminar in Alternative Technology | | |
| STS 530 | Growth and Structure of Urban Environments | | |
| STS 540 | The World of American Food | | |

Department of Economics

Edgar Cary Brown, Ph.D.
Professor of Economics
Head of the Department

Peter Arthur Diamond, 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

Jagdish Natwarlal Bhagwati, Ph.D.
Ford International Professor of
Economics

Robert Lyle Bishop, Ph.D.
Professor of Economics

Evsey David Domar, Ph.D.
Ford International Professor of
Economics

Rudiger Dornbusch, Ph.D.
Professor of Economics
(Absent)

Richard Samuel Eckaus, Ph.D.
Ford International Professor of
Economics
(Absent, spring)

Stanley Fischer, Ph.D.
Professor of Economics
(Absent, fall)

Franklin Marvin Fisher, Ph.D.
Professor of Economics

Harold Adolph Freeman, S.B.
Professor of Statistics, Emeritus
Senior Lecturer

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

Jerry Allen Hausman, D.Phil.
Professor of Economics

Paul Lewis Joskow, Ph.D.
Professor of Economics
(Absent)

Charles Poor Kindleberger,
Ph.D., D.H.C.
Ford International Professor of
Economics, Emeritus
Senior Lecturer

Edwin Kuh, Ph.D.
Professor of Economics

Daniel Little McFadden, Ph.D.
Professor of Economics

Franco Modigliani, D.Jur.,
D.Soc.Sci., LL.D.
Institute Professor
Professor of Economics
and Finance

Charles Andrew Myers, Ph.D.
Professor of Industrial Relations
Sloan Fellows Professor of
Management, Emeritus
Senior Lecturer

Michael Joseph Piore, Ph.D.
Professor of Economics
(Absent)

Jerome Rothenberg, Ph.D.
Professor of Economics

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
Associate Dean, Alfred P. Sloan
School of Management

Christopher Albert Sims, Ph.D.
Professor of Economics
(Visiting, fall)

Robert Merton Solow, Ph.D.,
LL.D., D.L.H.
Institute Professor
Professor of Economics

Lance J. Taylor, Ph.D.
Professor of Nutritional
Economics

Peter Temin, Ph.D.
Professor of Economics

Lester Carl Thurow, Ph.D.
Professor of Economics
and Management
(Absent, fall)

Martin Lawrence Weitzman, Ph.D.
Professor of Economics

Associate Professor

William Cody Wheaton, Ph.D.
Associate Professor of Economics

Assistant Professors

Henry Stuart Farber, Ph.D.
Assistant Professor of Economics

Jeffrey Earl Harris, M.D., Ph.D.
Assistant Professor of Economics

Harry Charles Katz, Ph.D.
Assistant Professor of Economics

Robert Bruce Litterman, Ph.D.
Assistant Professor of Economics

Eric Stark Maskin, Ph.D.
Assistant Professor of Economics

Marilyn Jo Simon, Ph.D.
Assistant Professor of Economics

Lawrence Henry Summers, Ph.D.
Assistant Professor of Economics

Thomas John Teisberg, Ph.D.
Assistant Professor of Economics

Instructor

Joseph von Rosthorn Farrell, M.Sc.

Administrative Officer

Idella Lyman Tapley, A.B.

Professors Emeriti

Harold Adolph Freeman, S.B.
Professor of Statistics, Emeritus
Senior Lecturer

Everett Einar Hagen, Ph.D.
Professor of Economics and
Political Science, Emeritus

Charles Poor Kindleberger,
Ph.D., D.H.C.
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Economics, Emeritus
Senior Lecturer

Charles Andrew Myers, Ph.D.
Professor of Industrial Relations
Sloan Fellows Professor of
Management, Emeritus
Senior Lecturer

Paul Pigors, Ph.D.
Professor of Industrial Relations,
Emeritus

Paul Narcyz Rosenstein-Rodan,
Dr.Rer.Pol.
Professor of Economics, Emeritus

 Department of Economics

 Undergraduate Study

Economics, the study of economic institutions and systems, is useful in an intellectual sense because it trains students to think carefully and logically about complex social phenomena and to bring to bear relevant information on them. With such knowledge it is possible to understand the impact of broad socioeconomic developments and policies on economic systems and institutions as well as the response of these units to them. The growing awareness of these interactions on the part of scientists and engineers makes the study of economics especially relevant at M.I.T.

**Bachelor of Science in Economics
Course XIV**

The Course leading to the Bachelor of Science in Economics combines training in technical economics with opportunities for a broad and balanced undergraduate education. Students may select programs that emphasize the relation of technology to economics by concentrating their free time in science and engineering; they may choose programs that concentrate more heavily on economics and other social sciences; or they may undertake to relate economics to history, philosophy, or literature. The successful completion of the degree prepares students for study in economics, industrial relations, business administration, law, and related fields, or for careers in teaching, government, research, unions, and business.

The aims of the degree program are threefold: to give students a firm grounding in modern economic theory; to provide a basic descriptive knowledge of the US and world economy; and to develop in students the capability for quantitative research and independent thought. These aims roughly correspond to the requirements of theory, electives, statistics, and research.

 Graduate Study

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. 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, statistics and econometrics, transportation economics, human resources and the income distribution, and (given outside the Department) finance and operations research.

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.

Subjects in Economics

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.

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 M.I.T.; 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.

Inquiries

Additional information concerning academic programs in the Department, admissions, financial aid, etc. may be obtained by writing to Professor Robert L. Bishop, M.I.T., Room E52-344, 50 Memorial Drive, Cambridge, Massachusetts 02139, (617) 253-6181.

(A) following the name of the subject indicates that it is an approved subject for a graduate degree and is given primarily for graduate students.

- 14.U.R. Undergraduate Research
- 14.01 Economic Principles I
- 14.014J Engineering Aspects of Economic Analysis
- 14.02 Economic Principles II
- 14.03 Applied Microeconomics
- 14.04 Intermediate Microeconomic Theory
- 14.05 Current Economic Problems
- 14.06 Intermediate Macroeconomic Theory
- 14.07 History of Economic Thought
- 14.09 Reading Seminar in Economics
- 14.101 Mathematics for Economists
- 14.102 Mathematics for Economists
- 14.11 Mathematical Economics
- 14.120 Microeconomic Theory (A)
- 14.121 Microeconomic Theory I (A)
- 14.122 Microeconomic Theory II (A)
- 14.123 Microeconomic Theory III (A)
- 14.124 Microeconomic Theory IV (A)
- 14.132 Schools of Economic Thought (A)
- 14.141 General Equilibrium Theory (A)
- 14.142 Mathematical Optimization and Economic Theory (A)
- 14.143 Advanced Theory of the Market (A)
- 14.144 Applied Price Theory (A)
- 14.145 Economics of Uncertainty (A)
- 14.146 Social Choice Theory (A)
- 14.147 Economic Applications of Game Theory (A)
- 14.148 Advanced Topics in Microeconomic Theory (A)
- 14.149 Advanced Topics in Microeconomic Theory (A)
- 14.151 Mathematical Approach to Economics (A)
- 14.191 Economics Seminar (A)
- 14.192 Economics Seminar (A)
- 14.193 Seminar: Topics in Economics (A)
- 14.194 Seminar: Topics in Economics (A)
- 14.195 Reading Seminar in Economics (A)
- 14.196 Reading Seminar in Economics (A)
- 14.197 First-Year Graduate Seminar (A)

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|---------|------------------------------------|---------|-----------------------------------|
| 14.198- | Teaching Introductory | 14.50 | State and Local Government |
| 14.199 | Economics | | Finance |
| 14.20 | Industrial Organization and | 14.51J | Urban Economics |
| | Public Policy | 14.52 | Economics of the Soviet Union and |
| 14.21J | Health Economics | | China |
| 14.22 | Energy Economics | 14.53 | Comparative Economic Systems |
| 14.24 | Law and Economics | 14.54 | International Trade |
| 14.271 | Problems in Industrial | 14.572 | Regional Economic Analysis (A) |
| | Economics (A) | 14.573J | Urban Economic Analysis I (A) |
| 14.272 | Government Regulation of | 14.574J | Urban Economic Analysis II (A) |
| | Industry (A) | 14.576J | Topics in Transportation |
| 14.281 | The Energy Industries | | Economics (A) |
| 14.291 | Industrial Economics Seminar (A) | 14.581 | International Economics I (A) |
| 14.292 | Industrial Economics Seminar (A) | 14.582 | International Economics II (A) |
| 14.30 | Introduction to Statistical Method | 14.63 | Labor in Industrial Society |
| | in Economics | 14.64 | Labor Economics and Public Policy |
| 14.31 | Econometrics | 14.671J | Labor Economics (A) |
| 14.381 | Statistical Method in Economics | 14.672J | Public Policy on Employment and |
| 14.382 | Econometrics I (A) | | Industrial Relations (A) |
| 14.383 | Econometrics II (A) | 14.674J | Comparative Systems of Industrial |
| 14.386 | Advanced Topics in | | Relations and Human Resource |
| | Econometrics (A) | | Development (A) |
| 14.388 | Applied Econometrics (A) | 14.691J | Research Seminar in Industrial |
| 14.389 | Econometrics Paper (A) | | Relations (A) |
| 14.39 | Economic Research Seminar | 14.692J | Research Seminar in Industrial |
| 14.391 | Workshop in Economic Research | | Relations (A) |
| | (A) | 14.71 | Economic History |
| 14.392 | Workshop in Economic Research | 14.731 | American Economic History (A) |
| | (A) | 14.732 | Problems in Russian Economic |
| 14.40 | Monetary and Banking Policy | | History (A) |
| 14.41J | Distribution of Income and | 14.733 | European Economic History (A) |
| | Employment Opportunity | 14.734 | Problems in Economic History (A) |
| 14.42 | Economics of Pollution | 14.74 | Economic Growth and Development |
| 14.43 | Public Finance | 14.771 | Problems of Economic |
| 14.451 | Macroeconomic Theory I (A) | | Development (A) |
| 14.452 | Macroeconomic Theory II (A) | 14.772 | Theory of Economic Development |
| 14.453 | Macroeconomic Theory III (A) | | (A) |
| 14.454 | Macroeconomic Theory IV (A) | 14.775J | Economics of World Food (A) |
| 14.458 | Advanced Topics in | 14.776 | Theory and Problems of |
| | Macroeconomic Theory (A) | | Economic Development (A) |
| 14.459 | Advanced Topics in | 14.781J | Political Economy: Theories of |
| | Macroeconomic Theory (A) | | the State and the Economy (A) |
| 14.462 | Monetary Economics I (A) | 14.782 | Capitalism, Socialism and |
| 14.463 | Monetary Economics II (A) | | Growth (A) |
| 14.471 | Fiscal Theory I (A) | 14.783 | Theory of Central Planning (A) |
| 14.472 | Fiscal Theory II (A) | | |
| 14.473 | Government Decision Theory (A) | | |
| 14.474 | Fiscal Economics III (A) | | |
| 14.475 | Fiscal Federalism and Local | | |
| | Government Economics (A) | | |
| 14.476 | Social Insurance (A) | | |
| 14.477 | Quantitative Fiscal Analysis (A) | | |
| 14.478 | Tax Institutions and | | |
| | Policy (A) | | |
| 14.482 | Income Distribution Economics (A) | | |

Department of Humanities

Richard Lee Cartwright, Ph.D.
Professor of Philosophy
Associate Chairman of the Faculty
Acting Head of the Department

Pauline Maier, Ph.D.
Professor of History
Acting Associate Head
of the Department

Professors

Elizabeth Bishop
Professor of Writing
(Visiting, fall)

Richard Mateer Douglas, Ph.D.
Professor of History

Martin Dyck, Ph.D.
Professor of German and
Literature

David Mayer Epstein, Ph.D.
Professor of Music
Conductor of the M.I.T.
Symphony Orchestra

Joseph Dee Everingham, M.A.
Professor of Literature

Robert Michael Fogelson, Ph.D.
Professor of History and
City Planning

Albert Ramsdell Gurney, Jr.,
M.F.A.
Professor of Literature

Harold John Hanham, Ph.D.
Professor of History and
Political Science
Dean, School of Humanities
and Social Science

James Wesley Harris, Ph.D.
Professor of Spanish and
Linguistics

Robert Emmet Jones, Ph.D.
Professor of French and
Humanities

Louis Kampf, B.A.
Professor of Literature

Alvin Charles Kibel, Ph.D.
Professor of Literature
(Absent)

Andor Andras Kovach, M.A.
Professor of Music
Composer in Residence
(Visiting)

Robert Ellsworth MacMaster,
Ph.D.
Professor of History and Literature

Thomas Henry Donald Mahoney,
Ph.D.
Professor of History
(Absent, spring)

Bruce Mazlish, Ph.D.
Professor of History
(Absent)

Wayne O'Neill, Ph.D.
Professor of Literature

Krystyna Pomorska, Ph.D.
Professor of Russian and
Literature

Harald Anton Thrap Olsen Reiche,
Ph.D.
Professor of Classics and
Philosophy

Robert Irwin Rotberg, D.Phil.
Professor of History and Political
Science

Merritt Roe Smith, Ph.D.
Professor of the History
of Technology

Barry Bernard Spacks, M.A.
Professor of Literature
(Absent)

Associate Professors

Jeanne S. Bamberger, M.A.
Associate Professor of Education
and Music

John La Boiteaux Buttrick, M.S.
Associate Professor of Music

Elzbieta Ettinger Chodakowska,
Ph.D.
Associate Professor of Writing

Catherine Vakar Chvany, Ph.D.
Associate Professor of Russian

Martin Diskin, Ph.D.
Associate Professor of
Anthropology

Peter Samuel Donaldson, Ph.D.
Associate Professor of Literature

Stephen Erdely, Ph.D.
Associate Professor of Music
Director of Music

John Harbison, M.F.A.
Associate Professor of Music

James Howe, Ph.D.
Associate Professor of Anthropology

Jean Elizabeth Jackson, Ph.D.
Associate Professor of Anthropology

Arthur Daniel Kaledin, Ph.D.
Associate Professor of History and
American Studies

Heather Nan Lechtman, M.A.
Associate Professor of Archaeology
and Ancient Technology
Director, Center for Materials
Research in Archaeology and
Ethnology

Travis Rhodes Merritt, Ph.D.
Associate Professor of Literature

David Bird Ralston, Ph.D.
Associate Professor of History
(Absent)

Margery Resnick, Ph.D.
Associate Professor of Spanish
Director of Modern Languages

Emma Rothschild, B.A.
Associate Professor of Technology,
Society and Rhetoric
Director, Writing Program

Arthur Steinberg, Ph.D.
Associate Professor of
Archaeology

Irene Tayler, Ph.D.
Associate Professor
of Literature

Marcus Aurelius Thompson, D.M.A.
Associate Professor of Music

David Thorburn, Ph.D.
Associate Professor
of Literature

Edward B. Turk, Ph.D.
Associate Professor of French
(Absent, spring)

Barry Lloyd Vercoe, D.M.A.
Associate Professor of Music

Ellen Voigt, M.F.A.
Associate Professor of Poetry

William Braasch Watson, Ph.D.
Associate Professor of History

Assistant Professors

Timothy Charles Aarset, D.M.A.
Assistant Professor of Music

A. Julia Alissandratos, Ph.D.
Assistant Professor of Russian

Alan D. Brinkley, Ph.D.
Assistant Professor of History

Isabelle de Courtivron, Ph.D.
Assistant Professor of French

Kathryn J. Crecelius, Ph.D.
Assistant Professor of French

David Dollenmayer, Ph.D.
Assistant Professor of German

Martin Dennis Farren, Ph.D.
Assistant Professor of Music

Elizabeth Garrels, Ph.D.
Assistant Professor of Spanish

A. Rae Goodell, Ph.D.
Assistant Professor of Science
Writing

Frederick Hodgson, Ph.D.
Assistant Professor of French

Amy Lang, Ph.D.
Assistant Professor of
Literature

Monroe H. Little, Jr., Ph.D.
Assistant Professor of History
(Absent, fall)

James Paradis, Ph.D.
Assistant Professor of Technical
Communication
(Absent, spring)

Ruth Perry, Ph.D.
Assistant Professor of Literature

Thomas Postlewait, Ph.D.
Assistant Professor of Writing

Jay Rosellini, Ph.D.
Assistant Professor of German

Robert N. Scanlan, Ph.D.
Assistant Professor of Drama
and Theatre Arts

Stephen James Tapscott, Ph.D.
Assistant Professor of Literature
(Absent, spring)

Wilma Elaine Wetterstrom, Ph.D.,
Assistant Professor of Anthropology
and Archaeology

John Wilkes, Ph.D.
Assistant Professor of Science
Writing and Technical Writing

Wilburn Williams, Ph.D.
Assistant Professor of Literature

Senior Lecturer

Claire Jeanne Kramsch, M.A.
Senior Lecturer in German

**Lecturers in English
as a Foreign Language**

Kathy Irving, M.A.
Abelle Mason, M.A.
Linda B. Sibley, Ph.D.

Lecturer in German

Ilse K. Evans, M.A.

Lecturer in Russian

George Kostich, Ph.D.

Lecturer in Humanities

Robert A. Fein, Ph.D.

Lecturer in Literature

Susan E. Linville, Ph.D.

Lecturers in Music

Edward Cohen, M.A.

John Cook, Mus.B.
Institute Organist

Adrianus Johannes Maria Houtsma,
Ph.D.

Melissa Howe, M.M.

John S. Oliver, M.Mus.
Director of M.I.T. Choral Society

Lecturers in Writing

Robin Becker, M.A.
David Breakstone, M.A.
Barbara Hartmann, Ph.D.
John Kirsch, A.B.
Kenneth Skler, S.B.
Lee Warren, Ph.D.

Instructors

Susan Dickman, M.A.
Gilberte Furstenberg, M.A.
Michael Geisler
David Halperin, M.A.
Stuart Johnson, M.A.
Katherine Paszkolovits, M.A.
Gladys Varona-Lacey, M.A.

Administrative Officer

Marjorie Stern Lucker, A.B.

Director, Language Laboratory

Ruth Trometer, B.A.

Professors Emeriti

Howard Russell Bartlett, B.S.,
A.M.
Professor of History, Emeritus

Lynwood Silvester Bryant, A.M.
Professor of History and
American Studies, Emeritus

Margaret Zarodny Freeman, S.M.
Associate Professor of Russian,
Emerita

William Chace Greene, M.A.
Professor of Literature, Emeritus

Edward Neal Hartley, A.M.
Professor of History, Emeritus
Institute Archivist, Emeritus

Richard Felix Koch, A.M.
Assistant Professor of Modern
Languages, Emeritus

Roy Lamson, Ph.D.
Class of 1922 Professor of
Literature, Emeritus
Special Assistant to the President
for the Arts

Klaus Liepmann
Professor of Music, Emeritus
Director of Music, Emeritus

Robert Reynolds Rathbone, A.M.
Professor of Technical
Communication, Emeritus

Cyril Stanley Smith, Sc.D.
Institute Professor, Emeritus
Professor of the History of Science
and Technology, Emeritus
Professor of Metallurgy, Emeritus

Theodore Wood, Jr., A.M.
Professor of Literature and American
Studies, Emeritus

Robert Smith Woodbury, S.B.,
A.M.
Professor of the History of
Technology, Emeritus

Department of Humanities

The Department of Humanities provides substantial curricula in anthropology/archaeology, foreign languages and literatures, history, literature, music, and writing, as well as special programs in American studies, Russian studies, the Western tradition, ancient and medieval studies, and drama. In view of M.I.T.'s particular educational character, the Humanities faculty is committed to complementary objectives: to affirm and sustain the distinctiveness of humanistic study in itself as an indispensable element in a whole education; and to explore opportunities for productive interaction with scientific and technical disciplines. These aims are reflected in the variety and depth of the subject offering.

As indicated in the descriptive summaries below, all of the programs in or associated with the Department provide subjects which help to satisfy the Institute Requirement in Humanities, Arts, and Social Sciences; most include Distribution Subjects and Fields of Concentration which meet the principal terms of that Requirement; several are available as undergraduate degree programs in Course XXI, either in combination with Engineering or Science curricula (XXI-A, XXI-B, 1) or as full majors (XXI-B, 2).

Anthropology/Archaeology

Distribution Subjects

Field of Concentration

Major Programs: XXI-A; XXI-B, 1; XXI-B, 2

Anthropology studies human beings and their great diversity in adapting to physical and social environments. While the discipline is interested in humankind as a biological species, its tools and technology, its languages, modes of organizations, ideas, religion, politics, and many other aspects, it is rooted in the notion that human creativity responds to these circumstances through the use of culture. It may be said, then, that anthropology is the study of culture. The ar-

chaeological emphasis examines human cultures over long time periods, mainly through the study of material remains.

The cultural anthropological perspective draws its materials from the direct study of contemporary peoples living in a wide range of circumstances, from peasant villagers, tropical forest hunters and gatherers, to urban populations in the US.

The Anthropology/Archaeology Program at M.I.T. offers students a broad exposure to the field. At the same time, the specialized research interests of its faculty permit students greater depth in certain areas. Members of the staff teach and conduct research on social and political organization, ecology, technology, and symbolic systems. Area interests tend to concentrate on studies of the New World, both highland cultures of Mexico and Peru as well as cultures of the tropical forest region of South and Central America. This focus includes contemporary groups and the ancient civilizations of the Andes and Mesoamerica. In addition, civilizations of the Mediterranean and ancient Near East are studied, particularly through their technological achievements.

Two fields of interest currently are being developed in collaboration with colleagues and students of other departments. One involves the study of the technological aspect of ancient cultures and is carried out together with colleagues in the Department of Materials Science and Engineering. The other deals with cross-cultural studies of nutrition in conjunction with the Department of Nutrition and Food Science. In both of these areas there are ongoing research projects in which students may participate by arrangement with the appropriate faculty members.

Foreign Languages and Literatures

Distribution Subjects

Field of Concentration

Major Programs: XXI-A; XXI-B, 1; XXI-B, 2

The Foreign Languages and Literatures Section offers a variety of programs. There are subject sequences in French, German, Greek, Russian, Spanish language and literature taught in the original; a subject sequence on literature taught in English translation; and a comprehensive program in English as a second language.

The study of a foreign language broadens one's cultural perspective, sharpens awareness of use and meaning of words in our own language, and increases one's range of expression. At M.I.T., students have the opportunity to bring their knowledge of a foreign language to the level at which they can not only speak fluently, but also read with pleasure. This skill, if preserved through use, will be an intellectual and personal asset throughout a lifetime, no matter what career a student pursues.

In the programs at M.I.T., introductory subjects aim to familiarize students with the basic principles of the language in both its spoken and written forms. Instruction includes reading of appropriate texts, practice in writing, and an introduction to the culture of the countries where the language is spoken. The intermediate level provides for review and refinement of grammar, study of more difficult reading matter with cultural and literary content, and compositions and discussions in the foreign language based on the reading material. Advanced subjects conducted in the foreign language stress analysis of the form and content of the literature and study of the culture and civilization of each country. A well-equipped language laboratory facilitates language learning.

Subjects in literature in translation make available in English great works from foreign literatures. These subjects enable students who do not know the original language to experience new avenues of thought, vision, and feeling. Although these subjects are given in English, students with a reading knowledge of a specific language will be encouraged to read works in the original. Courses in this sequence range from broad introductory subjects to more specific aspects of literary study.

Students may concentrate in any field of language and literatures. With respect to concentrations which include Foreign Language subjects, students should note that only subjects not lower than fourth-term language can be counted. Programs should be arranged on an individual basis in consultation with a designated advisor.

Major programs are offered (XXI-A, XXI-B, 1, XXI-B, 2) in French, German, Russian, and Spanish.

History

Distribution Subjects

Field of Concentration

Major Programs: XXI-A; XXI-B, 1; XXI-B, 2

Simply stated, history is the study of the recorded past — an accounting of human endeavor organized by period or by place. In fact, a compelling interest in the past almost always has been linked to a concern for the present, a shared sense of the need to reexamine contemporary values in terms of both continuity and change. The history curriculum at M.I.T., where technological and scientific change is so much stressed, is tailored to the study of transformations in society, especially modern society. The aim is to place the modern world in historical perspective; to show the scope of social and economic transformation in the re-

cent past; and to reflect on the fate of humane and ethical concerns within the context of technological imperatives. An effort is made to point out the role of traditional assumptions in present day politics, society, and culture; and to impart the skills needed to articulate this knowledge effectively.

The curriculum is centered in but not limited to modern American and European history, and is designed in sequence to encourage learning in progressively greater depth and complexity. In European history, for example, the offering includes a series of basic subjects which deal broadly and comparatively with specific historical periods; a series of subjects in national histories which stress particular institutional and cultural traditions; and a group of more advanced subjects which deal with the same material in terms of a single topical or methodological approach. The goal of such a program is solid grounding in historical fundamentals, as well as an exposure to specialized techniques of historical analysis. The American history program is constructed along the same lines, and there also are subjects in the history of non-Western areas which stress their links to the values and technology of the industrialized world. Such a program provides a coherent Concentration for the Humanities, Arts, and Social Sciences Requirement or a major in history in Course XXI. For history majors (XXI-A, XXI-B, 1, XXI-B, 2) the program is further enriched by tutorial work in historical methods, and an original research thesis closely supervised by a faculty member.

Literature

Distribution Subjects

Field of Concentration

Major Programs: XXI-A; XXI-B, 1, XXI-B, 2

The curriculum in literary studies at M.I.T., extensively revised for 1979-80, 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.

The literature offering is strong in American and modern subjects and in the diversity of its Humanities Distribution subjects. In 1979-80, subjects in film, the American novel, and American poetry will be offered for Humanities Distribution credit for the first time.

The curriculum is arranged in three categories or tiers: 1) **Introductory subjects** focus on major literary texts grouped in broad historical and generic sequences and specifically designed for students who want literary subjects for Humanities Distribution and also for students preparing for more advanced work in literature. 2) **Intermediate subjects**, some limited to students who have taken introductory subjects, explore literary forms in greater depth and in a somewhat more restricted range than subjects in the introductory tier and lay special emphasis on the shaping force of particular cultures and historical periods. 3) **Seminars** are restricted to students who have taken at least two previous subjects in literature and de-

Music, The Writing Program

mand considerable independent work, such as oral reports and other special projects. Enrollment in seminars is strictly limited to a maximum of 12 students.

Concentration programs in literature, meeting the Institute Requirement in Humanities, Arts, and Social Sciences, are available in a variety of combinations tailored to individual interests. The Literature Major, consistently recognized by professional and graduate schools as a desirable preparation, is offered both in combination with curricula in Engineering or Science (XXI-A and XXI-B, 1) and in a more intensive version (XXI-B, 2).

Music

Distribution Subjects

Field of Concentration

Major Programs: XXI-A; XXI-B, 1; XXI-B, 2

The Music Section offers a broad range of opportunities to experience and explore the field of music. A variety of subjects ranging from period and composer surveys to electronic music composition make up the subject offerings, with music theory and history forming the nucleus of study.

A symphony orchestra, choral groups, concert and jazz bands, and chamber music groups are an important part of M.I.T.'s cultural life and equally important to the music student's development, no matter what his or her technical proficiency. Academic credit is available for some performance-related subjects.

The music faculty comprises professional composers, performers, historians, and theorists, whose individual interest in the confluence of history, theory, and performance is central to an integrated music program.

A full major in music is available under Course XXI-B, 2. For students interested in combining the study of engineering or science with humanities, degree programs in Course XXI-A and XXI-B, 1 provide the opportunity to pursue special interests. Students wishing to enroll in any of these degree programs should present a proposal for a course of study to the Music Section no later than the beginning of their junior year.

The Writing Program

Distribution Subjects

Field of Concentration

Major Programs: XXI-A; XXI-B, 1; XXI-B, 2

The M.I.T. Writing Program provides students at the Institute opportunity to experiment with possibilities of writing as a craft and as a means of self-expression. The Program helps prepare students to communicate forcefully and clearly the results of their work to members of their professions and to larger audiences. All subjects in the Program's three categories — creative writing in poetry and fiction, 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 in a specified field or topic.

Some Writing Program subjects are tightly organized for students who want the discipline of directed study, while other subjects are structured to enable a student to follow his or her own initiative in selecting writing topics and forms of expression. In both kinds of classes, however, the student's writing receives considerable attention, advice, and encouragement. Many of the classes follow a workshop or seminar method.

Students may concentrate in Writing by selecting a program of four subjects. Concentrations may be developed in science and technical writing, essay writing, and in poetry or fiction. Writing Majors are designed so that students with a strong interest in writing may receive credit for a course of study which will be of use to them professionally as writers or as scientists and engineers whose writing is an important element of their careers. The Course XXI-A and B, 1, Option One Writing Majors require a combination of subjects in science or engineering, writing, and a related field of humanities or social science. A thesis also is required.

The Course XXI-B, 2 major in Writing and Literature is being revised, and students should contact the Course XXI Office and the Writing Program Office for information. Subjects in the Writing Program also may be used as one of the components of Course XXI-A and XXI-B, 1, Option Two.

Special and Interdisciplinary Programs

American Studies

Distribution Subjects

Concentration by Special Arrangement Major Programs: XXI-A; XXI-B, 1

American Studies at M.I.T. offers undergraduates the opportunity to organize subjects from various disciplines into coherent interdisciplinary programs, as a way of exploring different approaches to the study of society and culture and of gaining an integrated understanding of American society. By special arrangement, students can concentrate in American Studies in partial fulfillment of the Institute Requirement in Humanities, Arts, and Social Sciences; students who want this Concentration should consult first with the directors of Course XXI, Room 14N-305. Students can major in American Studies as part of the dual degree programs (Course XXI-A and Course XXI-B, 1) in the Department of Humanities. Both concentrators and majors will be referred to an American Studies advisor to work out a coherent and integrated program of study. American Studies is essentially a humanistic program. Concentrators are asked to take at least one subject in American literature and one in American history. Majors are asked to take at least two subjects in each of these fields. Other American Studies subjects may be drawn from the list of subjects offered outside the Department of Humanities.

Russian Studies

Distribution Subjects

Concentration by Special Arrangement Major Programs: XXI-A; XXI-B, 1

Russian Studies is an undergraduate humanities program of analytical, historical, and evaluative subjects about people with a tradition and form of life different from the American in ways that are now complementary, now competitive. With a focus on both the society

and the culture of a significant area of the world, this interdisciplinary and interdepartmental program is designed to make possible concrete exploration of important concerns of modern society, including tradition and radicalism; rural versus urban life; the place of imagination in historical change; industrialization, technology, and the expressivistic modern sensibility; and humanism and terror. The program may be used selectively (all students should make some study of history or politics together with some of literature) to fulfill the Concentration component of the Institute Requirement in Humanities, Arts, and Social Sciences. Students desiring this four-subject Concentration should consult first with the directors of Course XXI, Room 14N-305. Russian Studies is also available as a major in Programs XXI-A and XXI-B, 1. Readings and classes in all subjects are in English. Study of the Russian language is encouraged, however. Students may arrange language credits within the program and use their Russian within the subjects.

Drama Program

Distribution Subject 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 M.I.T. Dramashop and the Dance Workshop where students work and study with a professional staff who teach directing, acting, choreography, dance, aesthetics, scene design, costume design, stage lighting, makeup arts, and general scenecraft. Projects in the Dramashop are integrated with course work in the Literature Section of the Department of Humanities, where the thematic and literary content of the drama is discussed in the light of specific problems met and overcome in the process of mounting the plays in a theatre.

The object of the program is to deepen the student's knowledge of drama and performance and of its function within the society by exposing the student to the full range of theatre experience. Workshops in acting techniques, elements of dance, playwrighting, and experimental techniques are encouraged to supplement both the formal full-scale Dramashop productions and the more strictly literary reading subjects. Ultimately, the student should learn to recognize the theatre for what it has always been at its best: our culture's traditional laboratory of human motivation and character, a dynamic focal point within the community where our self-knowledge is tested and displayed.

Three subjects are required for a concentration in drama. Two must be chosen from the various literature offerings which concentrate on surveys of dramatic literature, theatre history, or specific major playwrights or dramatic movements. The other must be chosen from the available range of practical theatre arts courses in the curriculum. Each individual program is to be arranged in consultation with a field advisor. For information, please contact Professor Robert N. Scanlan, Room W16-018, (617) 253-2908.

 Associated Program

 The Western Tradition: Issues
and Texts

Distribution Subjects
Field of Concentration

This interdisciplinary program of the Department of Humanities offers subjects in major texts and issues in the intellectual and cultural traditions of the West. The subjects offered form a chronological sequence and include: the Bible, Greeks, Romans, the Medieval Period, the Renaissance, the Enlightenment, and the Modern Period. Our faculty is drawn from various fields (next year from History, Literature, Foreign Languages and Literatures, and Anthropology and Archaeology). Texts are drawn from literature, philosophy, and history as well as other fields, and the approach to them is non-specialist: Some experience of the historical method, the procedures of logic, and the tools of literary criticism occurs, but the emphasis is on first-hand encounter with the texts themselves. All subjects stress careful reading, and try, through directed discussion and attention to written work, to promote habits of perception and judgment, and to raise the question of cultural continuity: What is our own relation to the traditions of the Western past? Any one of these subjects may be used for Distribution. The Western Tradition is also a Field of Concentration. The Field Advisor is Professor Peter Donaldson.

 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 of the original languages. The chronological span of the program includes the 6,500 years between 5000 BC and 1350 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 to be taken in the medieval period by students whose focus is to be the Ancient World, or one in the ancient period by those whose focus is the Middle Ages. In either case, however, individual programs are to be 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.

 The Cambridge Humanities
Seminar

The Cambridge Humanities Seminar is a collaborative effort by universities in the Boston-Cambridge area to enrich and diversify their interdisciplinary offerings in the humanities at an advanced level. The program is centered at M.I.T. and offers subjects to students in the humanities at participating universities during the last two years of undergraduate and the first two years of graduate work in an area of scholarship periodically determined by its membership. The program currently involves faculty in literature, history, philosophy, and fine arts. Its current subject is the idea of the past as it plays a role in the study of various cultural activities. All subjects have limited enrollment. For further information please contact Professor Alvin C. Kibel, Room 14N-338, (617) 253-3581.

Degree Program Requirements

Bachelor of Science in Humanities and Engineering Course XXI-A; and Bachelor of Science in Humanities and Science Course XXI-B, Program 1

The major programs available under Courses XXI-A and XXI-B, 1 enable the student to combine humanistic studies with work in science or engineering, providing an educational experience of unusual scope and balance. There are two distinct paths by which the requirements for these degrees may be met.

Option One: In this version, groups of subjects from the humanistic and technical areas are conjoined in such a way as to emphasize centrally the basic command of each discipline, with or without an understood complementarity between them. One part is a selection from the undergraduate degree curriculum of a science or engineering department, or the Department of Psychology, usually omitting subjects of a more advanced or specialized nature. The other part consists of subjects in some field of the humanities, chosen by the student in consultation with a faculty advisor from one of the various disciplines of the Department of Humanities. Fields available include: Literature; Foreign Languages and Literatures (in French, German, Russian, or Spanish); History; Anthropology/Archaeology; Music; American Studies; Russian Studies; and Writing. A senior thesis (or, in some fields, a general examination) is required of all students in Option One.

In effect, Option One gives the opportunity to form a humanities major on a modest scale while allowing for continued serious commitment to a scientific or engineering interest. Some students may discover an interactive relationship between the two components, though this is not generally the program's central purpose.

Graduates of this option have gone on to advanced study in the humanities, engineering, and science, and into such professions as teaching, law, business, and medicine.

Option Two: This program is intended to integrate rigorous study in science or engineering with a systematic understanding of areas of humanistic knowledge. It offers a broad undergraduate education for students who are concerned with the social and cultural dimensions of science and technology and who plan to pursue careers in such fields as science, engineering, medicine, law, and management. Students in the program will be prepared for advanced work in technical and humanistic fields and in fields requiring a grasp of the relationship between the two kinds of knowledge.

Option Two is administered by the Department of Humanities in conjunction with faculty from the Program in Science, Technology, and Society. Students enrolled in the major are expected to acquire a solid foundation in the practice of science or engineering, to pursue a coherent sequence of humanistic subjects, and to integrate their humanistic and technical interests through a program of core subjects.

Two Reading Seminars, normally taken in either the sophomore or the junior year, provide a focus for the program's interdisciplinary orientation and a shared intellectual experience for all of its members. In addition, students are asked to take at least two subjects specifically chosen to increase their disciplined understanding of the relations between technical and humanistic fields of study. The remaining element in this program consists of a planned group of 10 electives centered around the student's individual interests.

Bachelor of Science in Humanities and Science Course XXI-B, Program 2

This program provides a full major in Foreign Languages and Literatures, History, Literature, Anthropology/Archaeology, Music, or Writing and Literature. Like XXI-A and XXI-B, 1, the program is based on the regular Institute requirements, but provides an opportunity to pursue a particular humanistic discipline in greater range and depth than do the other two programs. The required curriculum consists ordinarily of eight to ten subjects in a chosen field plus four subjects from a related field of humanities, social science, foreign literatures, linguistics, or visual arts. A generous number of electives makes it possible to continue work in science, engineering, humanities, or other fields, allowing students to increase their concentration in the chosen major discipline or to broaden intellectual interests by studies in fields outside the major program. Depending on the field of specialization, requirements may include seminars devoted to advanced study in the junior and senior years, and a thesis or general examination in the fourth year. Faculty counselors in each of the disciplines help students to arrange programs suitable to both their main lines of interest and future professional objectives.

Inquiries

Additional information concerning academic programs in the Department may be obtained from Professors Travis R. Merritt and Louis L. Bucciarelli, the Directors of Course XXI, Room 14N-305, M.I.T., Cambridge, Massachusetts 02139, (617) 253-4446.

Subjects in Humanities

(A) following the name of the subject indicates that it is an approved subject for a graduate degree and is given primarily for graduate students.

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| 21.U.R. Research in Humanities | 21.087 Twentieth-Century English and American Poetry | | Foreign Languages and Literatures |
| 21.Th.U. Undergraduate Thesis in Humanities | 21.088 Contemporary Literature | 21.211 French I | |
| 21.Ex Humanities General Examination | 21.101 The American Novel | 21.212 French II | |
| | 21.102 American Poetry | 21.213 French III | |
| | 21.103J Literature, Ideology and National Experience in the United States | 21.214 French IV | |
| | 21.105 American Voices | 21.215 French Reading, Intensive | |
| | 21.106 Literature and Lore of the American West | 21.217 French Conversation and Composition | |
| 21.001 Literature I | 21.107 Black American Literature | 21.218 French Civilization I | |
| 21.003 Introduction to Fiction | 21.112 Mark Twain | 21.219 French Civilization II | |
| 21.004 Major Poets, English and American | 21.113 Emerson and Thoreau | 21.220 Introduction to French Literature | |
| 21.005 Introduction to Drama | 21.118 American Drama | 21.221 Introduction to French Poetry | |
| 21.006 Introduction to American Literature | 21.120 Contemporary American Poetry | 21.222 French Film Classics | |
| 21.007 Forms of Western Narrative | 21.121 Modern Black Poetry | 21.223 French Literature in the 17th Century | |
| 21.009 Shakespeare | 21.140J The Study of Language | 21.224 Classical French Theatre: Corneille, Molière, Racine | |
| 21.021 Comedy | 21.141J Readings in Old and Middle English (A) | 21.225 The 18th-Century Novel: The Misadventures of Virtue | |
| 21.022 Tragedy | 21.142J Language and its Structure | 21.226 The French Novel in the 19th Century | |
| 21.023 The Short Story | 21.143J History of the English Language (A) | 21.227 The French Novel in the 20th Century | |
| 21.024 Autobiography | 21.150 Plays and Playwriting | 21.228 Contemporary French Drama | |
| 21.027 Utopian Literature | 21.151 Acting I | 21.229 The Adolescent in French Literature | |
| 21.030 Studies in Popular Narrative | 21.152 Acting II | 21.230 The Intellectual and Modern Society: Literature and Ideology | |
| 21.031 The Film Experience | 21.153 Theatre Arts: Elementary Stagecraft and Production Studies | 21.231 French Romanticism | |
| 21.032 American Television: A Cultural History | 21.154 Performance Workshop in Drama | 21.232 Seminar in French Literature | |
| 21.039 Fraternity in Literature | 21.155 Performance Workshop in Dance | 21.233 The Analysis of French Film Style: Jean Renoir and Marcel Carné | |
| 21.040 Literature by Women | 21.156 Design for the Performing Media | Wellesley French 250 | |
| 21.041 Women in Literature | 21.170 Literary Interpretation I | 21.240 German Review | |
| 21.045J Philosophy of the Arts | 21.171 Literary Interpretation II | 21.241 German I | |
| 21.046 Literature and History in Europe after the Industrial Revolution | 21.172 Advanced Studies in Fiction | 21.242 German II | |
| 21.060 Medieval Literature | 21.173 Advanced Studies in Drama | 21.243 German III | |
| 21.061 Chaucer | 21.174 Advanced Studies in Poetry | 21.244 German IV | |
| 21.063 Renaissance Literature: Magic and the Arts of Government | 21.175 T. S. Eliot and James Joyce | 21.245 German Reading, Intensive | |
| 21.064 English Renaissance Poetry: Wyatt to Milton | 21.180J Linguistics and Literary Study (A) | 21.247 Advanced German Conversation and Composition | |
| 21.070 Eighteenth-Century Literature | 21.198 Special Topics in Literature | 21.248 German Cultural and Social History I | |
| 21.071 Major English Novels | 21.199 Special Topics in Literature | 21.249 German Cultural and Social History II | |
| 21.076 English Romantic Poetry | | 21.251 Introduction to Literary Forms in German | |
| 21.078 The Realistic Novel | | 21.252 Introduction to German Poetry | |
| 21.079 Modern Russian Literature and its Historical Structure | | 21.255 Goethe: An Introduction | |
| 21.080 Dostoevsky, Tolstoi, Chekhov: Russia and the Modern Age | | 21.257 The German Romantic Novella | |
| 21.084 Victorians and Early Moderns | | | |
| 21.085 Twentieth-Century Fiction | | | |
| 21.086 Twentieth-Century Drama | | | |

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|---------|--|--------|--|---------|---|
| 21.258 | German Comedy | 21.313 | Advanced Spoken English: The Rhetoric of Lectures and Oral Presentations | 21.350 | History |
| 21.259 | Modern German Drama (1750 to the Present) | 21.315 | English as a Foreign Language: Expository Writing for Undergraduates | 21.351 | The Ancient World I: Ancient Near East and Greece |
| 21.260 | The Modern German Novel | 21.316 | English as a Foreign Language: Expository Writing Skills II | 21.352 | The Ancient World II: Rome |
| 21.261 | The World of Kafka | 21.317 | English as a Foreign Language: Scientific and Engineering Writing | 21.353 | The Middle Ages I |
| 21.263 | Challenges in Interpretation: Kleist-Kafka-Broch-Canetti | 21.318 | English as a Foreign Language: Workshop in Writing Research Papers and Reports | 21.356 | The Middle Ages II |
| 21.264 | Literature and Society in the German Democratic Republic | 21.324 | Pronunciation and Comprehension of American English Sounds | 21.357 | Modern World History I |
| 21.267J | Germanic Syntax (A) | 21.325 | Introduction to European Fictional Modes | 21.359 | Modern World History II |
| 21.271 | Classical Greek I | 21.327 | French Literature in Translation: The Search for Identity in an Alien World | 21.360 | Europe, 1763-1848: The Era of Revolutions |
| 21.272 | Classical Greek II | 21.329 | German Literature in Translation | 21.361 | Europe, 1848-1917: Unification, Consolidation and Conflict |
| 21.275 | Greek Literature I | 21.330 | The German Cinema | 21.365 | Europe, 1917-1948: The Era of Mass Politics |
| 21.276 | Greek Literature II | 21.331 | Civilization and Literature of Slavic Nations | 21.367 | The Renaissance in Italy |
| 21.277 | Greek Literature III | 21.332 | Russian Novel of the 19th Century | 21.368 | Ideas of Progress |
| 21.278 | Greek Literature IV | 21.335 | Soviet Literature and Moral Issues | 21.370 | Darwinism and Culture |
| 21.280 | Russian Review | 21.336 | Seminar on Tolstoy's War and Peace | 21.372 | Anarchism |
| 21.281 | Russian I | 21.337 | Seminar on the Prose of A. Solzhenitsyn | 21.372 | France 1789-1969: From the Revolution to Charles de Gaulle |
| 21.282 | Russian II | 21.338 | Religious Trends in Soviet Thought and Literature | 21.374 | Vienna and Versailles |
| 21.283 | Russian III | 21.339 | Russian Avant-Garde: Visual Arts, Literature | 21.376 | Imperial and Revolutionary Russia: Culture and Politics |
| 21.284 | Russian IIIA | 21.344 | The Avant-Garde Theatre in the 20th Century | 21.377 | The Soviet Union: A Communist Society in Historical Perspective |
| 21.285 | Russian IIIB | 21.345 | Evil and Decadence in Literature | 21.379 | Spanish Civil War: 1936-39 |
| 21.286 | Russian IV | 21.347 | Senior Seminar for Majors in Foreign Languages and Literature | 21.381 | The Origins of World War II |
| 21.287 | Advanced Spoken and Written Russian | 21.348 | Special Topics in Foreign Languages and Literatures | 21.383 | Revolution in the 20th Century |
| 21.288 | Russian Culture and Civilization | 21.349 | Special Topics in Foreign Languages and Literatures | 21.385 | War and the Military Institutions of the Modern State |
| 21.289 | Introduction to Russian Literature I | | | 21.390 | American History to 1865 |
| 21.290 | Introduction to Russian Literature II | | | 21.391 | American History since 1865 |
| 21.291 | Studies in Russian Prose: Gogol | | | 21.400 | Early America: From the Puritans to the Revolution |
| 21.292 | Contemporary Russian Prose and Poetry | | | 21.401 | The American Revolution |
| 21.295 | Spanish I | | | 21.402 | The Establishment of the American Republic, 1790-1850 |
| 21.296 | Spanish II | | | 21.404 | America in the Progressive Era, 1877-1917 |
| 21.297 | Spanish III | | | 21.405 | America in the Twenties and Thirties, 1917-1941 |
| 21.298 | Spanish IV | | | 21.406 | America since World War II, 1941 to the Present |
| 21.299 | Advanced Spanish Conversation and Composition | | | 21.410 | American Intellectual History: The Classical Age |
| 21.304 | Contemporary Hispanic Literature | | | 21.411 | American Intellectual History: The Modern Age |
| 21.305 | The Novel in Spain | | | 21.412J | American Urban History |
| 21.306 | Literature and Social Conflict: Perspectives on Spain 1820-Present | | | 21.413J | American Urban History |
| 21.307 | Latin American Literature from Independence to the Present | | | 21.418 | The American South: Portrait in Black and White I |
| 21.310 | Intensive Review of English Language Skills | | | 21.419 | The American South: Portrait in Black and White II |
| 21.311 | Advanced English Structure | | | 21.431 | Thomas Jefferson and His Age |
| 21.312 | Vocabulary Development, Reading and Discussion | | | | |

| | | Anthropology/Archaeology | Music |
|---------|--|---------------------------------|--------------|
| 21.433J | Industrialization and Cultural Change in 19th-Century America | 21.50 | 21.60 |
| 21.435 | Color, Class and Social Stratification in the Black Community | 21.501 | 21.601 |
| 21.436 | Racism, Sexism and Nativism in American Society | 21.502 | 21.602 |
| 21.438J | Modern Social Movements and Mass Phenomena in Historical Perspective | 21.503 | 21.603 |
| 21.439 | Fortress America: the Rise of the American Military, 1945-1975 | 21.510 | 21.611 |
| 21.441 | Youth Movements | 21.511 | 21.612 |
| 21.447 | Topics in 19th-Century American Social History | 21.512 | 21.613 |
| 21.449 | Seminar in American Studies | 21.523 | 21.614 |
| 21.450 | The History of Africa | 21.541J | 21.620 |
| 21.451J | Nationalism and Nation Building in 20th-Century Africa | 21.544 | 21.621 |
| 21.452 | Comparative African Politics: Crises in Southern Africa | 21.545 | 21.622 |
| 21.453J | Race Relations, Politics and Development in the Caribbean (A) | 21.550 | 21.623 |
| 21.455J | Third World: History, Politics, and Literature | 21.552 | 21.624 |
| 21.456 | Explorers and Exploration: Accomplishments, Motives, and Methods | 21.553 | 21.625 |
| 21.457J | Research Seminar in Imperialism and Colonialism (A) | 21.554 | 21.626 |
| 21.458 | China, Japan, and the West | 21.555 | 21.627 |
| 21.460 | Special Topics in History | 21.559 | 21.628 |
| 21.461 | Special Topics in History | 21.580 | 21.629 |
| | | 21.583J | 21.640 |
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| The Western Tradition: Issues and Texts | | The Writing Program | Special Interdisciplinary Subjects |
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| 21.710 | The Bible and Western Tradition | 21.725 Writing and Experience I | 21.901J Reading Seminar in Humanities, Science, and Technology I |
| 21.711 | The Greeks | 21.726 Writing and Experience II | 21.902J Reading Seminar in Humanities, Science, and Technology II |
| 21.712 | Roman Humanism | 21.727 Expository Writing | 21.913 Marx and Marxism |
| 21.713 | Major Medieval Texts | 21.728 Writing: Meaning and Expression | 21.914 Sports and Physical Training |
| 21.714 | The Renaissance in the North and the Reformation | 21.729 The Writing of Prose I | 21.915 Intellectuals and Social Change |
| 21.715 | The Enlightenment: The Isolated Individual | 21.730 The Writing of Prose II | 21.916 Contemporary Issues in Politics and Ideology |
| 21.716 | Romanticism | 21.731 Writing Workshop | 21.917 Seminar I: International Students and Participation in Development |
| 21.717 | The Modern Period: 1900-1970 | 21.732 Fiction Workshop | 21.918 Seminar II: International Students and Participation in Development |
| | | 21.733 The Writing of Poetry I | 21.919J The Finite Earth: Agendas for a More Just, Sustainable and Participatory Society |
| | | 21.734 Poetry Workshop | Wellesley Religion 108 |
| | | 21.735 The Writing of Poetry II | 21.930 Greek Philosophy and Science: The Presocratics, Plato and Aristotle |
| | | 21.736 Prose and Poetry in Experimental Forms | 21.932 Being and Nothingness |
| | | 21.737 Writing and Reading Short Stories | 21.933 Being and Time: I |
| | | 21.738 Writing and Reading the Essay | 21.934 Being and Time: II |
| | | 21.739 The Writing and Reading of Autobiography | 21.940 Rhetoric and Journalism |
| | | 21.740 Descriptions of Society | 21.953J Cognitive Aspects of Musical Development and Learning (A) |
| | | 21.741 Special Seminar in Poetry Writing | 21.955J Seminar on the Structure of Musical Time |
| | | 21.742 Advanced Science Writing | 21.956J Aesthetics |
| | | 21.743 Science Writing for the Public | 21.961J Education and Society I (A) |
| | | 21.744 Science Writing Workshop | 21.965J Seminar on Astronomy and Archaic Mythology |
| | | 21.745 Science Writing Internship | 21.972 The Culture of Technology in Contemporary America |
| | | 21.746 The Essay in Science | 21.978 Culture, Science and Technology in the Non-White Communities |
| | | 21.747 Scientific and Engineering Writing | 21.980 Painters and Philosophical Issues in Modernism |
| | | 21.748 Naturalist Writing | 21.981 On Quality in Art |
| | | 21.750J Writing about Work | 21.988 Concourse Topics in Literature |
| | | 21.751 Writing the Metropolis: The City in Germany and America | 21.989 Concourse Topics in Writing |
| | | 21.755 Writing and Television | 21.991 Special Topics in Interdisciplinary Studies |
| | | 21.756 Special Topics in Writing and Literature | 21.992 Special Topics in Interdisciplinary Studies |
| | | 21.757 Special Topics in Writing and Literature | |

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

George Stephen Boolos, Ph.D.
Professor of Philosophy
(Absent, spring)

Joan Wanda Bresnan, Ph.D.
Professor of Linguistics

Sylvain Bromberger, Ph.D.
Professor of Philosophy

Richard Lee Gartwright, Ph.D.
Professor of Philosophy
Associate Chairman of the Faculty
Acting Head, Department
of Humanities

Noam Avram Chomsky, Ph.D.
Institute Professor
Professor of Linguistics

Jerry Alan Fodor, Ph.D.
Professor of Philosophy
and Psycholinguistics
(Absent, fall)

Kenneth L. Hale, Ph.D.
Professor of Linguistics

Morris Halle, Ph.D.
Ferrari P. Ward Professor of
Modern Languages and Linguistics

James Wesley Harris, Ph.D.
Professor of Spanish and
Linguistics

René Paul Viktor Kiparsky, Ph.D.
Professor of Linguistics

Thomas S. Kuhn, Ph.D.
Professor of Philosophy
and History of Science

Wayne O'Neil, Ph.D.
Professor of Literature

John Robert Ross, Ph.D.
Professor of Linguistics

Irving Singer, Ph.D.
Professor of Philosophy

James Frederick Thomson, M.A.
Professor of Philosophy
(Absent, fall)

Judith Jarvis Thomson, Ph.D.
Professor of Philosophy

Associate Professor

Ned Joel Block, Ph.D.
Associate Professor of Philosophy

Assistant Professors

Joshua Cohen, Ph.D.
Assistant Professor of Philosophy
and Political Science

Judith Wagner DeCew, Ph.D.
Assistant Professor of Philosophy

Barbara Herman, Ph.D.
Assistant Professor of Philosophy

Paul Horwich, Ph.D.
Assistant Professor of Philosophy

Edwin William McCann, Ph.D.
Assistant Professor of Philosophy
(Absent)

Administrative Officer

Marilyn Matthes Silva, A.B.

Professor Emeritus

Roman Jakobson, Ph.D.
Institute Professor, Emeritus

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.

Bachelor of Science in Philosophy Course XXIV

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 linguistic 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.

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 also must 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); 3) academic work of high quality in mathematics, the natural sciences, philosophy, psychology, history, linguistics, theory of literature; and 4) work experience in a relevant area, especially if it required considerable application, imagination, or ingenuity.

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 and to pass general examinations demonstrating competence in three of the following four areas: metaphysics and epistemology; value theory; philosophy of logic, language, science, and mathematics; and the history of philosophy.

Candidates for the doctorate may take a minor in a field other than philosophy. Possibilities include linguistics, mathematics, physics, psychology, computer science, and other humanities or other social sciences. There is no general language requirement for the doctorate, except in those cases in which competence in one or another foreign language is needed to carry on research for the dissertation.

Inquiries

Information regarding undergraduate or graduate academic programs, research activities, admissions, financial aid, assistantships, etc. may be obtained from the Department of Linguistics and Philosophy, Room 20D-105, M.I.T., Cambridge, Massachusetts 02139, (617) 253-4141.

Subjects in Linguistics and Philosophy

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| (A) following the name of the subject indicates that it is an approved subject for a graduate degree and is given primarily for graduate students. | 24.301- Reading Seminar in | 24.933J History of the English Language (A) |
| 24.U.R. Undergraduate Research | 24.302 Philosophy | 24.936J Germanic Syntax (A) |
| 24.01 Contemporary Moral Issues | 24.401 Plato's Later Dialogues (A) | 24.941 Topics in the Grammar of a |
| 24.02 Philosophy of Art: Classic and Contemporary | 24.403 Aristotle (A) | Non-Indo-European Language (A) |
| 24.03 Logic, Language and Values | 24.410 Topics in the History of | 24.942 Topics in the Grammar of a |
| 24.04 Problems of Philosophy | Philosophy (A) | Non-Indo-European Language (A) |
| 24.05 Science and Philosophy | 24.421 Background of Contemporary | 24.943 Studies in American Indian |
| 24.06 Philosophy of Plato | Philosophy (A) | Linguistics (A) |
| 24.07 Classics in the History | 24.425 Philosophy of G. Frege (A) | 24.944 Studies in American Indian |
| of Philosophy | 24.501 Problems in Metaphysics (A) | Linguistics (A) |
| 24.08 Existentialism and Phenomenology | 24.511 Problems in Theory of Knowledge | 24.945 Language Typology (A) |
| 24.09 Freedom and Authority | (A) | 24.946 Workshop in Linguistics |
| 24.112 Modern Social Theory | 24.513 Phenomenology (A) | and Education (A) |
| 24.114 Concepts of Love in the Western | 24.517J Cognitive Theories (A) | 24.947 Syntax and Mental |
| World | 24.518 Philosophy of Mind | Representation (A) |
| 24.115 Concepts of Genetic Determination | and Psychology (A) | 24.951 Introduction to Linguistics I: |
| 24.117 Philosophy of Mind and | 24.521 Topics in Philosophy of Mind (A) | Syntax |
| Psychology | 24.525 Topics in the Theory of Action (A) | 24.952 Introduction to Linguistics III: |
| 24.119 Minds and Machines | 24.601 Topics in Moral Philosophy (A) | Theory of Grammar (A) |
| 24.121J Philosophy of the Arts | 24.602 Seminar on Moral Psychology (A) | 24.953 Advanced Grammar I (A) |
| 24.151 Introduction to Philosophy of | 24.603 Twentieth-Century Ethics (A) | 24.954 Advanced Grammar II (A) |
| Language | 24.611J Topics in Political Philosophy (A) | 24.955 Computational Psycholinguistics: |
| 24.161 Classics in the Philosophy | 24.621 Aesthetics (A) | The Syntactic Component (A) |
| of Science | 24.701 Topics in Logic (A) | 24.956 Introduction to Linguistics IV: |
| 24.200 Ancient Philosophy | 24.703 Set Theory (A) | Universal Grammar (A) |
| 24.201 Medieval Philosophy | 24.711 Philosophy of Logic (A) | 24.957 Introduction to Linguistic Theory |
| 24.202 Modern Philosophy: | 24.712 Algorithms, Grammars, and | at an Advanced Level (A) |
| Descartes to Kant | Syntax (A) | 24.958 Linguistic Structure (A) |
| 24.206 Continental Philosophy: Romanticism | 24.721 Reference (A) | 24.959 Workshop in Syntax (A) |
| and Existentialism | 24.725 Meaning (A) | 24.961 Introduction to Linguistics II: |
| 24.208 Wittgenstein | 24.727 Logic and Language (A) | Phonology |
| 24.211 Theory of Knowledge | 24.801 Philosophy of Mathematics (A) | 24.962 Advanced Phonology (A) |
| 24.221 Metaphysics | 24.811 Philosophy of Physics (A) | 24.963 Studies in Indo-European |
| 24.223 Philosophy of Mind | 24.831 Topics in Philosophy of | Accentology (A) |
| 24.231 Ethics | Psychology (A) | 24.964 Theory of Phonology |
| 24.233J Political Philosophy | 24.851 Problems of Explanation and | 24.966J Laboratory on the Physiology, |
| 24.235 Philosophy of Law | Theory Formation (A) | Acoustics and Perception of |
| 24.241 Symbolic Logic | 24.852 Topics in Scientific | Speech (A) |
| 24.251 Philosophy of Science | Method (A) | 24.968J Speech Communication (A) |
| 24.253 Induction and Probability | 24.853 Philosophy of Scientific | 24.969 Workshop in Phonology (A) |
| 24.261 Philosophy of Religion | Development (A) | 24.972 Mathematical Models in |
| 24.270J Topics in the History of | 24.891 Special Graduate Topics in | Linguistics (A) |
| Physical Science | Philosophy | 24.982 Linguistic Change (A) |
| 24.271 Phenomenology | 24.892 Special Graduate Topics in | 24.985J Serial and Temporal Factors |
| 24.292 Special Topics in Philosophy | Philosophy | in Language Processing (A) |
| 24.293 Special Topics in Philosophy | 24.900J The Study of Language | 24.992 Survey of General Linguistics I (A) |
| | 24.901J Language and Its Structure | 24.993 Tutorial in Linguistics and |
| | 24.903J Language and Culture | Related Fields (A) |
| | 24.905 Seminar on Poetic Form | |
| | 24.906J Linguistics and Literary Study (A) | |
| | 24.908J Readings in Old and Middle | |
| | English (A) | |
| | 24.921 Special Graduate Topics in | |
| | Linguistics (A) | |
| | 24.922 Special Graduate Topics in | |
| | Linguistics (A) | |
| | 24.931 Linguistic Structures: Romance (A) | |

Department of Political Science

Alan Anthony Altshuler, Ph.D.
Professor of Political Science and
Urban Studies and Planning
Head of the Department

Professors

Hayward Rose Alker, Jr., Ph.D.
Professor of Political Science

Suzanne Berger, Ph.D.
Professor of Political Science
(Absent)

Donald Laurence Morton
Blackmer, Ph.D.
Professor of Political Science
Associate Dean, School of
Humanities and Social Science
Director, Program in Science,
Technology, and Society

Lincoln Palmer Bloomfield, Ph.D.
Professor of Political Science

Walter Dean Burnham, Ph.D.
Professor of Political Science
(Absent)

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
(Absent, fall)

William Weed Kaufmann, Ph.D.
Professor of Political Science

Daniel Lerner, Ph.D.
Professor of Sociology
(Absent)

Michael Lipsky, Ph.D.
Professor of Political Science

Ithiel de Sola Pool, Ph.D.
Arthur and Ruth Sloan Professor
of Political Science

Lucian Wilmot Pye, Ph.D.
Ford International Professor
of Political Science
(Absent)

George William Rathjens, Ph.D.
Professor of Political Science
(Absent, spring)

Robert Irwin Rotberg, D.Phil.
Professor of History and Political
Science

Harvey Morton Sapolsky, Ph.D.
Professor of Public Policy
and Organization

Eugene Bertram Skolnikoff, Ph.D.
Professor of Political Science
Director, Center for International
Studies

Myron Weiner, Ph.D.
Ford Professor of Political Science

Associate Professors

Lloyd Stanley Etheredge, Ph.D.
Associate Professor of Political
Science

Ted Ronald Ivan Greenwood, Ph.D.
Associate Professor of Political
Science

Martha Wagner Weinberg, Ph.D.
Associate Professor of Political
Science

Langdon Winner, Ph.D.
Associate Professor of Technology
Studies and Political Science

Assistant Professors

Joshua Cohen, Ph.D.
Assistant Professor of Philosophy
and Political Science

Emma Jackson, Ph.D.
Assistant Professor of Political
Science

Deborah Anne Stone, Ph.D.
Assistant Professor of Political
Science

Senior Lecturers

Edwin Diamond, M.A.
Louis Menand III, Ph.D.

Lecturers

Stephen M. Meyer, Ph.D.
Joel Yellin, Ph.D.

Visiting Lecturer

Richard J. Greene, Ph.D.

Administrative Officer

Elizabeth Terlingen Merkle,
Pharm.

Instructor

Albert Thomas Ferguson, Jr., A.M.

Professors Emeriti

Everett Hagen, Ph.D.
Professor of Economics and
Political Science, Emeritus

Harold Robert Isaacs, A.B.
Professor of Political Science,
Emeritus

Norman Judson Padelford, Ph.D.
LL.D.
Professor of Political Science,
Emeritus

Department of Political Science

Undergraduate Study

Political science is concerned with the systematic study of government and the political process. Within the discipline, scholars analyze the development, distribution, and uses of political power; the determinants and consequences of various forms of political behavior and sources of political conflict; the ways in which conflicts are both intensified and resolved; and the relationship between the individual and the state. It is a discipline of special interest to scientists and engineers who must understand the political system within which they live in order to evaluate their influence upon that system, as well as to those students who are considering careers in public service or university teaching and research.

The Department has a research-oriented faculty which welcomes the association of both undergraduate and graduate students in ongoing research. Among the major features of the Department are: 1) an emphasis on empirical methods and research training, 2) a concern with issues of public policy, particularly in the areas of arm 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 17.26J or 17.63. Through the Washington and Boston Internship Program, students may work in Congress, the 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 will want to focus on political systems themselves; others will 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 (numbered 17.01-17.69) 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 17.69 Pre-thesis 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.

Graduate Study

Bachelor of Science in Political Science: Public Policy Course XVII-A

The Department has developed a major field of study for students who wish to combine the study of politics with the study of substantive social and technical problems, policy options, and change strategies. It focuses on the ways in which political and non-political factors combine to shape policy choices, implementation strategies, and ultimate policy outcomes.

Students who major in public policy studies will take subjects on disciplinary approaches to the study of public policy; process approaches to policy formulation, implementation, or evaluation; and one subject on a substantive policy area. They will complete an internship in a public sector agency, either in conjunction with course work, the summer intern program, or other appropriate work experience. Expertise in a substantive policy area or an aspect of policy studies must be developed through course work and exhibited through the pre-thesis and thesis courses.

The Department of Political Science offers work leading to the Master of Science in Political Science and the Doctor of Philosophy.

Entrance Requirements for Graduate Study

The Department specifies as prerequisites for graduate study in political science at least six term subjects in English, history, and other humanities or social science subjects equivalent in scope to those included in the undergraduate curriculum of the Institute. Except for a recommended upper-level year subject on the history of political thought, these subjects normally should be in other than the candidate's own professional field.

Master of Science in Political Science

The Master of Science is particularly intended for students concerned with developing skills in applied research and those seeking careers in public service. The master's program emphasizes intensive preparation in a single field of study. The Department offers special concentrations at the master's level in the fields of arms control and defense analysis, and science and public policy, although other fields may be offered by special arrangement. Students seeking admission as master's candidates should state the field in which they intend to concentrate and outline their proposed course of study. Subjects to be included in the student's program need not be restricted to those offered within the Department, but the entire program must meet with the approval of the student's advisory board. The general requirements for the S.M. are described in Chapter IV of this catalogue.

Accelerated Master of Science in Political Science

The Department offers a five-year program leading to the Bachelor of Science and Master of Science, awarded simultaneously. This program is open to M.I.T. 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 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

Subjects in Political Science

jointly with the Department of Urban Studies and Planning, and a program in international planning is offered with the International Nutrition Program. There are also a variety of joint M.I.T.-Harvard University teaching programs in subjects such as Analysis of Complex Systems, West European Studies, and the field of political demography.

Programs of study logically combining advanced work in some scientific or engineering fields with political science will be welcomed. 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 supported by the Department and through M.I.T.-affiliated research facilities such as the Center for International Studies, the Harvard-M.I.T. 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, Room E53-470, M.I.T., Cambridge, Massachusetts 02139, (617) 253-5262.

(A) following the name of the subject indicates that it is an approved subject for a graduate degree and is given primarily for graduate students.

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| 17.U.R. | Undergraduate Research | 17.40J | Legal, Ethical and Scientific Issues in the Regulation of Dangerous Industries |
| 17.01 | Political Science Laboratory | 17.41 | Science, Technology and Politics |
| 17.02 | Human Nature and Public Policy | 17.42J | Theories of Technological Society and Politics |
| 17.03J | Value, Choice and Risk in Modern Technology | 17.43 | Determinants of Strategic Nuclear Forces |
| 17.05 | The Quest for Equality and Development in Third World Countries | 17.44 | Determinants of General Purpose Forces |
| 17.07 | Aggression, War and Civilization | 17.45J | In Pursuit of Arms Control: Analysis of the Past and Choices for the Future |
| 17.08 | American Politics and Social Change | 17.46 | Arms Trade and Foreign Policy |
| 17.09J | Politics and Public Policy | 17.48J | Nutrition, National Development and Planning |
| 17.12 | Formal Logics and Political Arguments | 17.49 | Mass Politics in Latin America |
| 17.13 | Socialism | 17.50 | Political Crises in South Asia: India, Pakistan, and Bangladesh |
| 17.14 | Revolution and the Theory of Politics | 17.52 | Communist China |
| 17.15J | Political Philosophy | 17.53 | Political and Economic Development of Tropical Africa |
| 17.16J | Knowledge and Analysis for Public Policy Decisions | 17.54J | Nationalism and Nation Building in 20th-Century Africa |
| 17.18 | Introduction to Political Theory: Individual and Community | 17.55J | Third World: History, Politics, and Literature |
| 17.19 | Modern Political Theory: Democracy and Freedom | 17.56 | International Relations: War and Peace |
| 17.20 | The Evolution of American Politics | 17.57 | American Foreign Policy in a Changing World |
| 17.21 | Introduction to the American Political Process | 17.58 | Seminar in Middle Eastern Politics |
| 17.22 | Political Parties | 17.60 | Collective Decision Making |
| 17.23 | The Supreme Court and Constitutional Processes | 17.61 | The Design of Regulatory Policy: Health and the Environment |
| 17.24 | Politics, Television, and the News | 17.62 | Comparative Social Policy |
| 17.25 | Bureaucracy and Public Policy | 17.63 | Media and Public Policy Internships |
| 17.26J | State and Local Government Internships | 17.64 | Politics of Environmental Policy |
| 17.27 | Media and Public Policy | 17.65J | Distribution of Income and Employment Opportunity |
| 17.28 | Congress and the American Political System | 17.66- | Reading Seminar in Social Science |
| 17.29 | Executive Leadership: Presidents, Governors, and Mayors | 17.67 | Independent Undergraduate Research |
| 17.30 | Workshop in Cable Television | 17.69 | Pre-thesis Reading Seminar |
| 17.31 | Urban Politics | 17.701 | Public Opinion and Propaganda (A) |
| 17.32J | Politics, Planning and Urban Policy | 17.705 | Mass Media and Communication Systems (A) |
| 17.33 | Ideology and Participation in Black American Politics | 17.727 | Political Culture (A) |
| 17.35 | Political Economy of Urbanization | 17.729 | Executive Branch Learning |
| 17.36 | Politics of Urban Education | 17.730 | Identity and Ideology (A) |
| 17.39 | Seminar on Health Policy | 17.731 | Graduate Seminar in Normative Political Psychology (A) |

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|---------|--|---------|--|---------|--|
| 17.732 | Topics in Political Economy and Political Sociology | 17.825 | Radical and Revolutionary Ideologies (A) | 17.899 | Research: International Relations and Foreign Policy (A) |
| 17.743 | Graduate Seminar in American Politics (A) | 17.830 | Development of Strategic Nuclear Forces (A) | 17.915 | Theories of Political Development (A) |
| 17.744 | Federal Programs and City Politics (A) | 17.832 | Development of General Purpose Forces (A) | 17.917 | Migration and Political Development (A) |
| 17.745 | Dynamics of Electoral Politics (A) | 17.835 | Defense Issues and Budgets (A) | 17.918J | Nutrition Policy and Planning in Selected Countries (A) |
| 17.746 | Collective Decision Making (A) | 17.838 | Principles of Systematic Policy Analysis (A) | 17.920 | Field Research in Political Development (A) |
| 17.747 | Research Seminar on Congress (A) | 17.841J | The Technology and Politics of Nuclear Weapons and Arms Control (A) | 17.921J | International Food and Nutrition Policy (A) |
| 17.748 | Black Politics in America (A) | 17.850 | Science, Technology and the State (A) | 17.927 | Field Seminar: Politics of Development and Underdevelopment (A) |
| 17.749 | Seminar on the Evolution of American Politics (A) | 17.851 | The Domestic and International Politics of Energy (A) | 17.928 | Politics of Development and Underdevelopment in Africa (A) |
| 17.750J | The Policy-Making Process (A) | 17.854J | Comparative Health Systems (A) | 17.929J | The Finite Earth: Agendas for a More Just, Sustainable and Participatory Society |
| 17.751J | Comparative Topics in Administrative Practice (A) | 17.855J | Analytical Methods for Health Policy and Management (A) | 17.940 | Basic Concepts of the Social Sciences (A) |
| 17.752 | Executive Leadership: Presidents, Governors, and Mayors in the US (A) | 17.857 | The Design of Regulatory Policy: Health and the Environment | 17.945J | Political Economy I: Theories of the State and the Economy (A) |
| 17.753 | Seminar on Domestic Policy Origins and Outcomes (A) | 17.860 | Topics in the Public Management of Science and Technology (A) | 17.946J | Modern Social Theory (A) |
| 17.759 | Research Seminar on Bureaucratic Politics and Institutional Analysis (A) | 17.861 | Seminar in Systematic Policy Analysis and Technology Assessment (A) | 17.947 | Political Philosophy (A) |
| 17.760 | Comparative Asian Politics (A) | 17.862 | Theories of Technological Society and Politics (A) | 17.948J | Topics in Political Philosophy (A) |
| 17.765 | Chinese Politics (A) | 17.865 | International Organization, Legal and Political Response to Science and Technology (A) | 17.950 | Concept Formation and Research Technique in the Social Sciences (A) |
| 17.767 | Political Development in South Asia (A) | 17.867 | Transfer and Adaptation of Technology in Developing Countries (A) | 17.952 | Statistics for the Social Sciences |
| 17.771 | Comparative Afro-American and African Politics (A) | 17.875 | Field Seminar in Science and Public Policy (A) | 17.955 | Introduction to Mathematical Models in the Social Sciences (A) |
| 17.772 | Nationalism and Nation Building in 20th-Century Africa | 17.880 | Theories of International Relations (A) | 17.957 | The Uses of Multi-Purpose Programming Languages in the Social Sciences (A) |
| 17.773 | Comparative African Politics: Crises in Southern Africa (A) | 17.881 | World Politics and International Economics (A) | 17.973 | Multivariate Political Analysis (A) |
| 17.775 | African Philosophy and Political Thought (A) | 17.885 | United States-Latin American Relations | 17.975 | Seminar on Complex Models of Social Systems (A) |
| 17.780 | Theories and Approaches to the Study of Comparative Politics (A) | 17.890 | Comparative Foreign Policy (A) | 17.976 | Advanced Topics in Statistical Modeling (A) |
| 17.782J | Race Relations, Politics and Development in the Caribbean (A) | 17.892J | International Air Transportation | 17.980 | Seminar in Urban Politics (A) |
| 17.783 | Comparative Politics of Latin America (A) | 17.893J | Research Seminar in Imperialism and Colonialism (A) | 17.982J | Urban Politics, Planning and Public Policy (A) |
| 17.784 | Politics of Mexican Development | 17.894 | The Politics of the Middle East (A) | 17.987 | Urban Bureaucracy and Public Employees (A) |
| 17.790 | Domestic Politics of Western Europe (A) | 17.895 | US Foreign Policy — Past, Present, Future (A) | 17.988 | Community Development in Urban Ghettos (A) |
| 17.793 | Research Seminar in Comparative Politics: Western Europe (A) | 17.896 | Comparative African Politics: Research Seminar (A) | 17.989 | Comparative Urban Politics (A) |
| 17.794 | Topics in the Sociology of Bureaucracy (A) | 17.897 | The Foreign Policy Process (A) | 17.990 | Political Economy of Urbanization (A) |
| 17.795 | Comparative Social Policy (A) | 17.898 | Field Seminar in International Relations and Foreign Policy (A) | 17.992 | Field Seminar in Urban Studies (A) |
| 17.801 | Soviet Communism (A) | | | 17.995- | Reading Seminar in Social Science (A) |
| 17.805 | Soviet and Chinese Foreign Policy and the Communist World (A) | | | 17.999 | |
| 17.820 | The Politics of Communist States and Parties in Eastern and Western Europe (A) | | | | |

Department of Psychology

Richard M. Held, Ph.D.
Professor of Experimental
Psychology
Head of the Department

Professors

Emilio Bizzi, M.D.
Professor of Neurophysiology

Stephan Lewis Chorover, Ph.D.
Professor of Psychology

Jerry Alan Fodor, Ph.D.
Professor of Philosophy and
Psycholinguistics
(Absent, fall)

Merrill Frederick Garrett, Ph.D.
Professor of Psychology

Norman Geschwind, M.D.
Professor, Harvard-M.I.T. Division of
Health Sciences and Technology
Professor of Psychology

Alan Hein, Ph.D.
Professor of Psychology

Walle Jetze Harinx Nauta, M.D.,
Ph.D.
Professor of Neuroanatomy
Institute Professor

Whitman Albin Richards, Ph.D.
Professor of Psychophysics

Peter Harkai Schiller, Ph.D.
Professor of Psychology

Gerald Edward Schneider, Ph.D.
Professor of Psychology

Associate Professors

Susan Carey, Ph.D.
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Ann M. Graybiel, Ph.D.
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and Brain Science

David C. Marr, Ph.D.
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Daniel N. Osherson, Ph.D.
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and Psychology

Mary Crawford Potter, Ph.D.
Associate Professor of Psychology

Technical Instructors

Henry Hall, S.B.
Diane Major
John Bruce Swan, A.E.

Principal Research Scientists

Suzanne H. Corkin, Ph.D.
Barbara Sakitt, Ph.D.
Edward C. T. Walker, Ph.D.

Research Associates/Scientists

Joseph Aloysius Bauer, Jr., M.S.
Rhea Diamond Gendzier, Ph.D.
Neville Hogan, Ph.D.
John Hollerbach, Ph.D.
David O. Pettijohn, M.S.
Kent Stevens, Ph.D.
Edith Vioni Sullivan, Ph.D.

Visiting Scientist

William Chapple, Ph.D.

Postdoctoral Associates

Jane Gwiazda, Ph.D.
Andrés C. Polit, Ph.D.
Joseph W. Thomas, Ph.D.

Administrative Officer

Diane McLaughlin, A.B., M.B.A.

Administrator for Academic Programs

Eva-Maria Ritter

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 M.I.T. stresses the connections with basic science and concentrates its efforts on the search for new knowledge in three distinct but inter-related 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). Instruction in psychology on all levels, undergraduate, graduate, and postdoctoral, is organized into these three areas bordering 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 M.I.T. psychology building contains machine shops and electronic shops, a specialized research library, and facilities for brain research (electrophysiology, experimental surgery, and neurohistology); the facilities are used 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 the knowledge of the word.

Undergraduate Study

Psychology subjects at the undergraduate level normally begin with 9.00 Introduction to Behavioral and Brain Sciences, or 9.55 Introduction to Language and Cognition, the prerequisite for all other undergraduate subjects in psychology. The remaining, more advanced subjects fall into the three areas covered by the Department: brain and behavior, and experimental and cognitive psychology. There is at present no undergraduate major in psychology at M.I.T.; however, psychology subjects can form an important part of the student's major in Course XXV (Interdisciplinary Science Program). For all undergraduates, many psychology subjects may be taken to fulfill the Institute Requirement in the Humanities, Arts, and Social Sciences. Students interested in developing strong backgrounds in psychology should examine the suggested options of the Master of Science program, as follows.

Graduate Study

The Department offers work leading to the Master of Science in Psychology and Brain Science and the Doctor of Philosophy. The program of studies leading to these graduate degrees is designed to prepare students for careers in teaching and research, or may also serve as a pre-medical orientation. The departmental program permits concentration in any one of the three areas already described: brain and behavior, experimental psychology, and developmental-cognitive psychology, including psycholinguistics. Throughout graduate study, students are involved in research projects occupying at least one-half of their time; aptitude is assessed as much in the light of demonstrated research abilities as in performance in seminars or tutorials.

Entrance Requirements for Graduate Degrees

Approximately one-half of 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 undergraduate 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 years. In the latter half of their junior year they should begin laboratory work in one of the following three areas: neurosciences, perceptual mechanisms, or cognitive systems. The major portion of the senior year and the subsequent summer may be devoted to research and thesis.

Subjects in Psychology

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 will 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 will ordinarily be 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, financial aid, etc. may be obtained from the Department of Psychology, Room E10-139, M.I.T., Cambridge, Massachusetts 02139, (617) 253-5745.

(A) following the name of the subject indicates that it is an approved subject for a graduate degree and is given primarily for graduate students.

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|--------|---|--------|--|
| 9.U.R. | Undergraduate Research | 9.631J | The Psychology of Reasoning (A) |
| 9.00 | Introduction to Behavioral and Brain Sciences | 9.65 | Cognitive Processes |
| 9.01 | Brain Science and Behavior | 9.651 | Cognitive Processes (A) |
| 9.016J | The Human Nervous System (A) | 9.652J | Seminar in Cognitive Development (A) |
| 9.017 | Nature, Nurture, and the Individual Brain | 9.653J | Cognitive Theories (A) |
| 9.019 | Special Topics in Neuropsychology (A) | 9.70 | Social Psychology |
| 9.021 | Topics in Brain and Behavior (A) | 9.88 | Development of Behavior |
| 9.022 | Topics in Neuroanatomy | 9.881 | Seminar in the Origins of Behavior (A) |
| 9.04 | Sensory Neurophysiology | 9.89J | Developmental Psychology |
| 9.05 | Psychotechnology: Scientific and Ethical Issues in Behavior Control | 9.901 | Proseminar in Psychology I (A) |
| 9.051 | Human Nature and Sociobiology (A) | 9.902 | Proseminar in Psychology II (A) |
| 9.30 | Animal Behavior | 9.91- | Topics in Psychology |
| 9.331 | Development of the Mammalian Visual System (A) | 9.92 | |
| 9.340 | Control of Movement in Biological and Robotic Systems (A) | 9.911- | Special Topics in Psychology (A) |
| 9.342 | Movement: Mechanisms and Models (A) | 9.916 | |
| 9.35 | Perception: Mechanisms and Models | 9.921 | Research in Psychology (A) |
| 9.36 | Natural Computation and Control | 9.922 | Research in Psychology (A) |
| 9.361 | Neurophysiology of the Visual System (A) | 9.923 | Research in Psychology (A) |
| 9.365 | Dissection by Psychophysics (A) | | |
| 9.366 | Vision Algorithms and Psychophysics (A) | | |
| 9.368 | Current Topics in Computer Vision Research (A) | | |
| 9.50 | Research in Psychology | | |
| 9.55 | Introduction to Language and Cognition | | |
| 9.59 | Psychology of Language and Communication | | |
| 9.590J | Serial and Temporal Factors in Language Processing (A) | | |
| 9.591 | Seminar in Psychology of Language and Communication I (A) | | |
| 9.592 | Seminar in Psychology of Language and Communication II (A) | | |
| 9.630J | Natural Concepts (A) | | |

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 M.I.T. 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 M.I.T.'s undergraduates. During this period many of the Institute's most distinguished graduates made their reputations as managers and business leaders. The gift of Alfred P. Sloan, Jr. in 1952, however, was the landmark in establishing a new level and a broader scope in management education at M.I.T., 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. 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

Sloan School of Management

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 health services, the management of education, and the management of public and urban affairs.

In addition to educating men and women for management, the Sloan School is equally committed to research directed at new understanding of and better solutions to management problems. Together, research and education are mutually reinforcing goals, and the School is confident of their continued impact on the fields of management and management education.

William Frank Pounds
Dean of the Sloan School of Management

Office of the Dean

William Frank Pounds, Ph.D.
Professor of Management
Dean

Abraham J. Siegel, Ph.D.
Professor of Industrial Relations
Associate Dean

Peter Paul Gil, Ph.D.
Associate Dean
Senior Lecturer

Michael Stewart Scott Morton, D.B.A.
Professor of Management
Associate Dean

Professors

Sidney Stuart Alexander, Ph.D.
Professor of Management and Economics

Thomas John Allen, Jr., Ph.D.
Professor of Organizational Psychology and Management

Fischer Black, Ph.D.
Professor of Finance

Edward Harry Bowman, Ph.D.
Professor of Management

John Frederick Collins, Ph.D., D.C.L.
Consulting Professor of Urban Affairs

Jay Wright Forrester, D.Eng.
Germeshausen Professor of Management

Arnoldo Cubillos Hax, Ph.D.
Professor of Management Science

Daniel Mark Holland, Ph.D.
Professor of Finance

David Kai-Mei Hsiao, Ph.D.
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(Visiting)

Henry Donnan Jacoby, Ph.D.
Professor of Management
Director, Energy Policy Research,
Energy Laboratory

Gordon Mayer Kaufman, D.B.A.
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and Management

Edwin Kuh, Ph.D.
Professor of Finance and Economics

John Dutton Conant Little, Ph.D.
George Maverick Bunker
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Thomas Lee Magnanti, Ph.D.
Professor of Operations Research
and Management

Robert Bruce McKersie, D.B.A.
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(Visiting)

Robert Cox Merton, Ph.D.
Professor of Finance

Franco Modigliani, D.Jur.,
D.Soc.Sci., LL.D.
Institute Professor
Professor of Finance and Economics

Leo Benjamin Moore, S.M.
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Stewart Clay Myers, Ph.D.
Professor of Finance

Robert Stephen Pindyck, Ph.D.
Professor of Management

William Frank Pounds, Ph.D.
Professor of Management
Dean

Edward Baer Roberts, Ph.D.
David Sarnoff Professor of
Management of Technology

Richard Dunlop Robinson, Ph.D.
Professor of Management

Edgar Henry Schein, Ph.D.
Sloan Fellows Professor
of Management

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Professor of Applied Economics

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D.B.A.
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Associate Dean

Eli Shapiro, Ph.D.
Alfred P. Sloan Professor of
Management

Jeremy Frank Shapiro, Ph.D.
Professor of Operations Research
and Management
Co-Director, Operations
Research Center
(Absent)

Abraham J. Siegel, Ph.D.
Professor of Industrial Relations
Associate Dean

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Norman Stanley Stearns, M.D.
Professor of Health Management
(Visiting)

Ezio Tarantelli, Ph.D.
Professor of Industrial Relations
(Visiting)

Lester Carl Thurow, Ph.D.
Professor of Management and
Economics
(Absent)

Glen Lee Urban, Ph.D.
Professor of Management
Science
(Absent)

Phyllis Ann Wallace, Ph.D.
Professor of Management

Roy Elmer Welsch, Ph.D.
Professor of Management Science
and Statistics
(Absent, fall)

Zenon Soteriou Zannetos, Ph.D.
Professor of Management

Associate Professors

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Research and Management

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Management Science

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Associate Professor of Management

Donald Roy Lessard, Ph.D.
Associate Professor of Management
(Absent, fall)

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Science

Peter Lorange, D.B.A.
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Science
(Absent)

Stuart Elliot Madnick, Ph.D.
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Albert Andrew Marcotte, Ph.D.
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(Visiting)

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and Electrical Engineering

Nathaniel Jordan Mass, Ph.D.
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Jeffrey Alan Meldman, Ph.D., LL.B.
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J. D. Nyhart, J.D.
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and Management

Eric Arthur von Hippel, Ph.D.
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Assistant Professors

Robert Malcombe Alloway, D.B.A.
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Science

Carliiss Young Baldwin, D.B.A.
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Gabriel Richard Bitran, Ph.D.
Assistant Professor of Management

Peter Brownell, Ph.D.
Assistant Professor of Management
Science

James Walter Driscoll, Ph.D.
Assistant Professor of Industrial
Relations

Stan Neil Finkelstein, M.D.
Assistant Professor of Health
Management

Alan Karl Graham, Ph.D.
Assistant Professor of Management

Stephen C. Graves, Ph.D.
Assistant Professor of Management

Manohar Kalwani, Ph.D.
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Science

Harry Charles Katz, Ph.D.
Assistant Professor of Management
and Economics

Paul Robin Krugman, Ph.D.
Assistant Professor of Management
(Visiting)

Terry Alan Marsh, Ph.D.
Assistant Professor of Management

James Berger Orlin, Ph.D.
Assistant Professor of Management
Science

Peter Michael Senge, Ph.D.
Assistant Professor of Management

Thomas Martin Stoker, Ph.D.
Assistant Professor of Management

Hoo-min David Toong, Ph.D.
Assistant Professor of Management

Michael Filmer van Breda, Ph.D.
Assistant Professor of Management
Science

Manchek Anthony Wong, Ph.D.
Assistant Professor of Management
Science

Martin Barry Zimmerman, Ph.D.
Assistant Professor of Management

Michael D. Zisman, Ph.D.
Assistant Professor of Management
Science
(Absent)

Adjunct Professors

Benjamin Calhoun Ball, Jr., M.S.
Adjunct Professor of Management
and Engineering

Louis Layton Banks, A.B.
Adjunct Professor of Management

Richard Beckhard, A.B.
Adjunct Professor of Management

James Suren Hekimian, Ph.D.
Adjunct Professor of Management

Senior Lecturers

Gordon Falk Bloom, Ph.D., J.D.

William Filbert Bottiglia, Ph.D.

Peter Paul Gil, Ph.D.,
Associate Dean

Herbert Franklin Goodwin, S.B.

Stanley Martin Jacks, A.M., LL.B.

Richard Alexander MacKinnon,
M.B.A., (Visiting)

James Morrison McInnes, D.B.A.

Harlan C. Meal, Ph.D.

Charles Andrew Myers, Ph.D.

Edwin C. Nevis, Ph.D.

John Fralick Rockart, Ph.D.,
Director, Center for
Information Systems Research

David O. Wood, B.S.

Lecturers

James Lester Paddock, Ph.D.
Pamela Walker Turner, S.M.
Alan Frederick White, S.M.

Administration

Loren Charles Cox, M.A.
Executive Director, Center for
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Charline Theresa Mahoney, B.A.
Programming Analyst

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Program Director for
Master's Program

Pamela Walker Turner, S.M.
SSM Director of Recruitment
and Placement
Manager, Accelerated
Master's Program

Alan Frederick White, S.M.
Director of Executive Development
Programs

Undergraduate Study

Professors Emeriti

William Filbert Bottiglia, Ph.D.
Professor of Management and
Humanities, Emeritus

Edward Lindley Bowles, D.Sc.
Professor of Industrial
Management, Emeritus

Edward Pennell Brooks, D.Sc.
Professor of Industrial
Management, Emeritus
Dean, Emeritus

Douglass Vincent Brown, Ph.D.
Alfred P. Sloan Professor of
Management, Emeritus

David Durand, Ph.D.
Professor of Management,
Emeritus

Billy Earl Goetz, Ph.D.
Professor of Management,
Emeritus

Mason Haire, Ph.D.
Alfred P. Sloan Professor of
Management, Emeritus

Charles Andrew Myers, Ph.D.
Sloan Fellows Professor of
Management, Emeritus

Carroll Louis Wilson, Sc.D.
Mitsui Professor in Problems of
Contemporary Technology,
Emeritus

Guests of the Institute

Alan Francis Kay, Ph.D.
Barbara Joyce McNeil, M.D.
Anselm Yaron, D.Sc.

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 an interrelated set of management disciplines in depth.

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 is related 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.

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.

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.

Graduate Study

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.

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 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 E52-455C, M.I.T., Cambridge, Massachusetts 02139, (617) 253-2931.

The Sloan School of Management provides opportunity for graduate work leading to the degrees of Master of Science in Management and Doctor of Philosophy.

Entrance Requirements for Graduate Study

Undergraduate preparation for the graduate programs should include: mathematics through differential and integral calculus and principles of macro and micro economics. However, any applicant strongly motivated to study in the Sloan School who has demonstrated high intellectual capacity, and who is prepared to eliminate any deficiencies in preparation before entering, will be seriously considered. Applicants for admission to degree candidacy, except in the Alfred P. Sloan Fellows Program, are required to take the Graduate Management Admission Test administered by the Educational Testing Service, Princeton, New Jersey 08540. Information about dates and locations may be obtained from that agency. The January test is the latest one appropriate for admission in the following June or September.

Master of Science in Management

Degree candidates normally are admitted in September to a program of study extending over two academic years. Those who have had two or more years of full-time work experience and who are otherwise well qualified may be considered for June admission to an accelerated course permitting satisfaction of all requirements in a period of 12 months.

The Accelerated Master's Program offers a breadth of exposure to management in an intensive 12-month program. It was developed at the Sloan School seven years ago to meet both the needs of organizations demanding professional middle management talent with

executive potential and the priorities of experienced individuals who, with a concentrated program in management, could assume these responsibilities.

Both programs are designed to educate managers who aspire over their careers to senior positions. The Sloan Master's Program offers students with or without previous work experience a general opportunity to establish a special competence that may lead them to positions of either general executive responsibility or technical leadership. Graduates with prior experience may build on existing expertise or shift their previous orientation and cross several functional areas during the course of their executive development.

Both Master's programs of the Sloan School are conducted along three distinguishable though closely related lines: theoretical studies, applied studies, and practical exposure.

The Master's thesis provides opportunity for intensive study of a specific management problem selected by the student. Thesis research is conducted under supervision of a faculty committee whose members share an interest in the topic. Joint theses, which permit attacking problems of somewhat larger scale, are generally encouraged. An alternative type of thesis, known as a "structured thesis," permits a group of students to join in a major project (designed by faculty members), with each student reporting on a specific phase of the study. In addition to the experience offered by the thesis *per se*, management students may participate in the structuring and solution of real problems through group projects associated with subject offerings.

Doctor of Philosophy

The purpose of the Sloan School's doctoral program is to prepare students for careers in teaching and research or for nonacademic positions requiring advanced research and analytical capabilities.

The program's philosophy is summarized by two propositions. First, advanced analytical work in management is done best by persons trained in an underlying theoretical discipline. Second, such work requires knowledge of applied work in management, as well as of underlying theory. 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 or 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 of management are behavioral science, economics, and mathematical 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
- Organizational Studies
- Strategy and Policy
- System Dynamics

The Management Science area offers majors in the following fields:

- Information Systems
- Marketing
- Operations Management
- Operations Research
- Planning and Control
- Public Systems

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 will provide 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 |
| Organizational 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 M.I.T., 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, although a research advisor and other interested faculty are available for advice and criticism. 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 is defined as a manageable project as early as possible. Candidates have the opportunity of completing dissertations within a year of entering this part of the program, but they should complete the dissertation within a maximum of two years.

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 to work 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. This usually is true, for example, in the field of International Management.

Programs for Executive Development in Management

Teaching and Research Assistantships

Except for limited funds designated by donors for aid to disadvantaged students, fellowships for graduate study in management are given only to doctoral degree candidates. All graduate students who have completed a year (or sometimes a term) of graduate study in the Sloan School are eligible to apply for the approximately 100 part-time research and teaching assistantships available each year.

Inquiries

Additional information concerning graduate programs, admissions, financial aid, etc., may be obtained from the Graduate Program Office, Room E52-472, Sloan School of Management, M.I.T., Cambridge, Massachusetts 02139, (617) 253-3730.

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). A limited number are selected from abroad. The 12-month Program, providing regular classroom work plus close contact with business and government leaders here and abroad, is taken in conjunction with the regular graduate program and leads to the degree of Master of Science in Management.

Health Management Executive Development Program

This 12-month Program leading to the degree of Master of Science in Management is aimed at mid-career to senior level health care practitioners, educators, researchers, and administrators who desire an intensive management development experience in preparation for continued career growth and increased responsibilities in the health field. A small group of health professionals are integrated with the Alfred P. Sloan Fellows Program. The Program builds on managerial applications of the underlying disciplines of economics, behavioral science, and quantitative analysis. These disciplines are studied in relation to general management issues as well as to specific health issues.

M.I.T. Program for Senior Executives

The Program for Senior Executives is an intensive nine-week course of study designed for the senior level executive already in or preparing for a position of major managerial responsibility. Enrollment in the Program, offered in the fall and spring of each year, is limited to groups of 30. Participants reside at Endicott House in Dedham, Massachusetts, taking their course work on campus at the Sloan School, and at Endicott House. A one-week trip to Washington, DC to visit policy makers of the Federal government is an important part of the Program.

Inquiries

Detailed information about these programs may be obtained from the Executive Development Programs Office, Room E52-456, Sloan School of Management, M.I.T., Cambridge, Massachusetts 02139, (617) 253-7166.

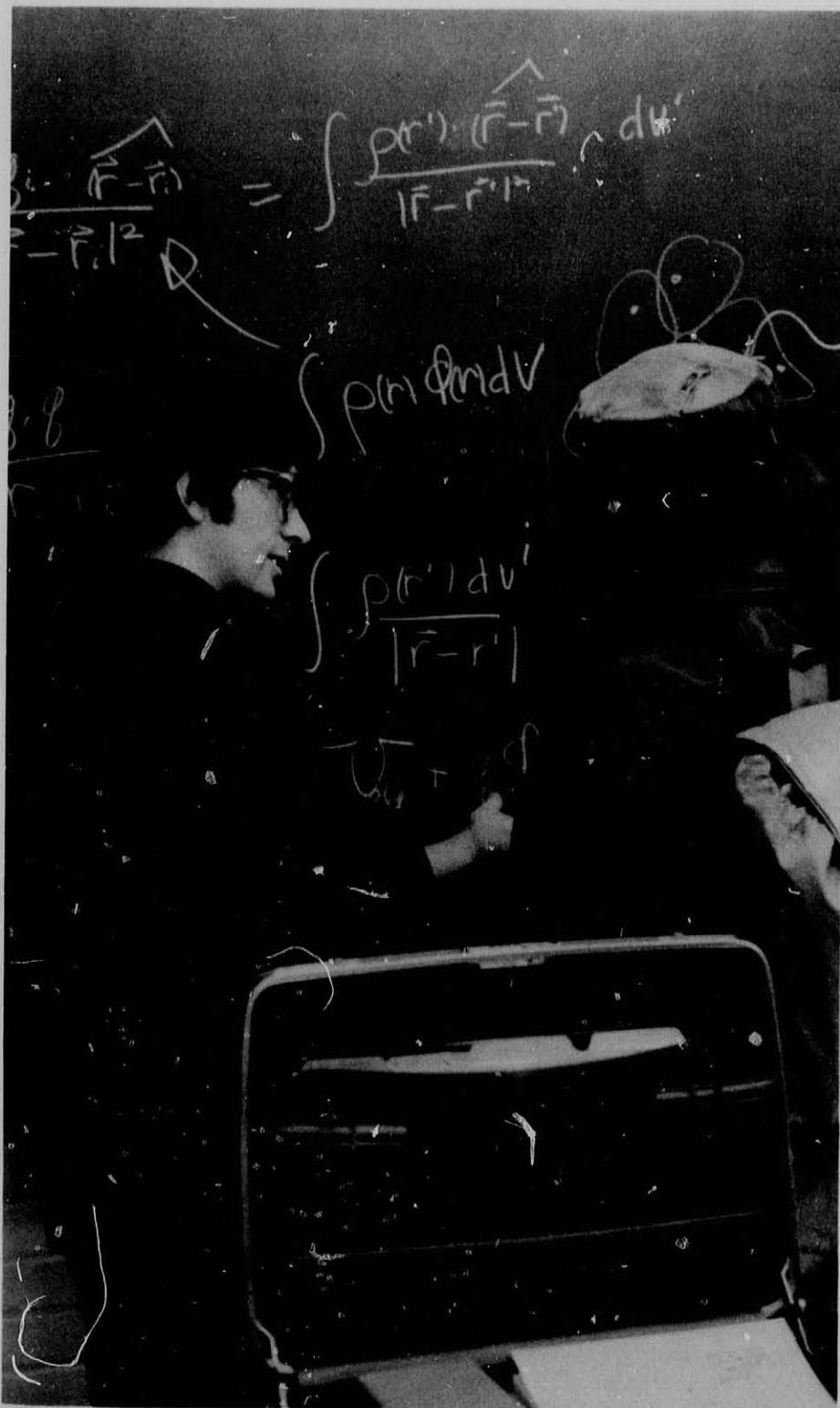
 Subjects in Management

(A) following the name of the subject indicates that it is an approved subject for a graduate degree and is given primarily for graduate students.

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|---------|---|---------|--|--------|---|
| 15.U.R. | Undergraduate Research | 15.099 | Seminar in Management Science (A) | 15.345 | Doctoral Seminar in Organization Studies I (A) |
| 15.001 | Managerial Economics | 15.121 | Seminar in Health Management (A) | 15.346 | Doctoral Seminar in Organization Studies II (A) |
| 15.011 | Economics for Management | 15.122 | Seminar in Health Management (A) | 15.347 | Doctoral Seminar in Research Methods I (A) |
| 15.012 | Applied Micro and Macroeconomics | 15.132 | Management of Change in Complex Health Organizations (A) | 15.348 | Workshop in Research Methods (A) |
| 15.013 | Industrial Economics | 15.141 | Comparative Health Systems (A) | 15.349 | Seminar on Work, Career and Family (A) |
| 15.014 | Macroeconomic Problems and Policies | 15.144J | Analytical Methods for Health Policy and Management (A) | 15.351 | Research and Development Management (A) |
| 15.016 | Public Sector Economics and Finance | 15.149 | Special Studies in Health Management (A) | 15.353 | Seminar on Management of Technology (A) |
| 15.017 | Economics of Government Regulation | 15.215 | International Dimensions of Management | 15.355 | New Enterprises (A) |
| 15.018 | Economics of International Business | 15.221 | International Business Management I (A) | 15.357 | Management of the Innovation Process (A) |
| 15.019 | Energy Economics and Policy | 15.222 | International Business Management II (A) | 15.411 | Financial Management (A) |
| 15.024 | Economics and Finance: Principles and Policies I | 15.223 | International Business Environments (A) | 15.412 | Financial Management (A) |
| 15.031 | Quantitative Approaches to Economic and Management Policy (A) | 15.224 | Intercultural Communication I (A) | 15.413 | Topics in Corporate Financial Management (A) |
| 15.053 | Introduction to Management Science | 15.225 | Intercultural Communication II (A) | 15.414 | Business Forecasting (A) |
| 15.061 | Statistics for Management | 15.227 | International Technology Transfer (A) | 15.415 | Finance Theory (A) |
| 15.062 | Decision Models for Management | 15.228J | Ocean Engineering and Law Seminar (A) | 15.418 | Taxation and Business Management (A) |
| 15.065 | Decision Analysis (A) | 15.268 | Readings in Power and Responsibility (A) | 15.419 | Finance for International Managers (A) |
| 15.066 | Statistical Decision Theory (A) | 15.301 | Managerial Psychology Laboratory | 15.423 | The Management of Financial Intermediaries (A) |
| 15.071 | Management Decision Support Models | 15.304 | Complex Organizations | 15.432 | Capital Markets and Financial Institutions (A) |
| 15.073J | Introduction to Stochastic Processes (A) | 15.301 | Managerial Psychology Laboratory | 15.433 | Advanced Capital Market Theory (A) |
| 15.075 | Statistics for Applications (A) | 15.304 | Complex Organizations | 15.434 | Advanced Financial Administration (A) |
| 15.076J | Statistics for Model Building (A) | 15.306 | Behavioral Science Research Methods | 15.436 | International Managerial Finance (A) |
| 15.077 | Bayesian Analysis Studies (A) | 15.307 | Behavioral Science Research Practicum | 15.441 | Research Seminar in Finance (A) |
| 15.078J | Urban Operations Research (A) | 15.311 | Individuals, Groups and Organizations | 15.501 | Financial and Management Accounting |
| 15.081J | Introduction to Mathematical Programming (A) | 15.314 | Organization Theory (A) | 15.511 | Management Accounting and Control Systems |
| 15.082 | Network Optimization (A) | 15.317 | Comparative Studies of Organizations (A) | 15.515 | Financial and Management Accounting |
| 15.083 | Combinatorial Optimization (A) | 15.318 | Organization (A) | 15.516 | Management Accounting and Control Systems (A except XV) |
| 15.084J | Nonlinear Programming and Discrete-Time Optimal Control (A) | 15.319 | Seminar on Organization Change (A) | 15.521 | Management Control Systems (A) |
| 15.085 | Topics in Optimization (A) | 15.321 | Theories of Planned Change (A) | 15.522 | Planning and Control in Non-Profit Organizations (A) |
| | | 15.322 | Organizational Psychology (A) | | |
| | | 15.332 | Administrative Theory and Practice (A) | | |
| | | 15.333 | Management of Industrial Change (A) | | |
| | | 15.334 | Managing Planned Change I (A) | | |
| | | 15.335 | Managing Planned Change II (A) | | |
| | | 15.337 | Sociology of Work and Organizations (A) | | |
| | | 15.339 | Social Psychology of Work and Organizations (A) | | |
| | | 15.344 | Doctoral Seminar on Career Development and Adult Socialization (A) | | |

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|---------|--|---------|---|
| 15.532 | Long-Range Planning Systems (A) | 15.768 | Operations Management in the Public Sector and Service Industry (A) |
| 15.541 | Computer Based Models for Planning and Control (A) | | |
| 15.544 | Theory and Problems of Financial Accounting (A) | 15.795 | Seminar in Operations Management (A) |
| 15.545 | Seminar in Management Planning and Control (A) | 15.811 | Marketing (A) |
| 15.561 | Benchmark Computer Programming | 15.812 | Marketing Management (A) |
| 15.562 | Principles of Management Information Systems (A) | 15.813 | Marketing Issues in Public Systems (A) |
| 15.564 | Management Information Technology I (A) | 15.824 | Marketing Communications (A) |
| 15.565 | Management Information Technology II (A) | 15.825 | Marketing Models (A) |
| 15.568 | Management Information Systems (A) | 15.826 | Industrial Marketing (A) |
| 15.569 | Decision Support Systems (A) | 15.828 | Marketing New Products (A) |
| 15.571 | Advanced Computer Systems (A) | 15.832 | Measurement for Management (A) |
| 15.572 | Systems Simulation (A) | 15.838 | Research Seminar in Marketing (A) |
| 15.581 | Information Systems and Law (A) | 15.851 | Dynamics of Physical and Social Systems |
| 15.612 | Structure of American Law | 15.852 | Principles of Dynamic Systems I |
| 15.616 | American Legal System (A) | 15.872 | Principles of Dynamic Systems I (A) |
| 15.625 | Labor Law (A) | 15.873 | Principles of Dynamic Systems II (A) |
| 15.632 | Seminar on Regulatory Law and Its Impact Upon Business | 15.874 | Industrial Dynamics (A) |
| 15.662 | Collective Bargaining and Public Policy (A) | 15.875 | Applications and Implementation of Industrial Dynamics (A) |
| 15.663 | Labor-Management Relations | 15.876 | Dynamics of Health Service Systems (A) |
| 15.664 | Management of Human Resources (A) | 15.878 | Seminar in System Dynamics Policy Analysis I (A) |
| 15.671J | Labor Economics (A) | 15.879 | Seminar in System Dynamics Policy Analysis II (A) |
| 15.672J | Public Policy on Employment and Industrial Relations (A) | 15.880 | System Dynamics (A) |
| 15.674J | Comparative Systems of Industrial Relations and Human Resource Development (A) | 15.915 | Information and Decision Systems |
| 15.675 | Equal Employment Opportunity and Management of Human Resources (A) | 15.921 | Business and Social Pressures (A) |
| 15.691J | Research Seminar in Industrial Relations (A) | 15.922 | Business and the Media (A) |
| 15.692J | Research Seminar in Industrial Relations (A) | 15.931 | Corporate Strategy, Policy and Planning (A) |
| 15.761 | Operations Management (A) | 15.933 | Financial Strategy (A) |
| 15.762 | Quantitative Analysis for Managerial Decisions (A) | 15.935 | Seminar on Corporate Strategy and Structure (A) |
| 15.763 | The Practice of Operations Management (A) | 15.936 | Seminar in Administration |
| 15.764 | The Theory of Operations Management (A) | 15.937 | Seminar in Administration |
| 15.765 | The Operating Manager (A) | 15.938 | Seminar in Administration (A) |
| 15.766 | Innovation and Industrial Development (A) | 15.939 | Seminar in Administration (A) |
| 15.767 | Industrial Project Evaluation (A) | 15.951 | Special Studies in Management |
| | | 15.961 | Special Studies in Management (A) |
| | | 15.962- | Special Seminars in |
| | | 15.969 | Management (A) |

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 M.I.T. 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 M.I.T., the biological sciences are represented by a wide range of disciplines from cell biology, microbiology, biochemistry, and biophysics to food science and technology, nutritional biochemistry and metabolism, 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 Arteriosclerosis Center and the Clinical Research Center are interdepartmental laboratories which are closely related to the Department of Nutrition and Food Science. The new Whitaker College 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 M.I.T., the four main areas are astrophysics; experimental nuclear and particle physics; solid state, laser, plasma, and atomic physics; and nuclear and particle theory. A great deal of physics research is carried out in the interdepartmental laboratories listed below. In chemistry, research and education are carried out in organic, inorganic, physical, analytical, biological, biophysical, and chemical physics. These sciences are heavily involved in industry and many graduates find their careers in applications as well as in research. Science has, of course, contributed in the most fundamental way to the advancement of technology, and technology has contributed importantly to the advancement of science. At M.I.T., 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, and 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 UROP program. Through this program, students obtain first-hand research experience in fields that interest them, and learn in a different environment from the classroom or instructional laboratory. The Undergraduate Seminar Program provides study and associations with faculty members in smaller and less formal groups.

The School of Science also is involved in providing parts of the general education of undergraduate students through the Science Requirement Subjects, Science Distribution Subjects, and laboratory subjects.

Course XXV offers S.B. and S.M. degree programs in Interdisciplinary Science. These programs provide special opportunities for students to arrange their curricula in consultation with faculty advisors in fields involving more than one

area of science. The S.M. programs prepare students for positions in industry, government, education, or medicine where training beyond the bachelor's degree is required.

Interdisciplinary laboratories and centers associated with the School include the following:

Arteriosclerosis Center
Francis Bitter National Magnet Laboratory
Cell Culture Center
Center for Cancer Research
Center for Materials Science and Engineering
Center for Space Research
Clinical Research Center
Energy Laboratory
Haystack Observatory
Laboratory for Computer Science
Laboratory for Nuclear Science
Lincoln Laboratory
Research Laboratory of Electronics

Robert Arnold Alberty
Dean of the School of Science

Office of the Dean

Robert Arnold Alberty, Ph.D., Sc.D.
Professor of Chemistry
Dean

Department of Biology

Gene Monte Brown, Ph.D.
Professor of Biochemistry
Head of the Department

Malcolm Lawrence Gefter, Ph.D.
Professor of Biochemistry
Executive Officer

Professors

David Baltimore, Ph.D.
American Cancer Society
Professor of Microbiology

Eugene Bell, Ph.D.
Professor of Biology

David Botstein, Ph.D.
Professor of Genetics

John Machlin Buchanan, Ph.D.,
D.Sc.
John and Dorothy Wilson Professor
of Biochemistry

Herman Nathaniel Eisen, M.D.
Professor of Immunology

Maurice Sanford Fox, Ph.D.
Lester Wolfe Professor
of Molecular Biology

Bernard Sidney Gould, Ph.D.
Professor of Biochemistry,
Emeritus
Senior Lecturer

Howard Green, M.D.
Professor of Cell Biology

Charles Edward Holt III, Ph.D.
Professor of Biology

Vernon Martin Ingram, Ph.D.,
D.Sc.
Professor of Biochemistry

Har Gobind Khorana, Ph.D.
Alfred P. Sloan Professor of
Biology and Chemistry

Jonathan Alan King, Ph.D.
Professor of Biology

Jerome Ysrael Lettvin, M.D.
Professor of Communications
Physiology

Harvey Franklin Lodish, Ph.D.
Professor of Biology

Irving M. London, M.D.
Grover M. Hermann Professor of
Biology
Director, Joint Harvard-M.I.T.
Division of Health Sciences and
Technology
Director, Whitaker College of Health
Sciences, Technology, and
Management

Salvador Edward Luria, M.D.,
D.Sc.
Institute Professor, Emeritus
Director, Center for Cancer
Research

Boris Magasanik, Ph.D.
Jacques Monod Professor
of Microbiology

Sheldon Penman, Ph.D.
Professor of Cell Biology

Uttam Lal RajBhandary, Ph.D.
Professor of Biochemistry

Alexander Rich, M.D.
Professor of Biophysics
Sedgwick Professor of Biology

Phillips Wesley Robbins, Ph.D.
American Cancer Society
Professor of Biochemistry

Paul Reinhard Schimmel, Ph.D.
Professor of Biochemistry and
Biophysics

Phillip Allen Sharp, Ph.D.
Professor of Biology

Ethan Royal Signer, Ph.D.
Professor of Biology

Annamaria Torriani, Ph.D.
Professor of Biology

Christopher Walsh, Ph.D.
Professor of Chemistry and
Biology

David Floyd Waugh, Ph.D.
Professor of Biophysics

Associate Professors

Raymond Milton Baker, Ph.D.
Associate Professor of Genetics

Michael J. Bevan, Ph.D.
Associate Professor of Biology

Paul David Gottlieb, Ph.D.
Associate Professor of Immunology

Linda McIntyre Hall, Ph.D.
Associate Professor of Biology
(Visiting)

Nancy Haven Hopkins, Ph.D.
Associate Professor of Biology

David Evan Housman, Ph.D.
Associate Professor of Biology

Richard Olding Hynes, Ph.D.
Associate Professor of Biology

Mary Lou Pardue, Ph.D.
Associate Professor of Biology

Lisa Amelia Steiner, M.D.
Associate Professor of Immunology

Bonnie Moreland Tyler, Ph.D.
Associate Professor of Microbiology
(Visiting)

Robert Allen Weinberg, Ph.D.
Associate Professor of Biology

Assistant Professors

Howard R. Horvitz, Ph.D.
Assistant Professor of Biology

Robert Thomas Sauer, Ph.D.
Assistant Professor of Biochemistry

Frank Solomon, Ph.D.
Assistant Professor of Biology

Alexander Varshavsky, Ph.D.
Assistant Professor of Biology

Graham Charles Walker, Ph.D.
Assistant Professor of Biology

Technical Instructor

Erika A. Hartweg

Operations Administrator

Edward Joseph Gaudiano

Financial Administrator

Elaine Mary Petrino

Personnel Administrator

Genevieve Mary Morash

Senior Research Associate

Daniel H. Levin, Ph.D.

Research Scientists

Vivian Gwyn Eira Ernst, Ph.D.
Stephanie Ellsworth Sher, Ph.D.
Joan Lucia Suit, Ph.D.

Postdoctoral Associates

Takachika Azuma, Ph.D.
Dorothy Breda Berkoben, Ph.D.
Marjorie C. Brandriss, Ph.D.
Robert Newton Brey III, Ph.D.
Jerry L. Bryant, Ph.D.
John Green Burr, Ph.D.
Rakha Hari Das, Ph.D.
Asim Dasgupta, Ph.D.
Margaret J. Duncan, Ph.D.
Jeffrey Tobin Fayerman, Ph.D.

Forrest LeRoy Foor, Jr., Ph.D.
Alice Bordwell Fulton, Ph.D.
Carol Chaia Halpern, Ph.D.
Phyllis Hammer, Ph.D.
Izumi Hayashi, Ph.D.
Joyce Ellen Heckman, Ph.D.
Thomas Harvey Hudson, Ph.D.
Raymond John Ivatt, Ph.D.
Celik Kayalar, Ph.D.
Robert Weston Keane, Ph.D.
Hie-Joon Kim, Ph.D.
Mary Lou King, Ph.D.
Ichiro Kudo, Ph.D.
Su-ray Lee, Ph.D.
Jack Nelson Lindon, Ph.D.
Edward Leon Loechler, Ph.D.
Maria Li Lung, Ph.D.
Donald T. Moir, Ph.D.
Norio Nakatsuji, Ph.D.
Norma Faye Neff, Ph.D.
Jeffrey R. Neumann, Ph.D.
Juan Cristian Orrego, Ph.D.
Marcia S. Osburne, Ph.D.
Duncan R. Paton, Ph.D.
Robert Poss, M.D.
Charles W. Pratt, Ph.D.
Gary J. Quigley, Ph.D.
Edward Bowman Reilly, Ph.D.
Lawrence J. Reitzer, Ph.D.
Ziva Reuveny, Ph.D.
Margaret L. Riggs, Ph.D.
Varda Rotter, Ph.D.
Susan P. Schlegel, Ph.D.
Donald Robert Senger, Ph.D.
Ben-Zion Shilo, Ph.D.
Harlee Sue Strauss, Ph.D.
Michael Ronald Sutton, Ph.D.
Martha M. Teeter, Ph.D.
Vladimir Zeev Volloch, Ph.D.
Joseph Richard Votano, Ph.D.
Andrew Hwei-Jiung Wang, Ph.D.
Barry Lee Wanner, Ph.D.
Scott C. Wittlesberger, Ph.D.
Nancy Helen Woo, Ph.D.
Paul Wrede, Ph.D.

Professors Emeriti

Bernard Sidney Gould, Ph.D.
Professor of Biochemistry,
Emeritus
Senior Lecturer

Kurt Siegfried Lion, Dr. Ing.
Professor of Applied Biophysics,
Emeritus

Salvador Edward Luria, M.D., D.Sc.
Institute Professor, Emeritus
Director, Center for Cancer
Research

Francis Otto Schmitt, Ph.D., Sc.D.
Institute Professor, Emeritus
Professor of Biology, Emeritus

Irwin Whiting Sizer, Ph.D.
Professor of Biochemistry,
Emeritus

Department of Biology

Undergraduate Study

The Department of Biology offers undergraduate, graduate, and post-doctoral 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

This program leads 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 institutions. 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 they plan to include laboratory investigations bearing on human disease as part of their careers.

Bachelor of Science Course VII-A

Course VII-A is designed for students who wish to obtain a background in the life sciences as preparation for careers without laboratory research such as medicine, graduate study of psychology, or management studies. This program, leading to the Bachelor of Science, allows more time for electives so that students can plan their programs to suit their particular goals.

Bachelor of Science 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.

Inquiries

Additional information regarding academic programs, research opportunities, admissions, financial aid, etc. may be obtained from Biology Headquarters, Room 56-509, M.I.T., Cambridge, Massachusetts 02139, (617) 253-4701.

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 co-enzymes; 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 physicochemical 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.

Biological Oceanography M.I.T. 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, please see M.I.T.-Woods Hole Joint Program in Oceanography, which follows the School of Science.

Entrance Requirements for Graduate Study

In the Department of Biology, the Master of Science is not a prerequisite for a program of study leading to the doctorate. The Department expects that entering graduate students have formal training in the following subjects: a year of calculus, including some experience in differential equations; a year of physics; organic chemistry; physical chemistry; and subjects in the biological sciences, 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 Chapter IV of this catalogue. 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.

Subjects in Biology

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 possible acceleration of their programs. In addition, a number of predoctoral and postdoctoral fellowships are available in cell biology, microbiology, physiology, biochemistry, and biophysics.

Inquiries

Any additional information regarding graduate academic programs, research activities, admissions, financial aid, assistantships, etc. may be obtained from Biology Headquarters, Room 56-509, M.I.T., Cambridge, Massachusetts 02139, (617) 253-4701.

| | | |
|--|-------|---|
| (A) following the name of the subject indicates that it is an approved subject for a graduate degree and is given primarily for graduate students. | 7.61 | The Mammalian Cell in Differentiation |
| | 7.62 | Tumor Biology (A) |
| | 7.63 | Immunogenetics and Cellular Immunology |
| 7.U.R. Undergraduate Research | 7.65 | Cell Motility and Cell Form |
| 7.01 General Biology | 7.66 | Cell Surfaces (A) |
| 7.011 Introduction to Experimental Biology | 7.70 | Seminar in Protein and Nucleic Acid Structure (A) |
| 7.021 Experimental Immunology | 7.71J | Biophysical Chemistry |
| 7.03 Genetics | 7.72J | Enzymatic Reaction Mechanisms (A) |
| 7.031 Experimental Microbial Genetics | 7.73 | General Immunology |
| 7.04 Cell and Developmental Biology | 7.74J | Seminar in Biochemistry (A) |
| 7.041 Experimental Cell Biology | 7.75 | Advanced Biochemistry (A) |
| 7.05 General Biochemistry | 7.86 | Molecular Genetics (A) |
| 7.051 Experimental Biochemistry | 7.90 | Special Problems in Biology for Undergraduates |
| 7.06 Biology of Cells of Higher Organisms | 7.93 | Selected Topics in Biology (A) |
| 7.09 Biology, Medicine and Social Policy | 7.941 | Research Problems (A) |
| 7.11 Biology Teaching | 7.942 | Research Problems (A) |
| 7.13 The Biosphere | 7.99 | Molecular Configuration in Biological Systems Seminar (A) |
| 7.14J Atoms, Genes and Stars — A Joint Reality | | |
| 7.21 Microbial Physiology | | |
| 7.24 Topics in Bacteriology (A) | | |
| 7.25 Topics in Bacterial Viruses | | |
| 7.26 Animal Virology | | |
| 7.27 Molecular Biology of Bacteria and Bacterial Viruses | | |
| 7.30 Method and Logic in Molecular Biology (A) | | |
| 7.32 Analysis of Differentiation and Development | | |
| 7.36 Advanced Neurophysiology (A) | | |
| 7.411- Seminars in Biological | | |
| 7.419 Oceanography (A) | | |
| 7.421- Special Problems in Biological | | |
| 7.429 Oceanography (A) | | |
| 7.43 Phytoplankton and Nutrient Cycling (A) | | |
| 7.44 Ecology of Oceanic Zooplankton | | |
| 7.45 Benthos and Fish (A) | | |
| 7.46 Topics in Physiology and Biochemistry of Marine Animals (A) | | |
| 7.491- Research in Biological | | |
| 7.497 Oceanography (A) | | |
| 7.51J General Physiology | | |
| 7.52 Morphogenesis | | |
| 7.53 Laboratory in Biological Electron Microscopy | | |
| 7.60 Cell Biology (A) | | |

Department of Chemistry

James Lloyd Kinsey, Ph.D.
Professor of Chemistry
Head of the Department

Professors

Robert Arnold Alberty, Ph.D.,
Sc.D.
Professor of Chemistry
Dean of the School of Science

Glenn Allen Berchtold, Ph.D.
Professor of Chemistry

Klaus Blemann, Ph.D.
Professor of Chemistry

George Hermann Buchi, D.Sc.
Camille Dreyfus Professor of
Chemistry

Alan Davison, Ph.D.
Professor of Chemistry

John Mark Deutch, Ph.D., Sc.D.
Professor of Chemistry

Carl Wesley Garland, Ph.D.
Professor of Chemistry

Frederick Davis Greene II, Ph.D.,
Sc.D.
Professor of Chemistry

David Newton Hume, Ph.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

Richard Collins Lord, Ph.D., Sc.D.
Professor of Chemistry,
Emeritus
Senior Lecturer

Satoru Masamune, Ph.D.
Professor of Chemistry

Irwin Oppenheim, Ph.D.
Professor of Chemistry

John Ross, Ph.D.
Frederick G. Keyes Professor of
Chemistry

Dietmar Seyferth, Ph.D.
Professor of Chemistry

John Clark Sheehan, Ph.D., Sc.D.
Professor of Organic Chemistry,
Emeritus
Senior Lecturer

Robert James Silbey, Ph.D.
Professor of Chemistry

Clark Conkling Stephenson, Ph.D.
Professor of Chemistry,
Emeritus
Senior Lecturer

Charles Gardner Swain, Ph.D.
Professor of Chemistry

Christopher Thomas Walsh, Ph.D.
Professor of Chemistry and Biology

John Stewart Waugh, Ph.D.
Arthur Amos Noyes Professor of
Chemistry

George McClelland Whitesides,
Ph.D.
Arthur Clay Cope Professor
of Chemistry

Mark Stephen Wrighton, Ph.D.
Professor of Chemistry

Associate Professors

Robert Warren Field, Ph.D.
Associate Professor of Chemistry

Gregory Anthony Petsko, D.Phil.
Associate Professor of Chemistry

Richard Royce Schrock, Ph.D.
Associate Professor of Chemistry

Edward Ira Solomon, Ph.D.
Associate Professor of Chemistry

Jeffrey Irwin Steinfeld, Ph.D.
Associate Professor of Chemistry

Assistant Professors

Rick Lane Danheiser, Ph.D.
Assistant Professor of Chemistry

Ellen Jane Henderson, Ph.D.
Assistant Professor of Chemistry

Fenton Read McFeely, Ph.D.
Assistant Professor of Chemistry

William Harry Rastetter, Ph.D.
Assistant Professor of Chemistry

Mary Fedarko Roberts, Ph.D.
Assistant Professor of Chemistry

William Richard Roush, Ph.D.
Assistant Professor of Chemistry

Ralph Horton Staley, Ph.D.
Assistant Professor of Chemistry

Instructor

Dagmar Ringe Ponzi, Ph.D.

Technical Instructors

Stephen Andrew Corteselli
John Robert Linzi
James Alexander Simms

Financial Administrator

Sharon Lee Harris

Operations Administrator

Lawrence William Ryan, Jr.

Personnel Administrator

Anne Marie Lees

Professors Emeriti

James Alexander Beattie, Ph.D.
Professor of Physical Chemistry,
Emeritus

Edmund Lee Gamble, Ph.D.
Professor of Inorganic Chemistry,
Emeritus

Louis Harris, Ph.D.
Associate Professor of Physical
Chemistry, Emeritus

Lawrence Joseph Heidt, Ph.D.
Associate Professor of Physical
Chemistry, Emeritus

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
Senior Lecturer

Stephen Gershom Simpson, Ph.D.
Associate Professor of Analytical
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.

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 will 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.

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, and chemical physics. The thesis frequently will involve 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 M.I.T. 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.

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 would be 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 M.I.T.

Master of Science in Chemistry

The general requirements for the Master of Science are listed in Chapter IV of this catalogue. Students interested in the Master of Science in Chemistry should also investigate the Master's Program in Interdisciplinary Science (Course XXV).

 Subjects in Chemistry

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, biophysical chemistry 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, M.I.T., Cambridge, Massachusetts 02139, (617) 253-1845.

(A) following the name of the subject indicates that it is an approved subject for a graduate degree and is given primarily for graduate students.

| | |
|--------|--|
| 5.U.R. | Undergraduate Research |
| 5.03 | Principles of Inorganic Chemistry I |
| 5.04 | Principles of Inorganic Chemistry II |
| 5.05 | Principles of Inorganic Chemistry III |
| 5.065 | Advanced Inorganic Chemistry (A) |
| 5.066 | Special Topics in Inorganic Chemistry (A) |
| 5.067 | Inorganic Chemistry (A) |
| 5.10 | Principles of Analytical Chemistry |
| 5.121J | Planetary Physics and Chemistry I |
| 5.122J | Planetary Physics and Chemistry II |
| 5.125J | Planetary Atmospheres (A) |
| 5.129J | Current Research in Meteoritics (A) |
| 5.194 | Design and Analysis of Experiments (A) |
| 5.195 | Interpretive Spectroscopy (A) |
| 5.310 | Laboratory Chemistry |
| 5.311 | Introduction to Chemical Experimentation |
| 5.32 | Intermediate Chemical Experimentation |
| 5.33 | Advanced Chemical Experimentation |
| 5.40 | General Chemistry |
| 5.41 | Introduction to Structure, Bonding and Mechanism |
| 5.42 | Organic Chemistry |
| 5.43 | Organic Chemistry |
| 5.50J | Enzymatic Reaction Mechanisms (A) |
| 5.51 | Advanced Organic Chemistry: Synthesis (A) |
| 5.53 | Molecular Structure and Reactivity (A) |
| 5.54 | Physical Organic Chemistry (A) |
| 5.55 | Organic Chemistry: Natural Products (A) |
| 5.56 | Special Topics in Organic Chemistry (A) |
| 5.57 | Chemistry of Amino Acids, Peptides, and Proteins (A) |
| 5.58 | Biochemistry of Membranes (A) |
| 5.60 | Chemical Thermodynamics |
| 5.61 | Physical Chemistry |
| 5.62 | Physical Chemistry |
| 5.64J | Biophysical Chemistry |
| 5.65 | Physical Chemistry of Macromolecular Solutions |
| 5.66 | Spectroscopic Techniques in Biochemistry (A) |

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- 5.68 Kinetics of Chemical Reactions (A)
 - 5.70 Introduction to Statistical Thermodynamics (A)
 - 5.72 Statistical Mechanics (A)
 - 5.73 Introductory Quantum Mechanics I (A)
 - 5.74 Introductory Quantum Mechanics II (A)
 - 5.76 Molecular Spectra and Molecular Structure (A)
 - 5.80 Special Topics in Chemical Physics (A)
 - 5.82 Advanced Topics in Solid State Chemistry (A)
 - 5.83 Advanced Topics in Statistical Mechanics and Kinetic Theory (A)
 - 5.84 Advanced Topics in Spectroscopy and Quantum Mechanics (A)
 - 5.89 Special Problems in Chemistry for Undergraduates
 - 5.90 Special Problems in Chemistry (A)
 - 5.913 Seminar in Organic Chemistry (A)
 - 5.914 Seminar in Organic Chemistry (A)
 - 5.915 Seminar in Analytical Chemistry (A)
 - 5.916 Seminar in Analytical Chemistry (A)
 - 5.931 Seminar in Physical Chemistry (A)
 - 5.932 Seminar in Physical Chemistry (A)
 - 5.941 Seminar in Inorganic Chemistry (A)
 - 5.942 Seminar in Inorganic Chemistry (A)
 - 5.981J Seminar in Biochemistry (A)
-

Department of Earth and Planetary Sciences

Carl Isaac Wunsch, Ph.D.
Cecil and Ida Green Professor
of Physical Oceanography
Head of the Department

Professors

Keiiti Aki, Ph.D.
Professor of Geophysics

William Francis Brace, Ph.D.
Cecil and Ida Green Professor
of Geology

Burrell Clark Burchfiel, Ph.D.
Professor of Geology

Roger George Burns, Ph.D.
Professor of Geochemistry

Stanley Robert Hart, Ph.D.
Professor of Geology and
Geochemistry

Theodore Richard Madden, Ph.D.
Professor of Geophysics

Gordon Hemenway Pettengill,
Ph.D.
Professor of Planetary Physics

Frank Press, Ph.D.
Robert R. Shrock Professor
of Geophysics
(On leave)

John George Sclater, Ph.D.
Professor of Marine Geophysics

Irwin Ira Shapiro, Ph.D.
Professor of Geophysics
and Physics

M. Gene Simmons, Ph.D.
Professor of Geophysics

M. Nafi Toksöz, Ph.D.
Professor of Geophysics
Director, George R. Wallace, Jr.,
Geophysical Observatory

Associate Professors

Tanya Maria Atwater, Ph.D.
Associate Professor of Marine
Geology
(On leave)

Charles Claude Counselman III,
Ph.D.
Associate Professor of Planetary
Sciences

John Marmion Edmond, Ph.D.
Associate Professor of
Oceanography

James Luc'low Ellicott, Ph.D.
Associate Professor of Astronomy
and Physics
Director, George R. Wallace, Jr.
Astrophysical Observatory

Frederick August Frey, Ph.D.
Associate Professor of
Geochemistry

John Simpson Lewis, Ph.D.
Associate Professor of
Geochemistry

Peter Molnar, Ph.D.
Associate Professor of Earth
Sciences
(On leave)

William Hamet Pinson, Jr., Ph.D.
Associate Professor of Geology

Sean Carl Solomon, Ph.D.
Associate Professor of Geophysics

John Brelsford Southard, Ph.D.
Associate Professor of Geology

Assistant Professors

Edward Allen Boyle, Ph.D.
Assistant Professor of Chemical
Oceanography

Charles C. Eriksen, Ph.D.
Assistant Professor of Physical
Oceanography

Timothy L. Grove, Ph.D.
Assistant Professor of Petrology

Frank S. Spear, Ph.D.
Assistant Professor of Geology

Honorary Lecturer

Cecil H. Green, S.M., D.S.C.,
LL.D.

Administrative Officer

Douglas Pfeiffer

Administrative Staff

Deborah W. Gillett
MaryLou G. Leclair

Senior Research Associate

Michael A. Chinnery, Ph.D.

Senior Research Scientists

Thomas Bard McCord, Ph.D.
Joseph Broughton Walsh, Ph.D.

Principal Research Scientist

Nobumichi Shimizu, D.Sc.
Director, Ion Probe Facility

Research Associates

Bernard Chouet, Ph.D.
Brian Corey, Ph.D.
William Cotton, Ph.D.
Peter G. Ford, Ph.D.
Sergei Gourevitch, Ph.D.
D. Edmunds Harrison, Ph.D.
Albert Hsui, Ph.D.
Robert King, Ph.D.
George Lorlot, Ph.D.
Paul MacNeil, Ph.D.
Elaine Padovani, Ph.D.

Alan Parkes, Ph.D.,
Director, Microprobe Facility

Barry Parsons, Ph.D.
Michael Ratner, Ph.D.
Robert Reasenberg, Ph.D.
Brian Tucker, Ph.D.

Postdoctoral Associates

Michel Bouchon, Ph.D.
Chuen Hon Cheng, Ph.D.
Wai-Ying Chung, Ph.D.
Larry Cox, Ph.D.
Edward Dunham, Ph.D.
Brian Evans, Ph.D.
Richard French, Ph.D.
Marc Gorenstein, Ph.D.
Ichiro Kawasaki, Ph.D.
Ozer Kenar, Ph.D.
Richard Langley, Ph.D.
Russell McDuff, Ph.D.
Christopher Measures, Ph.D.
Debra Stakes, Ph.D.
Jill Wittels, Ph.D.

Crosby Visiting Professors

Tor H. Nilsen, Ph.D.
Richard H. Sillitoe, Ph.D.

Visiting Scientists

Peter Baines, Ph.D.
Aviva Brecher, Ph.D.
Hu Dunxin
Giselher Gust, Ph.D.
Barbara Romanovicz, Ph.D.
Wu Ru Shan

Professors Emeriti

Martin Julian Buerger, Ph.D.
Institute Professor, Emeritus
Professor of Mineralogy and
Crystallography, Emeritus

Harold Williams Fairbairn, Ph.D.
Professor of Geology, Emeritus

Patrick Mason Hurley, Ph.D.
Professor of Geology, Emeritus

Robert Rakes Shrock, Ph.D.
Professor of Geology, Emeritus

The study of earth and planetary sciences at M.I.T. 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 the Institute, modern problems that receive special emphasis include: mineralogy-crystallography; experimental petrology; rock mechanics; geochemistry; geochronology; seismology; planetary magnetism and electricity; heat flow; high pressure geophysics; geophysical fluid dynamics; optical, radio, and radar astronomy; dynamical astronomy; planetary atmospheres and surfaces; meteoritics; particles in planetary fields; physical and chemical oceanography; and marine geology and geophysics.

These problems are attacked by *in situ* physical and chemical measurements, laboratory studies, and theoretical treatments. Experimental facilities for training and research are available in the Department; in M.I.T. laboratories and centers such as the Center for Space Research, the Lincoln Laboratory, the Haystack radar and radio observatory, and the Wallace Astrophysical and Geophysical observatories; and in cooperating institutions such as the Woods Hole Oceanographic Institution.

Undergraduate Study

Bachelor of Science in Earth and Planetary Sciences Course XII

The Department offers undergraduate preparation for professional careers in the earth and planetary sciences. Some students concentrate in specific fields. Others choose to combine basic studies in mathematics, physics, chemistry, or engineering with applications to the earth and planetary sciences.

Fifth-Year Programs

Studies in physics, chemistry, biology, applied mathematics, and electrical or civil engineering are directly relevant preparation for work in earth and planetary sciences. Students from these departments can arrange flexible programs of study in Course XII which lead to a second Bachelor of Science in one of these areas.

Students with strong academic records from the Departments of Chemistry, Electrical Engineering and Computer Science, Physics, Earth and Planetary Sciences, or Mathematics should be able to complete a Master of Science in Earth and Planetary Sciences in one year of additional study, particularly if their programs are arranged for this purpose from the beginning of the fourth year. Applications for graduate enrollment in the Department are considered any time after the beginning of the fourth year. The decision on admission of M.I.T. undergraduates to the graduate program can be made about one month after receipt of the completed application. Students may receive the Bachelor of Science as soon as the requirements are completed, or may elect to defer the award for simultaneous presentation with the Master of Science.

Inquiries

Additional information may be obtained from the Department of Earth and Planetary Sciences, Room 54-912, M.I.T., Cambridge, Massachusetts 02139, (617) 253-3381.

Graduate Study

The Department of Earth and Planetary Sciences offers opportunities for graduate study and research in a wide range of fields, as outlined in Chapter IV of this catalogue. 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.

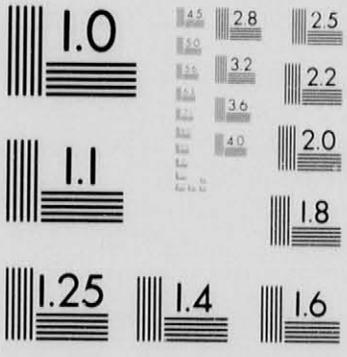
Graduate students pursue both theoretical and experimental aspects of these subjects. Modern laboratory facilities, computers, instrumentation, and extensive collections of specimens and data are available to students. Field study is an essential part of the graduate curriculum in geology, geophysics, and geochemistry, and special arrangements may be made for summer employment and field research on Departmental projects and with industrial organizations and government agencies.

M.I.T. 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 M.I.T.-Woods Hole Joint Program in Oceanography, following the School of Science.

Entrance Requirements for Graduate Study

In addition to the General Institute Requirements for admission, the Department requires preparation equivalent to the curriculum for the Bachelor of Science in Earth and Planetary Sciences at M.I.T. 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.



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OF

11

Subjects in Earth and Planetary Sciences

Master of Science in Earth and Planetary Sciences or in Oceanography

The General Institute Requirements for the degree of Master of Science in Earth and Planetary Science or in Oceanography are described in Chapter IV. An individual program of study and research is arranged to suit the special background, needs, and goals of each student. The program is worked out in detail by the student with his or her personal faculty advisor and a Departmental committee.

Doctor of Philosophy and Doctor of Science

General Institute Requirements for the degree of Doctor of Philosophy or Doctor of Science are given in Chapter IV. A specialized program of study and research is tailored to each student's background, needs, and goals by the student in consultation with a personal faculty advisor and a Departmental committee. A doctoral candidate's program is expected to be broad and to include formal study in other departments in addition to the specialized subjects which prepare the candidate for thesis research. Thesis research normally is begun immediately after successful completion of the general examination, by the end of the second year. The general examination is intended to test the candidate's preparation for, and ability to perform, independent research.

Thesis research is closely supervised by one or more faculty members who are interested and knowledgeable in the research topic, who are chosen by the student, and who may be members of other departments. The thesis is expected to meet high professional standards, and to be a significant original contribution to the scientific field.

Teaching and Research Assistantships

The Department regularly appoints 50 to 60 assistants who are candidates for a graduate degree. Teaching assistants conduct scheduled laboratory sections and examinations, grade papers, and prepare teaching materials. Research assistants work on Departmental research projects. Such work may be closely related to, and even identical to, the student's thesis research.

Inquiries

Additional information regarding academic and research programs in earth and planetary sciences, admission requirements, assistantship appointments, financial aid, etc. may be obtained by writing to the Department of Earth and Planetary Sciences, Room 54-912, M.I.T., Cambridge, Massachusetts 02139, (617) 253-3381. The Department publishes, annually, a booklet describing current research activities.

(A) following the name of the subject indicates that it is an approved subject for a graduate degree and is given primarily for graduate students.

| | |
|---------|--|
| 12.U.R. | Undergraduate Research |
| 12.00 | Evolution of the Earth |
| 12.002 | The Earth and the Planets |
| 12.003J | Environmental Ecology I |
| 12.004J | Environmental Ecology II |
| 12.01 | Geological Processes, Features and History |
| 12.011 | Sedimentary Processes: Rivers |
| 12.012 | Sedimentary Processes: Glaciers |
| 12.013 | Sedimentary Processes: The Wind |
| 12.014 | Sedimentary Processes: Coastlines |
| 12.016 | Sediments and Sedimentary Rocks |
| 12.02 | Physics and Chemistry of Minerals and Rocks |
| 12.03 | Structural Geology |
| 12.043J | Introduction to Mining and Mineral Technology |
| 12.051 | Field Geology I |
| 12.052 | Field Geology II |
| 12.053 | Field Geology III |
| 12.061 | Petrology I |
| 12.062 | Petrology II |
| 12.066 | Analysis of Geological Materials |
| 12.071 | Geochemistry |
| 12.091- | Special Problems |
| 12.094 | |
| 12.095 | Teaching Earth and Planetary Sciences |
| 12.101 | Physics of the Earth |
| 12.102 | Introduction to Marine Geophysics (A) |
| 12.103 | Plate Tectonics |
| 12.105 | Introduction to Field Geophysics |
| 12.106 | Geophysics Field Study |
| 12.107 | Geophysics Field Study II |
| 12.111 | Survey of Astronomy I |
| 12.112 | Survey of Astronomy II |
| 12.113 | Astronomy I |
| 12.114 | Astronomy II |
| 12.115J | Dynamical Astronomy |
| 12.116 | Observational Techniques of Optical Astronomy |
| 12.121 | Exploration of the Solar System |
| 12.131J | Planetary Physics and Chemistry I |
| 12.132J | Planetary Physics and Chemistry II |
| 12.20J | Environmental Chemistry of the Ocean-Atmosphere System |

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|---------|---|---------|--|
| 12.21 | Physics of the Ocean | 12.77 | Marine Geophysical Data Interpretation (A) |
| 12.221- | Project Studies in | | |
| 12.229 | Oceanography | 12.771- | Seminar in Oceanography |
| 12.301- | Seminar in Geology and | 12.779 | at Woods Hole (A) |
| 12.304 | Geochemistry (A) | 12.781- | Special Problems in |
| 12.31 | World Regional Tectonics (A) | 12.789 | Chemical Oceanography at Woods Hole (A) |
| 12.311 | Seminar in Regional Tectonics (A) | 12.791- | Special Problems in Marine |
| 12.32 | Mechanics of Sedimentary Processes (A) | 12.799 | Geology and Geophysics at Woods Hole (A) |
| 12.33 | Petroleum Geology | 12.80 | Marine Chemistry |
| 12.34 | Mineral Deposits | 12.81 | Waves and Tides (A) |
| 12.35 | Rock Mechanics (A) | 12.82 | Marine Geochemistry of Sediments |
| 12.355 | Seminar in Rock Mechanics (A) | 12.83 | Marine Geochemistry (A) |
| 12.385- | Special Problems in | 12.84 | Organic Geochemistry (A) |
| 12.399 | Geology-Geochemistry (A) | 12.85 | Oceanographic Time Series (A) |
| 12.40 | Chemistry of the Earth (A) | 12.86 | General Circulation of the Oceans (A) |
| 12.411 | Isotope Geology (A) | 12.87 | Equatorial Physical Oceanography |
| 12.42 | Geochemistry of the Solid State (A) | 12.881- | Seminar in Oceanography |
| 12.45 | Trace Element Geochemistry (A) | 12.889 | at M.I.T. (A) |
| 12.46 | Geochemical Kinetics (A) | 12.891- | Special Problems in |
| 12.47 | Advanced Metamorphic Petrology (A) | 12.899 | Oceanography at M.I.T. (A) |
| 12.490- | Advanced Seminar in | | |
| 12.499 | Geology and Geochemistry | | |
| 12.512 | Geoelectricity (A) | | |
| 12.514 | Geomagnetism (A) | | |
| 12.521 | Elements of Seismology (A) | | |
| 12.522 | Advanced Seismology (A) | | |
| 12.523 | Seismology Seminar (A) | | |
| 12.53 | Inverse Problems in Geophysics (A) | | |
| 12.54 | Planetary Interiors (A) | | |
| 12.551 | Seminar on the Petrology and Physical Properties of Igneous and Metamorphic Rocks (A) | | |
| 12.56 | Advanced Seminar in Plate Tectonics (A) | | |
| 12.581- | Seminar in Geophysics (A) | | |
| 12.589 | | | |
| 12.591- | Special Problems in | | |
| 12.599 | Geophysics (A) | | |
| 12.626J | Radio Interferometry (A) | | |
| 12.627J | Techniques of Radar Astronomy (A) | | |
| 12.631J | Planetary Atmospheres (A) | | |
| 12.636J | Current Research in Meteoritics (A) | | |
| 12.691- | Special Problems in | | |
| 12.699 | Planetary Physics (A) | | |
| 12.72 | Oceanic Petrology (A) | | |
| 12.73 | Introduction to Marine Geology (A) | | |
| 12.74 | Marine Micropaleontology (A) | | |
| 12.75 | Marine Sediments (A) | | |
| 12.752 | Paleomagnetism (A) | | |

Department of Mathematics

Daniel J. Kleitman, Ph.D.
Professor of Applied Mathematics
Head of the Department

Louis Norberg Howard, Ph.D.
Professor of Mathematics
Chairman, Committee on Applied
Mathematics

Franklin Paul Peterson, Ph.D.
Professor of Mathematics
Chairman, Committee on Pure
Mathematics

Professors

Warren Ambrose, Ph.D.
Professor of Mathematics

Nesmith Cornett Ankeny, Ph.D.
Professor of Mathematics

Michael Artin, Ph.D.
Professor of Mathematics

David John Benney, Ph.D.
Professor of Applied Mathematics

Hung Cheng, Ph.D.
Professor of Applied Mathematics

Herman Chernoff, Ph.D.
Professor of Applied Mathematics

Richard Mansfield Dudley, Ph.D.
Professor of Mathematics

Harvey Philip Greenspan, Ph.D.
Professor of Applied Mathematics

Victor William Guillemin, Ph.D.
Professor of Mathematics

Sigurdur Helgason, Ph.D.
Professor of Mathematics

Francis Begnaud Hildebrand, Ph.D.
Professor of Mathematics

Kenneth Myron Hoffman, Ph.D.
Professor of Mathematics
(Absent)

Daniel Marinus Kan, Ph.D.
Professor of Mathematics

Steven Kleiman, Ph.D.
Professor of Mathematics
(Absent, spring)

Bertram Kostant, Ph.D.
Professor of Mathematics

Chia-Chiao Lin, Ph.D.
Institute Professor
Professor of Applied Mathematics

George Lusztig, Ph.D.
Professor of Mathematics

Willem Van Rensselaer Malkus,
Ph.D.
Professor of Applied Mathematics
(Absent)

Arthur Paul Mattuck, Ph.D.
Class of 1922 Professor
of Mathematics

Richard Burt Melrose, Ph.D.
Professor of Mathematics

James Raymond Munkres, Ph.D.
Professor of Mathematics

Steven Alan Orszag, Ph.D.
Professor of Applied Mathematics

Seymour Aubrey Papert, Ph.D.
Professor of Mathematics
Cecil and Ida Green Professor of
Education

Daniel Gray Quillen, Ph.D.
Professor of Mathematics

Hartley Rogers, Jr., Ph.D.
Professor of Mathematics
Associate Provost

Gian-Carlo Rota, Ph.D.
Professor of Applied Mathematics
and Philosophy

Gerald Enoch Sacks, Ph.D.
Professor of Mathematical Logic

Richard Donald Schafer, Ph.D.
Professor of Mathematics

Irving Ezra Segal, Ph.D.
Professor of Mathematics
(Absent, spring)

Claude Elwood Shannon, Ph.D.
Donner Professor of Science
(Absent)

Richard Peter Stanley, Ph.D.
Professor of Applied Mathematics

Harold Mead Stark, Ph.D.
Professor of Mathematics
(Absent, fall)

William Gilbert Strang, Ph.D.
Professor of Mathematics

Alar Toomre, Ph.D.
Professor of Applied Mathematics

George William Whitehead, Ph.D.
Professor of Mathematics

Associate Professors

William Hermas DuMouchel, Ph.D.
Associate Professor of Applied
Mathematics

Dorian Goldfeld, Ph.D.
Associate Professor of Mathematics

Victor Kač, Ph.D.
Associate Professor of Mathematics

Richard A. Shore, Ph.D.
Associate Professor of Mathematics
(Visiting, spring)

Michèle Françoise Vergne
Associate Professor of Mathematics

Assistant Professors

Leonard M. Adleman, Ph.D.
Assistant Professor of Applied
Mathematics

Mark Adler, Ph.D.
Assistant Professor of Mathematics
(Visiting, fall)

William Thomson Mulhinch
Dunsmuir, Ph.D.
Assistant Professor of Applied
Mathematics

Sy David Friedman, Ph.D.
Assistant Professor of Mathematics

Yue-Ying Lau, Ph.D.
Assistant Professor of Applied
Mathematics

Gary Lee Miller, Ph.D.
Assistant Professor of Applied
Mathematics

Frank Morgan, Ph.D.
Assistant Professor of Mathematics

Rodolpho Ruben Rosales, Ph.D.
Assistant Professor of Applied
Mathematics
(Absent)

Adi Shamir, Ph.D.
Assistant Professor of Applied
Mathematics

Ka Kit Tung, Ph.D.
Assistant Professor of Applied
Mathematics

David Alexander Vogan, Jr., Ph.D.
Assistant Professor of Mathematics

Lecturers

William A. Adkins, Ph.D.
Gregory Richard Baker, Ph.D.
Jonathan Sacks, Ph.D.
Patrick Sze Chau Yeung, Ph.D.

C. L. E. Moore Instructors

Constantine John Callias, Ph.D.
Leonard Chastkofsky, Ph.D.
Kaori Imai, Ph.D.
Woody Lichtenstein, Ph.D.
Hendrik Maazen, Ph.D.
Dale Harvey Peterson, Ph.D.
Robert Scott Rumely, Ph.D.
Paul Sydney Selick, Ph.D.
Theodore Shifrin, Ph.D.
Dennis Warren Stanton, Ph.D.
Michael Jay Stob, Ph.D.
Howard David Yingst, Ph.D.

Instructors

Deborah Faye Allinger, Ph.D.
Charles Roy Hamaker, Ph.D.
Alvany M. P. Rocha-Caridi, Ph.D.
Gunther Uhlmann, Ph.D.

Instructors in Applied Mathematics

Richard Davis, Ph.D.
Ira Martin Gessel, Ph.D.
Jeffrey N. Kahn, Ph.D.
Joseph Pee Sin Kung, Ph.D.
Kerry Anne Landman, Ph.D.
Livia Lustman, Ph.D.
Brian Michael McCay, Ph.D.
Simon Mochon, Ph.D.
Allen Mark Waxman, Ph.D.

Postdoctoral Associate

Leon Gardner Shiman, Ph.D.

Administrative Officer

James Edward Dalton

Professors Emeriti

Prescott Durand Crout, Ph.D.
Professor of Mathematics, Emeritus

William Ted Martin, Ph.D.
Professor of Education and
Mathematics, Emeritus

Isadore Manual Singer, Ph.D.
Professor of Mathematics, Emeritus

Dirk Jan Struik, Ph.D.
Professor of Mathematics, Emeritus

George Brinton Thomas, Jr., Ph.D.
Professor of Mathematics, Emeritus

George Proctor Wadsworth, Ph.D.
Professor of Mathematics, Emeritus

Department of Mathematics

Undergraduate Study

Bachelor of Science in Mathematics Course XVIII

Each undergraduate's program is arranged through continual collaboration between the individual student and his or her faculty counselor. In many cases, the undergraduate curriculum in mathematics is preparatory to further professional training at the graduate level. For this purpose students are encouraged both to obtain a substantial grounding in each of the fundamental branches of mathematics and to explore certain fields of application in order to establish a basis for the selection of an appropriate field of graduate specialization.

In light of students' career objectives — teaching, participation in research programs of an industrial or government-sponsored organization, or work as a consultant in a business or a modern high-speed computation center — the immediate educational aim of the Department is to provide both an understanding of a substantial part of the existing body of mathematical knowledge and an ability to impart this knowledge to others. Most importantly, however, the Department hopes to inspire a deep interest in the discovery or invention of new mathematics or in the application of mathematics to a new field.

Undergraduates wishing to work in small groups under the supervision of a faculty member or to do individual work with a member of the Department may elect either to participate in a mathematics seminar or to write a thesis. The experience gained from active participation in a seminar conducted by a research mathematician may be particularly valuable for a student planning to pursue graduate work in some branch of mathematics.

There are two programs: a general mathematics program, and a program for those students who wish to specialize in applied mathematics.

The requirements for the general mathematics program (any eight subjects beyond the basic elementary ones) are unspecific in order to accommodate several classes of students: those interested in a professional career in pure mathematics, those who need maximum flexibility in order to explore their interests in both pure and applied mathematics, and finally, those who may not be professionally interested in mathematics, but who wish to use it in connection with other work, or as a general Institute major.

Students who expect to pursue a career in **pure mathematics** should normally include in their program at least a year of analysis, a year of algebra, and a term of topology; remaining subjects may be chosen from such areas as logic, number theory, differential topology, combinatorial theory, probability and statistics, or other applied mathematics subjects. They should also, if possible, take one or two graduate-level subjects and a seminar.

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 M.I.T. concerns the following principles and their mathematical formulations: propagation, equilibrium, stability, optimization, cybernetics, statistics, and random processes. Students in the applied mathematics program normally take Principles of Applied Mathematics, algebra, and complex variables, followed by at least four subjects either in continuous applied mathematics, probability and statistics, or discrete applied mathematics (combinatorics, mathematical theory of computation).

Sample programs emphasizing different areas of specialization in applied mathematics are available in the Undergraduate Mathematics office.

Inquiries

Inquiries regarding academic programs may be addressed to the Undergraduate Mathematics Office, Room 2-108, M.I.T., Cambridge, Massachusetts 02139, (617) 253-2416.

Graduate Study

The Department offers programs covering a broad range of subjects which lead to the Master of Science, the Doctor of Philosophy, and the Doctor of Science. Numerous informal seminars, as well as weekly mathematics colloquia sponsored by M.I.T., Brandeis University, and Harvard University, supplement basic programs.

Candidates whose primary interest is in the field of **pure mathematics (Plan A)** ordinarily take most of their subjects in the Department. In addition to their advanced specialization, students will be encouraged to acquire breadth by taking basic subjects in analysis, algebra, geometry, logic, and topology. Candidates whose primary interest is in **applied mathematics (Plan B)** are encouraged to study important aspects of one or more engineering or scientific fields closely related to research in applied mathematics. Assistance or collaboration in problems in pure or applied mathematics which are being investigated by members of the staff may constitute part of a graduate student's program.

Entrance Requirements for Graduate Study

Students are expected to have one year of college-level natural science in addition to an undergraduate mathematics program which approximates that of mathematics majors at M.I.T. Students may enter the applied mathematics program from any undergraduate field of concentration; however, special consideration will be 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. Students in applied mathematics specializing in statistics may be admitted to work directly for the Master of Science; almost all other graduate programs lead directly to the Ph.D.

Doctor of Philosophy and Doctor of Science

The basic requirements for these degrees are given in Chapter IV, and the details of the program are outlined in a set of notes available from the Department.

Plan A In pure mathematics, the general examination is oral, and includes three areas which are chosen by the students in consultation with their advisors. (A written examination may also be required, and the student's proposal is reviewed by the Graduate Committee.) This examination should be passed in 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.

In either Plan A or Plan B, after successfully passing the general examination, the student may officially begin thesis research under the supervision of the thesis advisor. The thesis is expected to represent original research of high quality and should be finished normally by the end of the fourth year of graduate study. Upon submitting the thesis the student must pass an oral thesis examination.

Teaching and Research Assistantships

A limited number of fellowships, as well as teaching and research assistantships, are available to graduate students in mathematics.

Inquiries

Any additional information regarding academic or research programs in mathematics, admissions, or financial aid, may be obtained from Phyllis Ruby, Graduate Office, Room 2-233, M.I.T., Cambridge, Massachusetts 02139, (617) 253-2689.

Subjects in Mathematics

(A) following the name of the subject indicates that it is an approved subject for a graduate degree and is given primarily for graduate students.

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|---------|--|
| 18.U.R. | Undergraduate Research |
| 18.001 | Calculus |
| 18.002 | Calculus |
| 18.01 | Calculus |
| 18.012 | Calculus with Theory |
| 18.02 | Calculus |
| 18.022 | Calculus with Theory |
| 18.023 | Topics in Calculus |
| 18.03 | Differential Equations |
| 18.031 | Introduction to Linear Algebra and Differential Equations |
| 18.04 | Complex Variables with Applications |
| 18.041 | Principles of Applied Mathematics |
| 18.042 | Principles of Applied Mathematics |
| 18.05 | Introduction to Probability and Statistics |
| 18.055J | Biostatistics I (A except XVIII) |
| 18.057 | Introduction to Applied Statistics (A except XVIII) |
| 18.061 | Introduction to Algebraic Systems |
| 18.07 | Numerical Analysis with a Programmable Calculator |
| 18.075 | Advanced Calculus for Engineers (A except II, VI, VIII, XII, XIII, XVI, XVIII, XXII) |
| 18.076 | Advanced Calculus for Engineers (A except II, VI, XVI, XVIII, XXII) |
| 18.085 | Methods of Applied Mathematics for Engineers (A except VI and XVIII) |
| 18.089 | Review of Mathematics |
| 18.093 | Tutoring in Mathematics |
| 18.094 | Seminar in Mathematical Education |
| 18.099 | Independent Activities |
| 18.100 | Analysis I (A except XVIII) |
| 18.101 | Analysis II-M (A except XVIII) |
| 18.102 | Analysis II-L (A except XVIII) |
| 18.103 | Fourier Analysis — Theory and Applications (A except XVIII) |
| 18.104 | Seminar in Analysis |
| 18.109 | The Architecture of Modern Analysis (A) |
| 18.115 | Functions of a Complex Variable (A) |
| 18.116 | Topics in Complex Variables (A) |
| 18.117 | Topics in Several Complex Variables (A) |

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| 18.125 | Measure and Integration (A) | 18.395 | Applications of Group Theory to Quantum Mechanics (A) | 18.704 | Seminar in Algebra and Number Theory |
| 18.126 | Functional Analysis (A) | 18.396 | Topics in Theoretical Physics (A) | 18.705 | Algebra III (A) |
| 18.135 | Fourier Analysis (A) | 18.411 | Applied Algebra | 18.706 | Algebra IV (A) |
| 18.155 | Introduction to Partial Differential Equations (A) | 18.419J | Cryptography and Cryptanalysis (A) | 18.710 | Abstract Linear Algebra |
| 18.157 | Partial Differential Equations I (A) | 18.420J | Computability, Automata, and Formal Languages | 18.711 | Game Theory and Mathematical Programs |
| 18.158 | Partial Differential Equations II (A) | 18.424 | Computational Combinatorics | 18.715 | Homological Algebra (A) |
| 18.165 | Pseudodifferential Operators (A) | 18.425 | Diophantine Complexity (A) | 18.716 | Homological Algebra (A) |
| 18.168 | Analysis on Lie Groups and Homogeneous Spaces (A) | 18.427J | Theory of Computation (A) | 18.725 | Algebraic Geometry (A) |
| 18.175 | Theory of Probability (A) | 18.428 | Advanced Topics in Computation (A) | 18.727 | Topics in Algebraic Geometry (A) |
| 18.177 | Stochastic Processes (A) | 18.436 | Topics in Algorithms and Complexity | 18.735 | Topics in Algebra (A) |
| 18.194 | Seminar in Analysis | 18.437J | Algorithms (A) | 18.737 | Linear Algebraic Groups (A) |
| 18.199 | Topics in Analysis (A) | 18.438J | Advanced Algorithms (A) | 18.739 | Theory of Invariants (A) |
| 18.247 | Operator Theory (A) | 18.440 | Probability and Random Variables | 18.745 | Introduction to Lie Algebras (A) |
| 18.255 | Mathematical Mechanics and Field Theory (A) | 18.441 | Statistical Inference (A except XVIII) | 18.749 | Infinite-dimensional Lie Groups (A) |
| 18.257 | Group Theory and Fundamental Physics (A) | 18.443 | Statistics for Applications (A except XVIII) | 18.755 | Introduction to Lie Groups (A) |
| 18.259 | Theoretical and Observational Cosmology (A) | 18.445J | Introduction to Stochastic Processes (A) | 18.756 | Analysis of Lie Groups (A) |
| 18.275 | Numerical Analysis (A except XVIII) | 18.446 | Applied Time Series Analysis (A) | 18.757 | Representations of Lie Groups (A) |
| 18.276 | Numerical Analysis (A except XVIII) | 18.448 | The Analysis of Categorical Data (A) | 18.758 | Representations of Lie Groups (A) |
| 18.284 | Introduction to Functions of a Complex Variable (A except XVIII) | 18.455 | Analysis of Variance and Design of Experiments (A) | 18.759 | Automorphic Forms and Group Representations (A) |
| 18.285 | Introduction to Functions of a Complex Variable (A) | 18.456 | Multivariate Methods in Statistics (A) | 18.769 | Topics in Lie Theory (A) |
| 18.295 | Tensor Algebra (A) | 18.457J | Statistics for Model Building (A) | 18.775 | Algebraic Number Theory (A) |
| 18.301 | Introduction to Physical Mathematics I | 18.458 | Statistical Robustness (A) | 18.776 | Algebraic Number Theory (A) |
| 18.304 | Introduction to Physical Mathematics II | 18.459 | Statistical Laboratory (A) | 18.781 | Theory of Numbers |
| 18.305 | Methods of Applied Mathematics I (A) | 18.465 | Topics in Statistics (A) | 18.785 | Analytic Number Theory |
| 18.306 | Methods of Applied Mathematics II (A) | 18.466 | Mathematical Statistics (A) | 18.786 | Topics in Number Theory |
| 18.307 | Methods of Applied Mathematics III (A) | 18.467 | Mathematical Statistics (A) | 18.794 | Seminar in Algebra and Number Theory |
| 18.308 | Wave Motion (A) | 18.468 | Advanced Time Series Analysis (A) | 18.901 | Introduction to Topology I (A except XVIII) |
| 18.313 | Probability | 18.485 | Risk Theory (A) | 18.902 | Introduction to Topology II (A except XVIII) |
| 18.314 | Applied Combinatorial Analysis | 18.511 | Introduction to Mathematical Logic | 18.903 | Introduction to Algebraic Topology |
| 18.315 | Combinatorial Theory (A) | 18.515 | Mathematical Logic (A) | 18.904 | Seminar in Topology |
| 18.316 | Seminar in Combinatorics (A) | 18.525 | Seminar in Logic (A) | 18.905 | Algebraic Topology (A) |
| 18.325 | Topics in Applied Mathematics (A) | 18.565 | Recursion Theory (A) | 18.906 | Algebraic Topology (A) |
| 18.335 | Numerical Methods of Applied Mathematics I (A) | 18.566 | Higher Recursion Theory (A) | 18.915 | Graduate Topology Seminar (A) |
| 18.336 | Numerical Methods of Applied Mathematics II (A) | 18.575 | Theory of Models (A) | 18.917 | Advanced Topology (A) |
| 18.354 | Fluid Mechanics | 18.576 | Theory of Models (A) | 18.950 | Elementary Differential Geometry |
| 18.355 | Fluid Mechanics (A) | 18.585 | Set Theory (A) | 18.961 | Elementary Differential Topology |
| 18.356 | Rotating Fluids (A) | 18.586 | Set Theory (A) | 18.965 | Geometry of Manifolds (A) |
| 18.357 | Seminar in Fluid Dynamics (A) | 18.587 | Infinity Combinatorics (A) | 18.966 | Geometry of Manifolds (A) |
| 18.370 | Introduction to Dynamics in Astronomy | 18.595 | Seminar on Current Topics in Logic (A) | 18.969 | Topics in Geometry (A) |
| 18.375 | Stellar Dynamics, Galaxies, and Plasmas (A) | 18.599 | Philosophy of Mathematics and of Natural Science | 18.975 | Elliptic Operators (A) |
| | | 18.700 | Linear Algebra | 18.976 | Elliptic Operators (A) |
| | | 18.701 | Algebra I | 18.994 | Seminar in Geometry |
| | | 18.702 | Algebra II | 18.999 | Mathematical Reading |
| | | 18.703 | Modern Algebra | | |

Department of Meteorology

Edward Norton Lorenz, Sc.D.
Professor of Meteorology
Head of the Department

Professors

Jule Gregory Charney, Ph.D., Sc.D.
Alfred P. Sloan Professor of
Meteorology

John Ellsworth Hart, Ph.D.
Professor of Oceanography
(Visiting)

Erik L. Mollo-Christensen, Sc.D.
Professor of Oceanography

Reginald Edward Newell, Sc.D.
Professor of Meteorology

Frederick Sanders, Sc.D.
Professor of Meteorology

Peter Hunter Stone, Ph.D.
Professor of Meteorology

Associate Professors

Ronald George Prinn, Sc.D.
Associate Professor of Meteorology

Eugenia Kalnay de Rivas, Ph.D.
Associate Professor of Meteorology
(Absent)

Jagadish Shukla, Ph.D.
Associate Professor of Meteorology
(Visiting)

Assistant Professors

Mark Alan Cane, Ph.D.
Assistant Professor of
Oceanography

Kerry Andrew Emanuel, Ph.D.
Assistant Professor of Meteorology

Glenn Richard Flierl, Ph.D.
Assistant Professor of
Oceanography

Richard Eugene Passarelli, Jr., Sc.D.
Assistant Professor of Meteorology

David Allan Randall, Ph.D.
Assistant Professor of Meteorology

Senior Lecturer

John Vaughan Evans, Ph.D.

Administrative Officer

Jane Sinnott McNabb, B.A.

Postdoctoral Associates

James Howard Curry, Ph.D.
Bhupendra Nath Goswami, Ph.D.
Claude Jean Frankignoul, Ph.D.

Visiting Scientists

Petr Chýlek, Ph.D.
Kshudiram Saha, Ph.D.

Visiting Lecturer

Richard David Rosen, Ph.D.

Professors Emeriti

James Murdoch Austin, Sc.D.
Professor of Meteorology,
Emeritus

Henry Garrett Houghton, Sc.D.
Professor of Meteorology,
Emeritus

Delbar Pouleur Kelly, S.B.
Associate Professor of Meteorology,
Emeritus

Hurd Curtis Willett, Ph.D.
Professor of Meteorology,
Emeritus

Department of Meteorology

Undergraduate Study

Meteorology is the science of the atmospheres, primarily that of the earth but also of other planets. It is one of the sciences which deal with the physical properties of our environment. Many of our unsolved problems depend for their solution on increased knowledge of this environment. The Department's educational aim is to provide its students with a broad background in meteorology and related sciences, which will prepare them to meet these challenging problems.

The Department also offers a program in physical oceanography, the study of how oceanic waves, currents, and density fields are created and how they interact with the atmosphere.

Modern professional practice in both fields, at all educational levels from baccalaureate to doctoral, emphasizes the quantitative aspect of the subject. This requires a considerable background in the more basic sciences in addition to work in meteorology or oceanography proper. The Department, therefore, does not offer an undergraduate major or Bachelor of Science in meteorology or oceanography. A selection of undergraduate electives is offered instead.

Undergraduate students at M.I.T. who wish to prepare for graduate work in meteorology or physical oceanography are advised to register in the Interdisciplinary Science Program offered by the School of Science. Adequate preparation is also provided by other M.I.T. undergraduate curricula, particularly in the Departments of Mathematics and Physics, and in the Environmental Science program of Course XII (Earth and Planetary Sciences).

Advice on registration for this purpose and selection of subjects as electives is available from either Professor F. Sanders, Room 54-1612, from the faculty member in charge of each subject, or from Departmental Headquarters, Room 54-1712.

Graduate Study

Emphasis in the graduate program is placed on the theoretical and quantitative approach, supplemented by empirical information and quantitative data analysis. This approach is based on the conviction that progress in meteorology and oceanography depends on the applications of the laws of physics, and that predictive modeling requires more than blind usage of statistical inference.

Graduate study in the Department therefore consists of a mixture of theoretical and descriptive courses, sharing a common appreciation of the dynamics of the underlying process.

Undergraduate Preparation

The most essential element is a sound preparation in mathematics and physics, supplemented if possible by some chemistry. Exposure to subjects in earth sciences is helpful but not required. Students who are taking their undergraduate work at other institutions are advised to include in their programs the equivalent of the mathematics and physics contained in the M.I.T. curricula referred to in the section on "Undergraduate Study," in the Meteorology description in *Courses and Degree Programs*. Students with baccalaureate degrees in meteorology or oceanography may be asked to supplement their programs with mathematics and physics during the first year of graduate study, in lieu of some of the introductory meteorology subjects given in the Department.

Meteorology

The Department offers instruction in all the principal areas of meteorology, and conducts an extensive program of sponsored research. Graduate students often are able to participate in this program as Research Assistants. Such active participation is considered a valuable supplement to the formal academic program, and also provides some financial assistance. Active areas of research include the general circulation, synoptic meteorology, numerical weather prediction, turbulence, atmospheric chemistry, upper atmospheric physics and dynamics, climatology, geophysical fluid dynamics, and planetary atmospheres.

Special facilities are available for research and educational activities in all the principal areas of meteorology. There is a weather radar system, actively used in research, and equipped with data processing facilities. Current weather data are received from the National Weather Service, and data are kept on file for most areas of the world; some of these data are in computer-compatible formats. The Department has access to large-scale computing facilities via terminals, and is installing new facilities with the aim of taking better advantage of modern technology and communications in processing weather data and satellite information. The Department also has access to the high-speed computing facilities of the M.I.T. Information Processing Center.

Laboratory facilities include the weather radar and a small fluid mechanics laboratory, and electronics shops used for the assembly and maintenance of measuring equipment.

Cambridge and its surroundings contain a number of institutions active in meteorological research, which, in addition to private commercial firms, include Harvard University, the 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

The Department of Meteorology is an active participant in the joint M.I.T.-Woods Hole Oceanographic Institution graduate program in oceanography. Except in special circumstances, all students in the Department pursuing a doctorate in oceanography are entered in this joint program. At the present time the Master of Science in Oceanography is offered only by the Department of Meteorology and the Department of Earth and Planetary Sciences. Students pursuing this degree do have access to the facilities of the joint program, however. The Master of Science is not a prerequisite to the doctorate, but some students find it desirable to earn a Master of Science on the way to the doctorate. The Department of Meteorology is active in physical oceanography; faculty and students are currently engaged in theoretical studies of the oceanic circulation, observational studies at sea, laboratory models and field and laboratory investigations of the interactions between the atmosphere and the ocean. The programs of graduate students in oceanography also include subjects in oceanography and related areas offered by the Department of Earth and Planetary Sciences, several other M.I.T. departments, and the Woods Hole Oceanographic Institution. Further information on the joint programs with Woods Hole may be found at the end of the School of Science section of this catalogue.

Master of Science in Meteorology or in Oceanography Course XIX

The graduate ("A") subjects required for the Master of Science may be selected from those offered in meteorology or in oceanography and those in related fields offered by other departments. Undue specialization in one branch of the field is discouraged. There are no foreign language requirements for the degree.

Doctor of Philosophy and Doctor of Science

The general requirements for the degrees of Doctor of Philosophy and Doctor of Science are given in Chapter IV. The Department does not require candidates for the doctorate to present evidence of competence in a foreign language or languages. However, 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 foreign languages.

Subjects in Meteorology

Teaching and Research Assistantships

The Department offers a considerable number of Research and Teaching Assistantships each year. Research Assistants work on one of the many research projects in the department.

Teaching Assistants assist in laboratory instruction or in the preparation of teaching materials and the grading of papers. Information concerning these appointments may be obtained from the Head of the Department.

Inquiries

Further information on degree programs, research activities, admission requirements, assistantship appointments, financial aid, etc. may be obtained from Professor Edward N. Lorenz, Department of Meteorology, Room 54-1712, M.I.T., Cambridge, Massachusetts 02139, (617) 253-2281.

(A) following the name of the subject indicates that it is an approved subject for a graduate degree and is given primarily for graduate students.

19.U.R. Undergraduate Research
 19.02 Descriptive Meteorology
 19.03 Meteorological Aspects of Air Pollution
 19.05J Environmental Chemistry of the Ocean-Atmosphere System
 19.10 Climate of the Past
 19.34 Statistical Methods in Meteorology
 19.35 Statistical Problems in Meteorology (A)
 19.43 Synoptic Meteorology I (A)
 19.44 Synoptic Meteorology II (A)
 19.46 Numerical Weather Prediction (A)
 19.61 Dynamic Meteorology I (A)
 19.62 Dynamic Meteorology II (A)
 19.63 Diagnostic Studies of the General Circulation (A)
 19.64 Atmospheric Modeling (A)
 19.65J Turbulence and Random Processes in Fluid Mechanics (A)
 19.66 The Planetary Boundary Layer and Cumulus Convection (A)
 19.681 Dynamics of Large-Scale Circulation of Ocean and Atmosphere (A)
 19.682 Dynamics of Large-Scale Circulation of Ocean and Atmosphere (A)
 19.711 Atmospheric Precipitation Processes (A)
 19.712 Radar Measurements and Storm Structure (A)
 19.72 Atmospheric Radiation (A)
 19.73 Chemistry and Dynamics of Upper Atmospheres (A)
 19.80 Surface and Internal Gravity Waves (A)
 19.81 Introduction to Oceanic Models (A)
 19.82 Introduction to Oceanic Models (A)
 19.83 Physical Oceanography
 19.841 Waves (A)
 19.842 Mesoscale Ocean Dynamics (A)
 19.851 Dynamics of Shallow Seas (A)
 19.853 Turbulence and Friction in the Ocean

19.86 The General Circulation of the Oceans (A)
 19.87 Physical Properties of Seawater (A)
 19.89 Special Problems in Oceanography (A)
 19.891- Special Problems in
 19.899 Oceanography (A)
 19.901 Undergraduate Research Problem
 19.902 Undergraduate Research Program
 19.93 Special Problems in Oceanography
 19.94 Special Problems in Meteorology
 19.961- Special Subject in
 19.969 Meteorology (A)
 19.971- Special Subject in Oceanography
 19.979 (A)

Department of Nutrition and Food Science

Gerald Norman Wogan, Ph.D.
Professor of Toxicology
Head of the Department

Daniel I. C. Wang, Ph.D.
Professor of Biochemical
Engineering
Chairman, Committee on
Food-Related Sciences

Richard Jay Wurtman, M.D.
Professor of Endocrinology
and Metabolism
Chairman, Committee on
Nutrition-Related Sciences

Professors

John Francis Burke, M.D.
Professor of Experimental
Surgery
(Visiting)

Ranjit K. Chandra, M.D.
Professor of Nutritional
Immunology
(Visiting)

Arnold Lester Demain, Ph.D.
Professor of Industrial Microbiology
Graduate Admissions Officer

Samuel Abraham Goldblith, Ph.D.
Professor of Food Science
Vice President, Resource
Development

Marcus Karel, Ph.D.
Professor of Food Engineering

Charles J. Kensler, Ph.D.
Professor of Pharmacology
(Visiting)

Robert Spencer Lees, M.D.
Professor of Cardiovascular Disease
Director, Arteriosclerosis Center

Sanford Arthur Miller, Ph.D.
Professor of Nutritional
Biochemistry
(On leave)

Hamish Nisbet Munro, M.B., D.Sc.
Professor of Physiological
Chemistry

Paul M. 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 J. Sinskey, Sc.D.
Professor of Applied
Microbiology
Registration Officer

Steven Robert Tannenbaum, Ph.D.
Professor of Food Chemistry

Lance J. Taylor, Ph.D.
Professor of Nutritional
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George Wolf, D.Phil.
Professor of Physiological
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Vernon Robert Young, Ph.D.
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Associate Professors

Michael J. Baum, Ph.D.
Associate Professor of
Behavioral Endocrinology

Henri Brunengraber, M.D., Ph.D.
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Physiological Chemistry

Nicholas Catsimpeolas, Ph.D.
Associate Professor of Food
Biochemistry

Charles Leland Cooney, Ph.D.
Associate Professor of Biochemical
Engineering

John Dickson Fernstrom, Ph.D.
Associate Professor of
Physiology

James G. Fox, M.S., D.V.M.
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Animal Medicine
Director, Division of Laboratory
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Abraham Edward Nizel, D.M.D.,
M.S.D.
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(Visiting)

Cho Kyun Rha, Sc.D.
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Process Engineering

William George Thilly, Sc.D.
Associate Professor of
Toxicology

Barbara Underwood, Ph.D.
Associate Professor of Nutrition

Assistant Professors

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Assistant Professor of Food
Microbiology

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Michael A. Marletta, Ph.D.
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Toxicology

Michael Moskowitz, M.D.
Assistant Professor of
Neurosciences

Noel Willis Solomons, M.D.
Assistant Professor of
Clinical Nutrition

Senior Lecturers

Charles S. Davidson, M.D.
John Everett Gordon, Ph.D., M.D.
Edward S. Josephson, Ph.D.
John Burton Stanbury, M.D.

Lecturers

M. Elliot Alpert, M.D.
Mary O. Amdur, Ph.D.
George Blackburn, M.D., Ph.D.
James Carpenter, D.V.M. (Visiting)
David B. Coursin, M.D. (Visiting)
Johanna Dwyer, D.Sc. (Visiting)
Andrew G. Ebert, Ph.D.
James M. Flink, Ph.D.
Ray W. Fuller, Ph.D. (Visiting)
John H. Growdon, M.D.
Miguel Guzman, Ph.D. (Visiting)
Herbert Hultin, Ph.D. (Visiting)
Ronald D. Hunt, D.V.M.
Michael Latham, M.P.H. (Visiting)
Harry Lynch, Ph.D.
William Medden Rand, Ph.D.
Andrew Sivak, Ph.D. (Visiting)
Mitchell B. Wallerstein, Ph.D.
John Wishnok, Ph.D.
Joe D. Wray, M.D., M.P.H. (Visiting)
David Yesair, Ph.D.
Nicholas T. Zervas, M.D. (Visiting)

Instructor

Israel Saguy, Sc.D.

Administrative Officer

Lydia S. Snover, B.A., M.B.A.

Senior Research Scientists

Louis Kopito, M.S.
Ernst Reinhard Pariser, M.A.
Adrienne Ellefson Rogers, M.D.

Research Associates

Roger Anderson, Ph.D.
Bruce Bistrian, M.D., Ph.D.
Halina Brown, Ph.D.
William Busby, Ph.D.
Marilyn Crim, Ph.D.
John Essigmann, Ph.D.
Anne Forbes, M.D.
Janina Galler, M.D.
Ann Griffith, Ph.D.
Warren Grupe, M.D.
Franz Hefti, Ph.D.
Yasuro Kawabata, M.S.
Roger Keefe, Ph.D.
Cherl-Ho Lee, Ph.D.
Ashwin Madia, Ph.D.
Robert McConnell, Ph.D.
James Murphy, Ph.D.
Kathleen M. Nauss, Ph.D.
William F. Nelson, Ph.D.
Moshe Shalev, V.M.D.
Paul Skipper, Ph.D.
William Walker, M.D.
James Weaver, Ph.D.
Irene Wei, Ph.D.
Bette Weiss, Ph.D.
Robert Wolfe, Ph.D.
Leona Zacharias, Ph.D.

Postdoctoral Associates

Sally Bolmer, Ph.D.
William Dietz, M.D.
Yen-Ping Hsieh, Ph.D.
Hua-Fuan Lam, Ph.D.
Larisa Lastovetsky, Ph.D.
Shoichi Masushizi, Ph.D.
Dina Rait, Ph.D.
Santiago Santidrian, Ph.D.
Kelvin Ulmer, Ph.D.
Eleni Zanni, Ph.D.

Professors Emeriti

Cecil Gordon Dunn, Ph.D.
Associate Professor of Industrial
Microbiology, Emeritus

Robert Samuel Harris, Ph.D.
Professor of Nutritional
Biochemistry, Emeritus

John Theodore Roosevelt
Nickerson, Ph.D.
Professor of Food Technology,
Emeritus

Department of Nutrition and Food Science

Undergraduate Study

The Department of Nutrition and Food Science integrates knowledge from biology, chemistry, physics, microbiology, food science, medicine, and engineering in its teaching and research programs. Complex problems dealing with interactions which occur between people and various factors in the environment require systematic qualitative and quantitative analysis for their eventual solution. Examples include the prevalence of malnutrition in developing countries and of degenerative diseases in technologically advanced countries; the safety of new, and re-examination of old, chemical substances intentionally added to or accidentally appearing in the food supply; human nutritional and food toxicology; the regulation of metabolic processes in experimental animals and humans; exploration of non-conventional sources of nutrients and development of engineered foods; new and improved methods of food processing; the storage and distribution of foodstuffs; and even food and nutrition programs and policy planning.

In response to such challenges, the Department has developed integrated programs involving a broad range of scientific disciplines. Programs involve both research and educational opportunities through which students can acquire the professional expertise and perspective necessary to contribute meaningfully to the solution of problems of a complex multidisciplinary nature.

Bachelor of Science in Life Sciences Course VII-B Program 2. Applied Biology Curriculum

The Department of Nutrition and Food Science offers an undergraduate curriculum in Applied Biology as part of the Life Sciences program offered by the Department of Biology. This curriculum in Applied Biology emphasizes fundamental subjects in the physical and biological sciences and permits exploration of a variety of disciplinary areas leading to graduate or professional training including nutritional biochemistry and metabolism, food science, toxicology, animal pathology, human nutrition and metabolism, medicine, mathematical biology, and biochemical engineering. Programs of planned electives are arranged in consultation with an individual faculty advisor in the disciplinary area chosen by the student.

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 six areas — Nutritional Biochemistry and Metabolism, Food Science and Technology, Biochemical Engineering, Toxicology, Neural and Endocrine Regulation, and Human and Clinical Nutrition.

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 of various types of food processing (e.g., heat, dehydration, radiation, refrigeration, and freezing), and a modern pilot plant includes equipment for large-scale fermentations and other similar processes. Detailed summaries of research activities of the members of the departmental faculty are available on request.

Food Science and Technology

Academic and research programs are offered in food science and technology. These programs stress fundamental principles in three areas: food chemistry, food engineering, and food microbiology. Current research in food chemistry is concerned with the formation, occurrence, and analysis of chemical substances in foods, and in particular with compounds of toxicological significance and with reactions causing changes in nutritional and organoleptic quality. Another area under investigation is the separation, structure, and physical and biochemical properties of selective food proteins. Changes in food composition and nutrient value due to processing and storage also are being analyzed, simulated, and optimized. Food engineering research deals with the establishment of the fundamental

physical properties of foods and food materials and the identification and characterization of engineering parameters critical for the proper processing, materials handling, storage, and distribution of conventional and unconventional food systems. Food microbiology investigations emphasize the understanding of biological principles concerned with the control of undesirable microorganisms in foods, as well as the utilization of beneficial ones; projects in this area include both aerobic and anaerobic microorganisms.

Nutritional Biochemistry and

Metabolism Research in nutritional biochemistry and metabolism is concerned with nutritional, genetic, environmental, and endocrine variations in the metabolic processes of humans and various laboratory animals and their alterations in disease states. A program of training is offered to graduate students who wish to acquire knowledge and research experience in physiological chemistry and biochemistry as it applies to mammalian nutritional problems.

Human and Clinical Nutrition This is a program leading to a doctoral degree in Human and Clinical Nutrition. The training program provides graduate students with an opportunity to acquire knowledge and research experience in areas of metabolism and nutrition having direct relevance to the nutrition of humans under conditions of health and in disease.

Toxicology A program is offered leading to the Master of Science and doctoral degrees in the field of toxicology. The training program consists of a series of specialized subjects dealing with cellular responses to various chemical and physical agents of toxicological interest.

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.

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 investigators who will be interested in the mechanisms by which the brain and endocrine system maintain homeostasis and mediate the responses of the body to such environmental inputs as foods, drugs, and light.

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, nutrition, food science, or chemical engineering, or a professional degree such as the M.D., D.D.S., or D.V.M. The General Institute Requirements for graduate study are outlined in Chapter IV. Additional details concerning individual degrees given by this Department are summarized below.

Master of Science

Students who do not already possess a Master of Science or a professional degree are normally registered as S.M. candidates during their first year of graduate study. However, the S.M. is not a prerequisite for doctoral candidacy, and most students 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 major and minor programs of study together with an original thesis. The major and minor program comprise a total of 54 units of subjects consisting of a limited number of required subjects supplemented by electives. Programs for individual students are arranged in consultation with faculty advisors to meet the needs of individual research areas.

Written general examinations, taken during the fourth or fifth term 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 will be based.

Subjects in Nutrition and Food Science

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.

International Nutrition Program (I.N.P.)

provides an interdisciplinary focus for students interested in nutrition field studies, policy analysis, and evaluation of appropriate nutrition interventions. I.N.P. works on such problems as:

- 1) practical means of determining and monitoring the nutritional status of populations, including assessing the nature, magnitude, functional significance, and dynamics of malnutrition among vulnerable population groups;
- 2) determination of nutrition program benefits and the relative value of alternative nutrition program approaches or delivery systems;
- 3) interactions among such factors as nutrition, maternal-child health, infection, socioeconomic and cultural characteristics of the population, agriculture policy, sanitation and other public health problems;
- 4) the effects of income and price changes and of subsidized consumption programs on the nutritional intake of vulnerable populations; and,
- 5) food and agriculture policies of food exporting nations as these relate to international food needs.

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.

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, etc., may be obtained by writing to the Student Office, Department of Nutrition and Food Science, Room 16-321, M.I.T., Cambridge, Massachusetts 02139, (617) 253-5804 or 253-1712.

(A) following the name of the subject indicates that it is an approved subject for a graduate degree and is given primarily for graduate students.

| | |
|---------|---|
| 20.001 | Microbiology Laboratory |
| 20.002 | Laboratory in Applied Biology |
| 20.ThU | Undergraduate Thesis |
| 20.U.R. | Undergraduate Research Opportunities |
| 20.011 | Special Projects in Undergraduate Research |
| 20.012 | Special Projects in Undergraduate Research |
| 20.021 | Physiological and Nutritional Biochemistry |
| 20.022 | Mammalian Physiology |
| 20.023 | Human Nutrition |
| 20.024J | Nutrition, National Development and Planning |
| 20.025 | Human Reproduction and the Population Problem |
| 20.027 | Food Science |
| 20.028 | The Vitamins |
| 20.029J | Food, People and Cultures |
| 20.111 | Analytical Practices in Biochemistry (A) |
| 20.113J | Biostatistics I (A) |
| 20.114 | Biostatistics II (A) |
| 20.115 | Design of Field Studies |
| 20.211 | Mammalian Biochemistry and Metabolism I (A) |
| 20.212 | Mammalian Biochemistry and Metabolism II (A) |
| 20.213 | Basic and Human Nutrition I (A) |
| 20.214 | Basic and Human Nutrition II (A) |
| 20.215 | Nutrition, Growth and Development (A) |
| 20.216 | Human Genetics (A) |
| 20.217 | Trace Mineral Nutrition (A) |
| 20.218 | Nutrition and Immunity (A) |
| 20.311 | Advanced Clinical Nutrition (A) |
| 20.312 | Field Observations in Human Nutrition |
| 20.313 | Clinical and Public Health Nutrition (A) |
| 20.315 | Malnutrition, Learning and Behavior |
| 20.316 | Atherosclerosis (A) |
| 20.411J | International Food and Nutrition Policy (A) |

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|---------|---|--------|---|
| 20.412J | Nutrition: Policy and Planning in Selected Countries (A) | 20.752 | Food Plant Visits (A) |
| 20.413 | Social Sector Microeconomics and Planning (A) | 20.811 | Biochemical Engineering (A) |
| 20.414J | Economics of World Food (A) | 20.812 | Biochemical Engineering Laboratory (A) |
| 20.415 | Epidemiology of Malnutrition and Its Importance in the Social and Economic Progress of Developing Countries | 20.821 | Industrial Microbiology (A) |
| 20.511 | Biochemistry of the Neuron and the Synapse (A) | 20.822 | Industrial Microbiology Laboratory (A) |
| 20.512 | Neuroendocrine Regulation (A) | 20.901 | Research Programs in Nutrition and Food Science |
| 20.513 | Biochemical Bases of Behavior (A) | 20.902 | Seminar in Nutrition and Food Science |
| 20.514J | The Human Nervous System (A) | 20.903 | Seminar in Nutrition and Food Science |
| 20.515 | Seminar in Neuroscience Research Topics (A) | 20.911 | Seminar in Nutritional Pathology (A) |
| 20.516 | Basic Mechanisms Causing Diseases of the Human Nervous System | 20.912 | Seminar in Nutritional Pathology (A) |
| 20.517 | Advanced Topics in Neurotransmitter Biochemistry (A) | 20.921 | Selected Topics in Nutrition and Food Science (A) |
| 20.521J | Endocrinology (A) | 20.931 | Special Topics in Oral Science (A) |
| 20.610 | Principles of Toxicology | 20.932 | Special Topics in Oral Science (A) |
| 20.611 | Public and Regulatory Aspects of the Food Industry | 20.941 | Research Problems (A) |
| 20.612 | General Toxicology (A) | 20.942 | Research Problems (A) |
| 20.613 | Pharmacokinetics (A) | | |
| 20.614 | Metabolism of Foreign Compounds (A) | | |
| 20.615 | Chemical Mutagenesis and Carcinogenesis (A) | | |
| 20.617 | Pathobiology (A) | | |
| 20.618 | Laboratory Animals: Usage in Biological Experimentation | | |
| 20.701 | Food Engineering | | |
| 20.711 | Food Engineering Laboratory | | |
| 20.712 | Separation in Food Processes (A) | | |
| 20.713 | Food Process Engineering (A) | | |
| 20.721 | Physical and Engineering Properties of Food Materials (A) | | |
| 20.722 | Physical and Engineering Properties of Food Materials Laboratory (A) | | |
| 20.723 | Food Fabrication and Structure Synthesis (A) | | |
| 20.731 | Food Chemistry (A) | | |
| 20.732 | Physical Chemistry of Foods (A) | | |
| 20.733 | Separation Biophysics | | |
| 20.741 | Food Microbiology (A) | | |
| 20.742 | Food Microbiology Laboratory (A) | | |
| 20.751 | Food Marketing (A) | | |

Department of Physics

Herman Feshbach, Ph.D.
Cecil and Ida Green Professor
of Physics
Head of the Department

Anthony Philip French, Ph.D.
Professor of Physics
Academic Officer

Professors

Michel Baranger, Ph.D.
Professor of Physics

Walter Carlisle Barber, Ph.D.
Professor of Physics

Alan Hildreth Barrett, Ph.D.
Professor of Physics

Ulrich Justus Becker, Ph.D.
Professor of Physics

George Bekefi, Ph.D.
Professor of Physics

George Bernard Benedek, Ph.D.
Alfred H. Caspary Professor
of Physics

Aron Myron Bernstein, Ph.D.
Professor of Physics

William Bertozzi, Ph.D.
Professor of Physics

Robert Joseph Birgeneau, Ph.D.
Professor of Physics

Hale Van Dorn Bradt, Ph.D.
Professor of Physics

Herbert Sage Bridge, Ph.D.
Professor of Physics
Director, Center for Space
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Bernard Flood Burke, Ph.D.
Professor of Physics

Wit Busza, Ph.D.
Professor of Physics

George Whipple Clark, Ph.D.
Professor of Physics

Bruno Coppi, Ph.D.
Professor of Physics

Eric Richard Cosman, Ph.D.
Professor of Physics

Ronald Crosby Davidson, Ph.D.
Professor of Physics
Director, Plasma Fusion Center

Peter Theodore Demos, Ph.D.
Professor of Physics
Director, Bates Linear Accelerator

Martin Deutsch, Ph.D., Sc.D.
Professor of Physics

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

Jerome Isaac Friedman, Ph.D.
Professor of Physics

David Henry Frisch, Ph.D.
Professor of Physics

Jeffrey Goldstone, Ph.D.
Professor of Physics

Thomas John Greytak, Ph.D.
Professor of Physics

Lee Grodzins, Ph.D.
Professor of Physics

Albert Gordon Hill, Ph.D.
Professor of Physics, Emeritus
Senior Lecturer
Consultant to the President
and Chancellor

Kerson Huang, Ph.D.
Professor of Physics
(Absent)

Robert Inslee Hulsizer, Jr., Ph.D.
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Karl Uno Ingard, Ph.D.
Professor of Physics and
Aeronautics and
Astronautics

Roman Wladimir Jackiw, Ph.D.
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Ali Javan, Ph.D.
Francis Wright Davis
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Kenneth Alan Johnson, Ph.D.
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Henry Way Kendail, Ph.D.
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Arthur Kent Kerman, Ph.D.
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Director, Center for Theoretical
Physics

John Gordon King, Ph.D.
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of Physics

Vera Kistiakowsky, Ph.D.
Professor of Physics

Daniel Kleppner, Ph.D.
Professor of Physics

George Fred Koster, Ph.D.
Professor of Physics

Benjamin Lax, Ph.D.
Professor of Physics
Director, Francis Bitter National
Magnet Laboratory

Walter Hendrik Gustav Lewin,
Dr. Tech. Sci.
Professor of Physics

James David Litster, Ph.D.
Professor of Physics

Earle Leonard Lomon, Ph.D.
Professor of Physics
(Absent)

Francis Eugene Low, Ph.D.
Karl Taylor Compton Professor
of Physics
Director, Laboratory for Nuclear
Science

Philip Morrison, Ph.D.
Institute Professor
Professor of Physics

John William Negele, Ph.D.
Professor of Physics
(Absent)

Stanislaw Olbert, Ph.D.
Professor of Physics

Louis Shreve Osborne, Ph.D.
Professor of Physics

Irwin Abraham Plesch, Ph.D.
Professor of Physics

Miklos Porkolab, Ph.D.
Professor of Physics

Lawrence Rosenson, Ph.D.
Professor of Physics

Irwin Ira Shapiro, Ph.D.
Professor of Physics
and Geophysics

Clifford Glenwood Shull, Ph.D.
Professor of Physics

Malcom Woodrow Pershing
Strandberg, Ph.D.
Professor of Physics

Samuel C. C. Ting, Ph.D.
Professor of Physics
Holder of the Thomas Dudley Cabot
Institute Chair

Felix Marc Hermann Villars, D.Sc.
Professor of Physics

Rainer Weiss, Ph.D.
Professor of Physics

Victor Frederick Weisskopf,
Ph.D., Sc.D.
Institute Professor, Emeritus
Professor of Physics, Emeritus

Peter Adalbert Wolff, Ph.D.
Professor of Physics
Director, Research Laboratory
of Electronics

Richard Kumeo Yamamoto, Ph.D.
Professor of Physics

James Edward Young, Ph.D.
Professor of Physics

Associate Professors

John Winston Belcher, Ph.D.
Associate Professor of Physics

George Warner Brandenburg, Ph.D.
Associate Professor of Physics

Claude Roger Canizares, Ph.D.
Associate Professor of Physics

Min Chen, Ph.D.
Associate Professor of Physics

James Ludlow Elliot, Ph.D.
Associate Professor of Physics
and Astronomy
Director, George R. Wallace, Jr.
Astrophysical Observatory

Robert Loren Jaffe, Ph.D.
Associate Professor of Physics

John Dimitris Joannopoulos, Ph.D.
Associate Professor of Physics

Paul Christopher Joss, Ph.D.
Associate Professor of Physics

Marc Aaron Kastner, Ph.D.
Associate Professor of Physics

Susan Geisel Kleinmann, Ph.D.
Associate Professor of Physics

Margaret Love Agnes MacVicar,
Sc.D.
Associate Professor of Physical
Science
Director, Undergraduate Research
Opportunities Program

| | | |
|---|--|---|
| June Lorraine Matthews, Ph.D. Associate Professor of Physics | Lecturers | Professors Emeriti |
| Ernest Moniz, Ph.D. Associate Professor of Physics | Frederic John Epling, Ph.D. Associate Director, Laboratory for Nuclear Science | William Phelps Allis, Sc.D. Professor of Physics, Emeritus |
| Philip Cherdak Myers, Ph.D. Associate Professor of Physics | James Cowles Weaver, Ph.D. | Sanborn Conner Brown, Ph.D. Professor of Physics, Emeritus |
| David Edward Pritchard, Ph.D. Associate Professor of Physics | Technical Instructors | William Weber Buechner, Ph.D., Sc.D. Professor of Physics, Emeritus |
| Saul Alan Rappaport, Ph.D. Associate Professor of Physics | Angelo DeLara Larraga, B.S.E.E., J.D. | Robley Dunglison Evans, Ph.D. Professor of Physics, Emeritus |
| Stephen Geoffrey Steadman, Ph.D. Associate Professor of Physics | Harold Adolph Lundquist | Nathaniel Herman Frank, Sc.D. Professor of Physics, Emeritus |
| Toyoichi Tanaka, Ph.D. Associate Professor of Physics | Jan Orsula | George Graham Harvey, Ph.D. Professor of Physics, Emeritus |
| Charles Behan Thorn, Ph.D. Associate Professor of Physics | Thomas Joseph White, Jr. | Albert Gordon Hill, Ph.D. Professor of Physics, Emeritus Consultant to the President and Chancellor Senior Lecturer |
| Assistant Professors | Senior Research Scientists | Milton Stanley Livingston, Ph.D., Sc.D. Professor of Physics, Emeritus |
| Ahmet Nihat Berker, Ph.D. Assistant Professor of Physics | Roshan Lal Aggarwal, Ph.D. Associate Director, Francis Bitter National Magnet Laboratory | Philip McCord Morse, Ph.D., Sc.D. Professor of Physics, Emeritus |
| Judith Bostock, Ph.D. Assistant Professor of Physics | Joseph Dennis Burger, Ph.D. | Bruno Benedetto Rossi, Ph.D. Institute Professor, Emeritus Professor of Physics, Emeritus |
| Richard Jonathan Cohen, Ph.D., M.D. Assistant Professor of Physics and Health Sciences and Technology | Stanley Benedict Kowalski, Ph.D. | Laszlo Tisza, Ph.D. Professor of Physics, Emeritus |
| Roscoe C. Giles, Ph.D. Assistant Professor of Physics | Alan Jay Lazarus, Ph.D. | George Edward Valley, Ph.D. Professor of Physics, Emeritus |
| Elizabeth Scott Hafen, Ph.D. Assistant Professor of Physics | Paul David Luckey, Jr., Ph.D. | Bertram Eugene Warren, Sc.D. Professor of Physics, Emeritus |
| Dirk Joachim Muehlner, Ph.D. Assistant Professor of Physics | Charles Philip Sargent, Ph.D. | Victor Frederick Weisskopf, Ph.D., Sc.D. Institute Professor, Emeritus Professor of Physics, Emeritus |
| Robert Page Redwine, Ph.D. Assistant Professor of Physics | Edwin Floriman Taylor, Ph.D. Director, Educational Video and Video Operations | Jerrold Reinach Zacharias, Ph.D., L.H.D., Sc.D. Institute Professor, Emeritus Professor of Physics, Emeritus |
| Margaret Horton Weiler, Ph.D. Assistant Professor of Physics | William Ernest Turchinetz, Ph.D. | |
| John Scott Whitaker, Ph.D. Assistant Professor of Physics | Claude Finley Williamson, Ph.D. | |
| Edward Leonard Wright, Ph.D. Assistant Professor of Physics | Principal Research Scientist | |
| | George Rollins Ricker, Jr., Ph.D. | |
| | Research Associate | |
| | John Irwin Clark, Ph.D. | |
| | Postdoctoral Associates | |
| | Amiram Hochberg, Ph.D. Michael Cornelius Robel, Ph.D. Prabha Kumbhare Tedrow, Ph.D. John Edward Thomas, Ph.D. | |
| | Executive Officer | |
| | Daniel Henry Gould | |

Department of Physics

The programs of study and research in the Department of Physics emphasize fundamental principles but recognize the continually increasing connections of physics with other scientific fields. The Department is organized into the following four main areas of research.

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 also are 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 M.I.T., and, because of the strongly interdisciplinary and interdepartmental character of work in this area, a fuller description of it is found in a separate section entitled Astronomy and Astrophysics at the end of this chapter.

Experimental Nuclear and Particle Physics

Research activities in the Division of Nuclei and Particles include the broad fields of nuclear reaction and heavy ion physics, intermediate energy nuclear structure physics, and high-energy fundamental particle physics. The experimental research in these areas is based on M.I.T.'s new 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 M.I.T. 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 also is 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 M.I.T. and elsewhere.

The Center for Theoretical Physics houses a fairly large group of theorists including professional staff, postdoctoral fellows, senior visitors, and graduate students engaged in research in theory. Opportunities for communication and collaboration are maximized within the Center; lively interaction among the many specialists in the various areas of interest is unique to this M.I.T. group and is one of the major sources of the Center's strength.

Much of the research in the Department is carried out as part of the work of various interdepartmental laboratories and centers, including the Laboratory for Nuclear Science, the Research Laboratory of Electronics, the Spectroscopy Laboratory, the Center for Materials Science and Engineering, the Center for Space Research, and the Francis Bitter National Magnet Laboratory. These facilities provide close relationships among the research activities of a number of M.I.T. departments and give students opportunities for contact with research carried out in disciplines other than physics.

Undergraduate Study

Bachelor of Science in Physics Course VIII

An undergraduate degree in physics provides a good basis, not only for further work in physics, but also for professional work in such fields as astronomy, biophysics, engineering and applied physics, and geophysics. Many students have also found it to be an excellent preparation for subsequent graduate work in professional schools of medicine, law, and management. The undergraduate curriculum in physics offers students the opportunity to acquire basic competence in the fundamentals of both experimental and theoretical physics. The central core of requirements for the Bachelor of Science is designed not only to accomplish this objective but also to allow plenty of scope for students to select from a considerable variety of subjects and to proceed at the pace and degree of specialization best suited to their individual capabilities.

An important component of the physics program is the undergraduate thesis, 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.

Inquiries

Additional information concerning degree programs, admissions, financial aid, etc. may be obtained by writing to the Physics Undergraduate Office, Room 4-352, M.I.T., Cambridge, Massachusetts 02139, (617) 253-4841.

Graduate Study

The Department of Physics offers graduate work leading to the Master of Science in Physics, the Doctor of Philosophy, and the Doctor of Science. No stated curriculum of subjects is required for any of these degrees; rather, individual curricula are chosen in consultation with the Registration Officer in accordance with certain broad principles. Subjects of study include work in almost all of the experimental fields described in the Department's introduction, as well as in the various branches of theoretical physics. Graduate students are expected to gain familiarity with several of the branches of physics, not merely with one specialty. Students will be well prepared for either academic work or industrial research, since the training includes a broad and thorough understanding both of the fundamentals of physics and of some advanced applications.

Students should also note the possibilities of interdepartmental research, particularly in Astronomy and Astrophysics and in biophysical or biomedical areas (see Chapter V for further details).

Entrance Requirements for Graduate Study

Students intending to pursue graduate work in physics should have as a background the equivalent of the requirements for the Bachelor of Science in physics from M.I.T. However, some deficiencies may be removed in the course of graduate work.

Master of Science in Physics

The requirements for the Master of Science are the General Institute Requirements listed in Chapter IV. The Department has no language requirement for this degree.

Doctor of Philosophy and Doctor of Science

Candidates for the Doctor of Philosophy or the Doctor of Science are expected to take graduate subjects to prepare for the General Examination; however, there are no stated required subjects, and no language requirement.

Teaching and Research Assistantships

A number of research assistantships and teaching assistantships are available each year for graduate students.

Inquiries

Additional detailed information concerning degree programs, research activities, admissions, financial aid, teaching and research assistantships, etc. may be obtained by writing to the Physics Graduate Office, Room 6-107, M.I.T., Cambridge, Massachusetts 02139, (617) 253-4851.

Subjects in Physics

(A) following the name of the subject indicates that it is an approved subject for a graduate degree and is given primarily for graduate students.

| | | | | | |
|--------|--|--------|--|--------------|--|
| 8.U.R. | Undergraduate Research | 8.323 | Relativistic Quantum Field Theory (A) | 8.711 | Nuclear Physics I (A) |
| 8.01 | Physics I | 8.333 | Statistical Mechanics I (A) | 8.712 | Nuclear Physics II (A) |
| 8.012 | Physics I | 8.334 | Statistical Mechanics II (A) | 8.721 | High Energy Nuclear Physics (A) |
| 8.013J | Physics I | 8.341 | Mathematical Methods of Physics I (A) | 8.751 | Theory of Nuclear Structure (A) |
| 8.02 | Physics II | 8.342 | Mathematical Methods of Physics II (A) | 8.781, 8.782 | Selected Topics in Nuclear Theory (A) |
| 8.021 | Physics II | 8.361 | Quantum Theory of Many-Particle Systems (A) | 8.791, 8.792 | Special Problems in Nuclear Physics (A) |
| 8.022 | Physics II | 8.381, | Selected Topics in Theoretical Physics (A) | 8.810 | Particle Physics I (A) |
| 8.023J | Physics II | 8.382 | Special Problems in Theoretical Physics (A) | 8.811 | Particle Physics II (A) |
| 8.03 | Physics III | 8.391, | Physics Teaching (A) | 8.871, 8.872 | Selected Topics in Theoretical Particle Physics (A) |
| 8.04 | Statistical and Quantum Physics I | 8.392 | Advanced Atomic Physics (A) | 8.881, 8.882 | Selected Topics in Experimental Particle Physics (A) |
| 8.05 | Quantum Mechanics | 8.399 | Survey of Atomic and Molecular Physics (A) | 8.891, 8.892 | Special Problems in Particle Physics (A) |
| 8.06 | Mechanics II | 8.411 | Interaction of Lasers with Solids, Plasmas and Atoms (A) | 8.910 | Astrophysics I (A) |
| 8.07 | Electromagnetism II | 8.422 | Statistical Optics and Spectroscopy (A) | 8.911 | Astrophysics II (A) |
| 8.08 | Statistical and Quantum Physics II | 8.432 | Physics of Optical and Infrared Lasers (A) | 8.913 | Intermediate Theoretical Plasma Physics (A) |
| 8.11 | Physics Project Laboratory I | 8.442 | Seminar in Optical and Infrared Lasers (A) | 8.914 | Cosmic Electrodynamics II (A) |
| 8.12 | Physics Project Laboratory II | 8.451 | Selected Topics in Physics of Atoms and Radiation (A) | 8.921 | Stellar Structure and Evolution (A) |
| 8.13 | Experimental Atomic Physics I | 8.452 | Special Problems in Physics of Atoms and Radiation (A) | 8.942 | Cosmology (A) |
| 8.14 | Experimental Atomic Physics II | 8.481, | Physics of Solids II (A) | 8.952J | Radio Interferometry (A) |
| 8.18 | Special Problems in Undergraduate Physics | 8.482 | Theory of Solids I (A) | 8.962 | General Relativity (A) |
| 8.19 | Readings in Physics | 8.491, | Theory of Solids II (A) | 8.981, 8.982 | Selected Topics in Astrophysics (A) |
| 8.20 | Introduction to Special Relativity | 8.492 | Application of Group Theory to the Physics of Solids (A) | 8.991, 8.992 | Special Problems in Astrophysics (A) |
| 8.201J | Statistical and Biological Physics | 8.500J | Topics in Biological Physics (A) | 8.ThG | Graduate Physics Thesis (A) |
| 8.204J | Atoms, Genes and Stars — A Joint Reality | 8.511J | Correlations and Critical Behavior in Condensed Matter (A) | | |
| 8.206J | Seminar in Public Interest Science | 8.512J | Selected Topics in the Theory of Solids (A) | | |
| 8.211 | Introduction to Quantum Physics | 8.513J | Special Problems in Solid-State Physics (A) | | |
| 8.231J | Physics of Solids I | 8.522 | Introduction to Plasma Physics (A) | | |
| 8.236 | Topics in Quantum Theory of Matter | 8.561 | Plasma Kinetic Theory (A) | | |
| 8.242 | Quantum Electronics | 8.581, | Advanced Topics in Plasma Kinetic Theory (A) | | |
| 8.244 | Modern Optics | 8.582 | Waves and Nonlinear Interactions in Plasma (A) | | |
| 8.251 | Physics of Noise and Fluctuations | 8.591, | Physics of High Temperature Plasmas I (A) | | |
| 8.263 | Physics of Fluids | 8.592 | Physics of High Temperature Plasmas II (A) | | |
| 8.272 | Introduction to Nuclear Physics | 8.613J | Selected Topics in Fluid and Plasma Physics (A)* | | |
| 8.274 | Introduction to Particle Physics | 8.621J | Special Problems in Fluid and Plasma Physics (A) | | |
| 8.282 | Introduction to Astrophysics and Astronomy | 8.622J | | | |
| 8.285 | Topics in Astrophysics | 8.624 | | | |
| 8.291J | Planetary Physics and Chemistry I | 8.641 | | | |
| 8.292J | Planetary Physics and Chemistry II | 8.642 | | | |
| 8.293J | Dynamical Astronomy | 8.681, | | | |
| 8.299 | Physics Teaching | 8.682 | | | |
| 8.ThU | Undergraduate Physics Thesis | 8.691, | | | |
| 8.312 | Electromagnetic Theory (A) | 8.692 | | | |
| 8.321 | Quantum Theory I (A) | | | | |
| 8.322 | Quantum Theory II (A) | | | | |

Interdisciplinary Science Program

In addition to the Bachelor of Science programs offered by the Departments of Biology, Chemistry, Earth and Planetary Sciences, Mathematics, and Physics, the Interdisciplinary Science Program (Course XXV) is sponsored by the School of Science. The Program, leading to the Bachelor of Science without designation of field, is intended to provide special opportunities for students interested in science programs which differ significantly from established departmental offerings. For example, students may concentrate in fields such as astronomy, meteorology, oceanography, environmental sciences, neurosciences and behavior, perceptual systems, human cognition and artificial intelligence, medical science, and nutrition and food science. Students arrange their own curricula in consultation with faculty advisors, subject to the approval of a faculty committee. This committee, which includes representatives from Psychology and all departments in the School of Science, also helps students find suitable advisors.

The Interdisciplinary Science curriculum must include a strong and coherent set of science subjects going beyond the level of the Institute Science Distribution Requirement and, specifically, cannot be restricted to a sampling of introductory subjects. It is strongly recommended that 12 units of faculty supervised undergraduate research or thesis be included. In completing General Institute Requirements and the "core" subjects basic to their fields, students in the Interdisciplinary Science Program are expected to make progress which would be normal for a departmental curriculum. It is always possible for second-year students to arrange their course study so that they have 12 units of elective freedom each semester.

Registration procedures for the Interdisciplinary Science Program are like those of regular departmental programs. However, before registering in the program,

students must prepare a written plan for satisfying the Restricted Elective requirement of 84 units or more, as required, and if possible find a faculty member willing to serve as advisor. Since the Restricted Electives serve the function of core requirements in regular departments, continued registration is contingent on the approval of this program by the Course XXV committee. Such approval must be obtained before registration day of the senior year. General advice on possible curricula, help in preparing a detailed plan, and names of interested faculty members are available from Professor John M. Buchanan, faculty member in charge of the program, Room 6-219, M.I.T., Cambridge, Massachusetts 02139, (617) 253-5723. Professor Buchanan serves as registration officer for the purpose of signing forms on registration day, formal approval of course changes, etc. The individual advisors provide contact with a faculty member interested in the student's special field who can help in planning the overall program, suggesting modifications in it, etc.

Master's Program in Interdisciplinary Science

The Master of Science in Interdisciplinary Science is offered under the auspices of the Interdisciplinary Science Program. The objective of this program is to provide an opportunity for graduate study in an interdisciplinary area with a strong science core, and to prepare students for positions in industry, government, education, or medicine where training beyond a bachelor's degree is required. Students entering the program may elect either the specified or the unspecified degree option. (See listing of the specified programs below.) The requirements for each specified program are predetermined by a special faculty committee whose members have expertise in that area. When applying for admission, a

student should designate a particular specified option or submit a curriculum proposal. Admission is contingent on Committee approval of this proposal. The basic requirement for the Interdisciplinary Science S.M. is the completion of an approved program consisting of 66 subject units (including 42 units in A subjects) and a thesis. It is desirable, but not required, particularly in the unspecified option, for a suitable thesis advisor to be designated during the admission process. Students with strong preparation for their particular program can complete the subject requirements and thesis in one year. If a student is making a major change in field or has inadequate preparation, two years probably will be required. Further information may be obtained from the Interdisciplinary Science Office in Room 6-219.

Specified Programs

Science Education
Environmental Chemistry
Animal Cell Science
Science Communication

A new specified two-year Master's program in **Science Communication** will be offered for students interested in science writing for the print medium or in reporting and education through the audiovisual media of films, television, and radio. A selection of courses will be made to develop an integrated curriculum encompassing the technical aspects of science communication, policy issues involved in science and its public understanding, and a broadened comprehension of various aspects of science at an advanced level. Subject options are suggested principally from offerings listed in the School of Science, the School of Humanities and Social Science (Courses 17 and 21), and the School of Architecture and Planning (Course 4). A new graduate subject, 21.742 Advanced Science Writing, will be available in September 1979.

Joint Program in Oceanography with the Woods Hole Oceanographic Institution

M.I.T. and the Woods Hole Oceanographic Institution (W.H.O.I.) on Cape Cod offer joint programs of graduate study and research for students with special interests in biological oceanography, chemical oceanography, marine geology, marine geophysics, oceanographic engineering, and physical oceanography. These graduate programs are administered by committees drawn from the faculty and staff of both institutions. Students accepted to the Joint Program have access to the extensive intellectual and physical resources available for advanced study at both Woods Hole and M.I.T.

The Woods Hole Oceanographic Institution operates three ocean-going research ships, a deep-submergence research vehicle, and several inshore boats. A resident staff of more than 800 scientists, engineers, and support personnel conduct a wide range of ocean-related studies in biology, chemistry, physical oceanography, geology, geophysics, and oceanographic engineering from extensive laboratory facilities at Woods Hole. A marine facility is maintained by M.I.T. in Boston Harbor consisting of dock space and a small research vessel capable of coastal work. Subjects in various aspects of oceanography as well as a large number of subjects directly applicable to oceanography are offered by many M.I.T. departments. These include:

| | | | | | |
|--------|--|---------|---|---------|---|
| 1.030J | Introduction to Technology and Law | 1.692 | Wave Dynamics in Oceanographic Engineering (A) | 12.004J | Environmental Ecology II |
| 1.59J | Fracture of Structure Materials (A) | 1.697J | Oceanographic Systems I | 12.20J | Environmental Chemistry of the Ocean-Atmosphere System |
| 1.62 | Free Surface Hydraulics | 1.698J | Oceanographic Systems II | 12.21 | Physics of the Ocean |
| 1.64 | Transport and Mixing in Turbulent Flows (A) | 1.699J | Special Projects in Oceanographic Engineering (A) | 12.221- | Project Studies in Oceanography |
| 1.67 | Sediment Transport and Coastal Processes (A) | 1.75 | Limnology and Wetland Ecology (A) | 12.229 | |
| 1.681 | Physics of Natural Water Bodies (A) | 1.761 | Aquatic Chemistry (A) | 12.32 | Mechanics of Sedimentary Processes (A) |
| 1.69 | Introduction to Coastal Engineering (A) | 1.79 | Aquatic Ecology (A) | 12.56 | Advanced Seminar in Plate Tectonics (A) |
| 1.691 | Wave Dynamics in Coastal Engineering I (A) | 1.80 | Problems in Aquatic Biology and Chemistry (A) | 12.72 | Oceanic Petrology (A) |
| | | 2.065J | Flow Noise (A) | 12.73 | Introduction to Marine Geology (A) |
| | | 2.071J | Introduction to Structural Mechanics | 12.74 | Marine Micropaleontology (A) |
| | | 2.131J | Environmental Ecology I | 12.75 | Marine Sediments (A) |
| | | 2.132J | Environmental Ecology II | 12.752 | Paleomagnetism (A) |
| | | 2.283 | Fluid Physics of Pollution (A) | 12.77 | Marine Geophysical Data Interpretation (A) |
| | | 2.284 | Water Purification (A) | 12.774 | Plants, Animals, and Sediments |
| | | 2.63 | Energy Production from Renewable Resources (A) | 12.80 | Marine Chemistry |
| | | 3.20 | Thermodynamics of Materials (A) | 12.81 | Waves and Tides (A) |
| | | 3.21 | Kinetic Processes in Materials (A) | 12.82 | Marine Geochemistry of Sediments |
| | | 3.35 | Solidification Processing (A) | 12.83 | Marine Geochemistry (A) |
| | | 3.36J | Welding Engineering (A) | 12.84 | Organic Geochemistry (A) |
| | | 3.39 | Mechanical Behavior of Materials (A) | 12.85 | Oceanographic Time Series (A) |
| | | 3.54 | Corrosion — The Environmental Degradation of Materials (A) | 12.86 | General Circulation of the Oceans (A) |
| | | 3.701J | Materials for Ocean Engineering | 13.021 | Marine Hydrodynamics I (A) |
| | | 3.90J | Fracture of Structural Materials (A) | 13.022 | Marine Hydrodynamics II (A) |
| | | 3.93 | Materials Science of Polymers (A) | 13.07 | Free Surface Hydrodynamics (A) |
| | | 6.455J | Marine Data Systems (A) | 13.08 | Stability and Motion Control of Ocean Vehicles (A) |
| | | 7.411- | Seminars in Biological | 13.09 | Potential Flows (A) |
| | | 7.419 | Oceanography (A) | 13.10J | Introduction to Structural Mechanics |
| | | 7.421- | Special Problems in Biological | 13.15J | Materials for Ocean Engineering |
| | | 7.429 | Oceanography | 13.16J | Fracture of Structural Materials (A) |
| | | 7.43 | Phytoplankton and Nutrient Cycling (A) | 13.17J | Welding Engineering (A) |
| | | 7.44 | Ecology of Oceanic Zooplankton | 13.27 | Ocean Engineering Power Systems (A) |
| | | 7.45 | Benthos and Fish (A) | 13.48 | Offshore Engineering Design (A) |
| | | 7.46 | Topics in Physiology and Biochemistry of Marine Animals (A) | 13.74J | Marine Data Systems (A) |
| | | 7.491- | Research in Biological | 13.76 | Introduction to Random Processes in Ocean Engineering (A) |
| | | 7.497 | Oceanography (A) | 13.84J | Flow Noise (A) |
| | | 10.803 | Introduction to Technology and Law I | 13.85 | Fundamentals of Underwater Sound Applications (A) |
| | | 11.362 | Land Use and Environmental Policy Implementation (A) | 13.86 | Ocean and Seabed Acoustics (A) |
| | | 11.365J | Coastal Zone Management (A) | 13.92 | Public Policy and Use of the Sea (A) |
| | | 12.003J | Environmental Ecology I | 13.94J | Ocean Engineering and Law Seminar (A) |
| | | | | 13.961J | Resources Management (A) |

- 13.962 Legal Aspects of Ocean Resources and Systems Management (A)
- 13.97J Introduction to Technology and Law I
- 13.98J Coastal Zone Management (A)
- 13.990J Oceanographic Systems I
- 13.991J Oceanographic Systems II
- 13.992 Marine Navigation, Positioning and Data Telemetry (A)
- 13.994 Buoy Engineering (A)
- 13.997 Principles of Oceanographic Instrument Systems I — Measurement Platforms (A)
- 13.998 Principles of Oceanographic Instrument Systems II — Sensors and Measurements (A)
- 13.999J Special Projects in Oceanographic Engineering (A)
- 15.228J Ocean Engineering and Law Seminar (A)
- 16.082J Flow Noise (A)
- 16.792 Introduction to Technology and Law I
- 17.865 International Organization, Legal and Political Response to Science and Technology (A)
- 19.05J Environmental Chemistry of the Ocean-Atmosphere System
- 19.10 Climate of the Past
- 19.65J Turbulence and Random Processes in Fluid Mechanics (A)
- 19.681 Dynamics of Large-Scale Circulation of Ocean and Atmosphere (A)
- 19.682 Dynamics of Large-Scale Circulation of Ocean and Atmosphere (A)
- 19.80 Surface and Internal Gravity Waves (A)
- 19.81 Introduction to Oceanic Models (A)
- 19.82 Introduction to Oceanic Models (A)
- 19.83 Physical Oceanography
- 19.841 Waves (A)
- 19.842 Mesoscale Ocean Dynamics (A)
- 19.851 Dynamics of Shallow Seas (A)
- 19.853 Turbulence and Friction in the Ocean
- 19.86 The General Circulation of the Oceans (A)
- 19.89 Special Problems in Oceanography (A)
- 19.891- Special Problems in Oceanography (A)
- 19.899 Oceanography (A)
- 20.612 General Toxicology (A)
- 20.811 Biochemical Engineering (A)
- 22.85 Introduction to Technology and Law I

Subjects, seminars, and opportunities for research participation are offered at both institutions. Students live in either Cambridge or Woods Hole, and transportation is provided for them to commute the 80 miles between institutions so they can take advantage of all available resources. Students have the opportunity to participate in oceanographic cruises during graduate studies. Depending upon individual study and research programs, students are encouraged to reside for at least one year at each place. Upon admission, students register in the appropriate M.I.T. department and are assigned academic advisors at each institution.

The Joint Program involves several departments at M.I.T. — Biology, Earth and Planetary Sciences, and Meteorology in the School of Science, and Chemical Engineering, Civil Engineering, Electrical Engineering and Computer Science, Materials Science and Engineering, Mechanical Engineering, and Ocean Engineering in the School of Engineering. Details concerning entrance requirements, examinations, financial aid, etc. may be found in the descriptions of each individual department.

Chemical Oceanography, Marine Geology, Marine Geophysics and Physical Oceanography

The Department of Earth and Planetary Sciences and the Department of Meteorology offer programs with W.H.O.I. in chemical oceanography, marine geology, marine geophysics, and physical oceanography. The programs are coordinated by either department and may involve other departments such as Chemistry at M.I.T. The programs all lead to the Doctor of Philosophy or the Doctor of Science.

Biological Oceanography

Programs in biological oceanography are offered jointly with W.H.O.I. 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 W.H.O.I. or other departments at M.I.T., such as Nutrition and Food Science. Program requirements are tailored to individual needs and include preparation in basic areas of biology and marine ecology.

Astronomy and Astrophysics

Teaching and research in astronomy at M.I.T. are truly interdepartmental, involving more than 25 faculty members of the Departments of Physics, Earth and Planetary Sciences, Mathematics, Electrical Engineering and Computer Science, Chemistry, and Meteorology. The subjects offered and the opportunities for thesis research cover a correspondingly broad spectrum.

The observational astronomy program emphasizes the application of modern technology: objects as diverse as quasars, pulsars, supernova ejecta, and the planets are being investigated throughout the spectrum with X-ray, optical, and radio wavelengths. Radio galaxies, the cosmic microwave background, stars in the process of formation, and molecules in space are being studied with radio telescopes, often involving very-long-baseline interferometers; pulsating stars, galactic nuclei, and an unresolved background have all been detected at X-ray wavelengths; the properties of the interplanetary medium are being explored with particle detectors on spacecraft; planets are being viewed with radar, both from the earth and from spacecraft, and by optical telescopes in both the visible and the infrared.

Some of the theoretical astronomy work relates directly to these observations, as in testing general relativity in the solar system or in trying to understand the complex interactions of the solar wind with our own planet. A major theoretical effort lies in intensive studies of the structure and evolution of stars, the dynamics of spiral galaxies and the solar system, the origin of the solar system, composition and structure of meteorites, origin, evolution, and general circulation of planetary atmospheres, and problems of relativistic astrophysics or high-energy astrophysics as diverse as the origin of cosmic rays, the evolution of supernova events, and the formation of galaxies.

Opportunities for student research include the use of the Haystack radio telescope and the unique electronic instrumentation at the nearby 24-inch and 16-inch optical telescopes of our Wallace Observatory. M.I.T. is a joint participant, with Dartmouth College and the University of Michigan, in operating the 52-inch McGraw-Hill telescope at Kitt Peak in Arizona. Active experimental programs with student participation also involve instruments launched in balloons, rockets, satellites, and interplanetary spacecraft. M.I.T. experiments are operating on the two X-ray observatories now in orbit, and students are participating in its operation and in the interpretation of the data. In addition, M.I.T. 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; they also use the telescopes of both the Kitt Peak National Observatory and the Cerro-Tololo Inter-American Observatory in Chile.

The following astronomy subjects are offered by the various departments. The asterisks mark subjects that will be offered in 1979-80.

Undergraduate Study

- 8.282* Introduction to Astrophysics and Astronomy
- 8.285* Topics in Astrophysics
- 12.002* The Earth and the Planets
- 12.111* Survey of Astronomy I
- 12.112* Survey of Astronomy II
- 12.113* Astronomy I
- 12.114* Astronomy II
- 12.115J* } Dynamical Astronomy
- 8.293J* }
- 12.116 Observational Techniques of Optical Astronomy
- 12.121* Exploration of the Solar System
- 12.131J* } Planetary Physics and Chemistry I
- 5.121J* }
- 8.291J* }
- 12.132J* } Planetary Physics and Chemistry II
- 5.122J* }
- 8.292J* }
- 18.370 Introduction to Dynamics in Astronomy

Graduate Study

- 5.125J* } Planetary Atmospheres
- 12.631J* }
- 5.129J } Current Research in Meteoritics
- 12.636J }
- 6.661 Receivers, Antennas and Signals
- 8.910* Astrophysics I
- 8.911* Astrophysics II
- 8.913 Intermediate Theoretical Plasma Physics
- 8.914* Cosmic Electrodynamics
- 8.921* Stellar Structure and Evolution
- 8.942* Cosmology
- 8.962 General Relativity
- 8.981* Selected Topics in Astrophysics
- 8.982* Selected Topics in Astrophysics
- 12.54 Planetary Interiors
- 6.664J* } Radio Interferometry
- 8.952J* }
- 12.626J* }
- 6.663J } Techniques of Radar Astronomy
- 12.627J }
- 18.259* Theoretical and Observational Cosmology
- 18.375* Stellar Dynamics, Galaxies, and Plasmas
- 19.64* Atmospheric Modeling
- 19.72* Atmospheric Radiation
- 19.73* Chemistry and Dynamics of Upper Atmospheres

The Whitaker College of Health Sciences, Technology, and Management and the Harvard-M.I.T. Division of Health Sciences and Technology

In 1977, M.I.T. established the Whitaker College of Health Sciences, Technology, and Management to provide a major academic and administrative focus for the extensive developing health-related activities at the Institute. The educational and research activities of Whitaker College are expected to include new and enlarged programs in human biology, physiology, experimental medicine, and health care policy and management. The M.I.T. component of the Biomedical Sciences (M.D.) Program and the Medical Engineering and Medical Physics (Ph.D.) Program of the Harvard-M.I.T. Division of Health Sciences and Technology will be an integral part of Whitaker College.

The College represents a major commitment by M.I.T. to marshal its resources and strengths in science, engineering, and management in order to foster progress in the health and medical sciences and to improve the quality of health care. Since health-related activities in education and research transcend the concerns of any single department or School of the Institute, the term "College" is being used for the first time at M.I.T.

The program in human biology will include educational and research opportunities for undergraduate and graduate students in human genetics, the biology of human behavior, and environmental biology and toxicology. In the laboratories of human physiology and experimental medicine, research on major human health and medical problems will range from the most fundamental studies to clinical investigation in humans in normal and in disease states.

In health care policy and management, the Whitaker College will seek to enhance and complement the activities in the Sloan School of Management and in the Departments of Economics and Political Science. In addition, a new Ph.D. program is being planned which will combine education in health and

medical systems with policy analysis and management. The program will include subjects in health policy analysis, management information systems, health economics, government regulation, the sociology of the health professions, epidemiology, human biology, and the elements of clinical medicine.

Planning of the educational and research programs of Whitaker College is being conducted with the help and advice of the Faculty Advisory Council whose members are:

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American Cancer Society
Professor of Microbiology
Department of Biology

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Professor of Physics
Department of Physics

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Matsushita Professor of Mechanical Engineering in Medicine
Department of Mechanical Engineering
Associate Director of Medical Engineering and Medical Physics, Harvard-M.I.T.
Division of Health Sciences and Technology

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Department of Biology

Maurice S. Fox, Ph.D.
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Head, Department of Psychology

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Departments of Biology and Chemistry

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Head, Department of Nutrition and Food Science

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Department of Nutrition and Food Science

Laurence R. Young, Sc.D.
Professor of Aeronautics and Astronautics
Department of Aeronautics and Astronautics

Members ex officio of the Faculty Advisory Council are Dr. Jerome B. Wiesner, President; Professor Walter A. Rosenblith, Provost; Professor Sheila E. Widnall, Chairman of the Faculty; and Dr. Irving M. London, Director of Whitaker College and Director of the Harvard-M.I.T. Division of Health Sciences and Technology.

Harvard-M.I.T. Division of Health Sciences and Technology

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- Eugene Braunwald, M.D.
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Harvard Medical School
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Harvard Medical School
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Tutor in Medical Sciences
Harvard Medical School

William M. Kettyle, M.D.
Clinical Instructor in Medicine
Harvard Medical School

George E. Lewinnek, M.D.
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Medical School

The Harvard-M.I.T. Division of Health Sciences and Technology M.D., Ph.D., Sc.D.

Harvard University and M.I.T. are engaged in a major collaborative effort, the Harvard-M.I.T. 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 M.I.T. 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 M.I.T. 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; in Medical Engineering and Medical Physics leading to the Ph.D. degree or in biomedical engineering leading to the Ph.D. degree.

The educational program in **Biomedical Sciences** is oriented toward students with a strong interest and background in quantitative science, especially in the biological, physical, engineering, and chemical sciences. The subjects in human biology developed for this curriculum represent the joint efforts of life scientists and physicians, physical scientists and engineers, selected from the faculties of both universities. The subjects are presented at Harvard Medical School or at M.I.T.

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 will spend approximately one-half of their elective time. Faculty tutors will provide guidance in the

choice of subjects and in the pursuit of independent study. Prior to graduation, Division students will be 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 steeped 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 M.I.T. are eligible to apply to the Division in the junior or sophomore year. Early admission permits them to begin studies in the medical curriculum while still engaged in undergraduate studies. For these students, it is not essential that all requirements for admission to Harvard Medical School be completed prior to enrollment in the Division; undergraduates are required, however, to satisfy those requirements as part of their curriculum in the preclinical years of the program. Such applicants are urged to take the Medical College Admission Test in May or September of the year in which they apply. Their scores on the Test are considered with those of other junior or sophomore 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. Juniors or sophomores who apply and are not admitted into the Harvard-M.I.T. Division will be eligible to apply the following year to Harvard Medical School for the Harvard-M.I.T. program or the regular Harvard Medical School curriculum or both without prejudice to their candidacy. Interested applicants may obtain application forms from the Office of Admission, Harvard Medical School, 25 Shattuck Street, Boston, Massachusetts 02115. *Applications must be submitted by November 1 of the year prior to desired matriculation.*

Summary of Graduate Degree Opportunities in Biomedical Engineering at M.I.T.

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 medical engineering or medical physics problem of clinical importance.

Further information about the Division may be obtained from the office of the Director of the Division, Room 16-512, M.I.T., Cambridge, Massachusetts 02139, (617) 253-4305.

Students and faculty in many departments at M.I.T. are conducting research in biomedical engineering. These research interests, spanning the life sciences, physics, and engineering, have led to the development of new programs of graduate study for students wishing to pursue careers in these rapidly evolving fields. Each of these programs, although strongly interdepartmental in nature, has evolved out of the interests and professional specialties of the participating faculty. Many are based primarily in the academic departments of the School of Engineering and, therefore, are available to students as regular departmental activities. Virtually all of the engineering studies are in collaboration with life scientists, many of whom are members of medical faculties and affiliated with teaching hospitals in the Boston area.

There are presently five graduate programs in biomedical engineering available to graduate students at M.I.T. These are:

- 1
Departmental programs in the School of Engineering
- 2
M.I.T. Interdepartmental Doctoral Program in Biomedical Engineering
- 3
Harvard-M.I.T. Division of Health Sciences and Technology Doctoral Program in Medical Engineering and Medical Physics
- 4
Harvard-M.I.T. Program in Medical Radiological Physics
- 5
Combined M.D.-Ph.D. programs in the Harvard-M.I.T. Division of Health Sciences and Technology

Specific details for each of these graduate programs are given in *A Guide to Biomedical Engineering and Physics at Massachusetts Institute of Technology and Harvard University*. This booklet, prepared by the Harvard-M.I.T. Division of Health Sciences and Technology Committee on Medical Engineering and Physics, may be obtained from the Committee office, Room 16-512, M.I.T., Cambridge, Massachusetts 02139. The choice among the first three of these, which have certain commonalities and notable differences, depends on the desired breadth of exposure to the medical and life sciences and the career goals of the student, particularly with respect to the clinical aspects of biomedical engineering.

A student who is primarily attracted by a basic engineering discipline which is applicable to biological problems and who intends to pursue a professional engineering career which may lie outside the field of biomedical engineering is advised to apply for the departmental program. A background in mathematics and the physical sciences is a necessary prerequisite for graduate study in the School of Engineering departmental biomedical engineering programs; preparation in the biological sciences, though desirable, is not required.

A student who wishes a broader exposure to the life sciences as preparation for a career in the application of engineering and physics to a wide range of living systems is advised to apply for the Interdepartmental Doctoral Program in Biomedical Engineering, administered by the M.I.T. Committee on Biomedical Engineering. Graduate students from any department who possess an engineering Master's degree may apply for admission. Students should normally apply for admission to the M.I.T. engineering department most closely related to the field of their undergraduate major, and should contact the M.I.T. Committee on Biomedical Engineering office in Room 37-219, M.I.T., Cambridge, Massachusetts 02139.

A student who wishes intensive exposure to the medical sciences as preparation for a career of research on important clinical problems is advised to apply for the H.S.T. Doctoral Program in Medical Engineering and Medical Physics.

The Harvard-M.I.T. Graduate Program in Medical Radiological Physics is a special program supported by the National Cancer Institute. It is an inter-institutional pre-doctoral training program for students specifically interested in careers in radiological physics and/or radiation therapy. The focus for this program at M.I.T. is in the Department of Nuclear Engineering. Further details may be obtained from the Graduate Office of the Department of Nuclear Engineering.

The biomedical sciences curriculum of the Harvard-M.I.T. 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 M.I.T. departments. Students interested in such combined degree programs must apply independently to the department of interest and to Harvard Medical School.

R.O.T.C. Programs

Air Force R.O.T.C. Program

Adrian V. Polk, M.S.
Colonel, US Air Force
Visiting Professor of Aerospace
Studies
Director, Office of Aerospace
Studies

Billy F. Webster, M.S.
Major, US Air Force
Technical Instructor

Steven L. Orton, M.A.
Major, US Air Force
Technical Instructor

James F. Jenchura, M.S.
Captain, US Air Force
Technical Instructor

Thomas Paczkowski, B.S.
Technical Sergeant, US Air Force
Technical Instructor

Thomas M. Jones
Technical Sergeant, US Air Force
Technical Instructor

The Air Force R.O.T.C. program is designed to prepare students for commissions in the United States Air Force upon successful completion of an M.I.T. Course. The Office of Aerospace Studies offers two programs — one of four years and one of two years — for M.I.T. 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 R.O.T.C., 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, books, and required Institute fees plus \$100 monthly for subsistence. Non-scholarship students in the final two years of the program also receive the \$100 per month subsistence allowance.

Unless the student accepts a scholarship, there is no obligation to the Government for the first two years of the four-year program. At the beginning of the junior year all students who have not already done so are required to sign a formal agreement that they will complete the last two years of Air Force R.O.T.C. and accept a commission as a Second Lieutenant in the United States Air Force when granted a degree from M.I.T. The term of active duty commitment after commissioning varies depending upon the professional area chosen. For those entering research and development, en-

gineering, 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 R.O.T.C. 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 M.I.T. 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 R.O.T.C. at M.I.T. 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 R.O.T.C. program at M.I.T. 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 M.I.T. as a full-time student or enrolled at a neighboring university, such as Harvard University or Wellesley College, where a consortium or cross-town agreement allows cross-enrollment into A.F.R.O.T.C. at M.I.T.

Application Procedure

Eligible freshmen can sign up for the A.F.R.O.T.C. Program by simply electing A.F.R.O.T.C. subjects (AS11 and AS111) when they arrive on campus; however, it is advisable that interested students contact the A.F.R.O.T.C. 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, M.I.T., Cambridge, Massachusetts 02139, or by calling (617) 253-4472.

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 M.I.T. elective subjects.

First Year

| | |
|-------|---|
| AS11 | The Air Force Today (1-0-1) (no M.I.T. credit) |
| AS111 | Leadership Laboratory (0-1-0) (no M.I.T. credit) |
| AS12 | The Air Force Today (1-0-1) (no M.I.T. credit) |
| AS121 | Leadership Laboratory (0-1-0) (no M.I.T. credit) |

Second Year

| | |
|-------|---|
| AS21 | The Development of Air Power (1-0-1) (no M.I.T. credit) |
| AS211 | Leadership Laboratory (0-1-0) (no M.I.T. credit) |
| AS22 | The Development of Air Power (1-0-1) (no M.I.T. credit) |
| AS211 | Leadership Laboratory (0-1-0) (no M.I.T. credit) |
| AS221 | Leadership Laboratory (0-1-0) (no M.I.T. credit) |

Third Year

| | |
|-------|---|
| AS31 | Management and Leadership (3-0-3) (no M.I.T. credit) |
| AS311 | Leadership Laboratory (0-1-0) (no M.I.T. credit) |
| AS32 | Management and Leadership (3-0-3) (no M.I.T. credit) |
| AS321 | Leadership Laboratory (0-1-0) (no M.I.T. credit) |

Fourth Year

| | |
|-------|---|
| AS41 | The Military in American Society (3-0-3) (no M.I.T. credit) |
| AS411 | Leadership Laboratory (0-1-0) (no M.I.T. credit) |
| AS42 | U.S. National Security (3-0-3) (no M.I.T. credit) |
| AS421 | Leadership Laboratory (0-1-0) (no M.I.T. credit) |

Army R.O.T.C. Program

John S. Kark, Ph.D.
Colonel, Infantry
Visiting Professor of
Military Science
Director, Office
of Military Science

Brink P. Miller, M.S.
Major, Corps of Engineers
Technical Instructor

William F. Tobin, B.S.
Captain, Signal Corps
Technical Instructor

Daniel L. Johnson, B.A.
Captain, Air Defense Artillery
Technical Instructor

John H. Bell
Master Sergeant, US Army
Technical Instructor

William L. Cooper
Sergeant First Class, US Army
Technical Instructor

Robert A. Bigwood
Staff Sergeant, US Army
Technical Instructor

Patrick F. McDonough
Sergeant, US Army
Technical Instructor

All students at M.I.T. and Wellesley College are eligible to enroll in the Army R.O.T.C. 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 R.O.T.C. two-year program. Successful completion of both academic requirements and summer training requisites qualifies the student for commission upon graduation.

The academic portion of the R.O.T.C. program consists of one military science subject and one related elective subject offered by another M.I.T. or Wellesley teaching department per year, plus a one-hour leadership development subject in each term. Although the normal pattern is for the student to progress through the Military Science programs sequentially, individual students may, on a case-by-case basis, be granted credit for part or all of the basic program for appropriate academic or military work experience. Selected subjects are also offered during the Summer Session. Elective subjects accepted for the R.O.T.C. program are derived primarily from the humanities, political science, management, and psychology areas, and are intended to instill in the potential officer a balanced appreciation of the development and dynamics of military and social institutions and their inter-relationship with society, as well as an understanding of the interactions and management of individuals in groups. The purpose of this integrated approach to R.O.T.C. is to develop officers skilled not only in the pragmatics of military science, but in the related human and social institutions as well. The selection of approved elective subjects is by no means rigid, and any relevant subjects may be selected on the student's initiative and approved by his or her R.O.T.C. faculty advisor.

Students completing the R.O.T.C. program will receive their commissions upon graduation and go on to serve a specified period of active duty ranging from three months to four years, depending upon the student's choice of commissioning program, scholarship status, and the needs of the service. Commissions are offered in all of the Army's functional branches with actual branch assignment determined by the needs of the Army, the desires of the student, and his or her academic background and experience. Commissions may be awarded in any of the following branches: Infantry, Armor, Field Artillery, Air Defense Artillery, Chemical Corps, Signal Corps, Corps of Engineers, Military Intelligence, Transportation Corps, Quartermaster Corps, Finance Corps, Adjutant General's Corps, Ordnance Corps, and the Military Police Corps.

Commissions are also available in the Medical Service Corps and the allied health professions.

Enrollment in the first two years of the four-year program, called the Basic Course, is entirely voluntary and does not obligate the student to any type of active duty or reserve commitment. Those students desiring to continue in the program beyond the sophomore year must apply for and be selected to the Advanced Course, which comprises the junior and senior years. It is only at this point that the student incurs an active duty obligation.

Summer training requirements for students in the four-year program are limited to the six-week R.O.T.C. Advanced Camp which normally is completed between the junior and senior years. Students at the Advanced Camp are provided room and board, and are paid at the rate of half the pay of a Second Lieutenant, plus mileage to and from the camp location. All students in the final two years of the program receive a stipend of \$100 per month.

One-, two-, three-, and four-year scholarships are available each year, and are awarded on the basis of a national competition. In general, the scholarships cover the cost of tuition, books, laboratory fees, and related expenses, plus a stipend of \$100 per month. Full details on the scholarship program may be obtained by contacting the Director of Military Science.

In addition to the requirements outlined above, Army, airborne, and ranger training programs are also available to interested students on an optional, voluntary basis. Full details on these programs are also available from the Director of Military Science.

Eligibility Requirements

There are no formal eligibility requirements for entry into the Basic Course of the four-year program except that the student must be able to qualify for commission before reaching his or her 28th birthday. Non-citizens may enroll in and complete the program, but must become US citizens in order to receive a commission. All students must pass an Army medical examination prior to entry into the Advanced Course.

Applicants for the two-year program must successfully pass an aptitude test and an Army medical examination. Two-year applicants must also be able to qualify for commission before reaching their 28th birthday.

Application Procedures

To apply for the four-year program, students enroll in MS11 and MS111 in the same manner as in other Institute subjects. Please 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 during the year preceding the year in which they desire to be enrolled. Selections are based on nationwide competition with initial processing in January of each school year. Further details may be obtained from the Office of Military Science, 20E-126, M.I.T., Cambridge, Massachusetts 02139.

Program of Instruction

One Institute elective subject is required for each year in addition to the following:

First Year

MS11 Civil-Military Relations (2-0-1)
(no M.I.T. credit)

MS111 Introduction to R.O.T.C. and the Army (0-1-0)
(no M.I.T. credit)

MS121 Land Navigation (0-1-0)
(no M.I.T. credit)

Second Year

MS21 Leadership and Ethics (2-0-1)
(no M.I.T. credit)

MS211 Instructional Methodology (0-1-0)
(no M.I.T. credit)

MS221 Branches of the Army (0-1-0)
(no M.I.T. credit)

Third Year

MS31 Military Management (2-0-1)
(no M.I.T. credit)

MS311 Small Unit Tactics I (0-1-0)
(no M.I.T. credit)

MS321 Small Unit Tactics II (0-1-0)
(no M.I.T. credit)

Fourth Year

MS41 Military Law and Administration (2-0-1)
(no M.I.T. credit)

MS411 Advanced Leadership Practicum I (0-1-0)
(no M.I.T. credit)

MS421 Advanced Leadership Practicum II (0-1-0)
(no M.I.T. credit)

Naval R.O.T.C. Program

John H. Sweeney III, Nav.E.
 Captain, US Navy
 Visiting Professor of Naval Science
 Director, Office of Naval Science
 Professor of Naval Architecture

Kenneth B. Russell, B.S., M.S.
 Commander, US Navy
 Technical Instructor

Anthony M. Palermo, B.A., M.A.
 Major, US Marine Corps
 Technical Instructor

Ellis W. Merschoff, B.S.
 Lieutenant, US Navy
 Technical Instructor

James R. Fitzsimonds, B.S.
 Lieutenant, US Navy
 Technical Instructor

David A. Sanford, B.S.
 Lieutenant, US Navy
 Technical Instructor

Philip A. Zeman
 Chief Yeoman, US Navy
 Technical Instructor

Albert S. Wilson, Jr.
 Gunnery Sergeant, US Marine
 Corps
 Technical Instructor

Orlando Ramos Villanueva
 Chief Storekeeper, US Navy
 Technical Instructor

Arthur R. Little
 Quartermaster First Class, US Navy
 Technical Instructor

The purpose of the Naval R.O.T.C. program is to provide instruction and training in essential Naval Science subjects, which when coupled with the prescribed M.I.T. engineering or science curricula, qualify selected students for commissions in any of the many specialties in the Navy.

The M.I.T. Navy unit is one of the nationwide Naval R.O.T.C. 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 of the Navy, or the Marine Corps.

The Naval R.O.T.C. unit at M.I.T. offers two officer development programs. The Scholarship Program provides full tuition, certain fees, use of books and uniforms, and \$100 per month for four or two years. A four-year scholarship student must complete three summer cruises. Two-year students attend a six-week training session between the sophomore and junior years and must complete one summer cruise after their junior year. All scholarship students incur a four-year active duty obligation.

The College Program also consists of both the 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.

Two-year Scholarship and College Program students attend the six-week Naval Science Institute at Newport, Rhode Island prior to beginning the junior year. This is to bring their training up to the point of the four-year students before entering the advanced course. All students receive travel costs to and from their homes in connection with the summer cruises, as well as the current active duty pay rate during the cruises.

Upon completion of the program and receipt of a Bachelor of Science from M.I.T., the student is commissioned as an Ensign, US Navy or 2nd Lieutenant, USMC in the case of Scholarship Program students, and 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 R.O.T.C. program, an entering student must be: 1) a citizen of the United States; 2) at least 17 years of age and not more than 25 years of age by June 30 of the year of your college graduation. The lower age limit may be reduced to 16 years if the student is considered of sufficient maturity to take Naval Science subjects; 3) physically qualified in accordance with the standards for entrance to the Naval Academy, except that total visual acuity must meet the current standards, correctable to 20-20 by the use of lenses. (M.I.T. students are permitted considerable latitude in the visual requirements, and certain types of color blindness are acceptable); 4) planning to pursue work at M.I.T. leading to a bachelor's degree in any Course.

Application Procedure

Inquiries regarding the M.I.T. program should be addressed to the Commanding Officer, N.R.O.T.C. and Naval Administrative Unit, 20E-125, M.I.T., Cambridge, Massachusetts 02139, or any local US Navy Recruiting Station.

Program of Instruction

The N.R.O.T.C. program of instruction encompasses not only the science of nautical matters but also international affairs, national security policy, and principles of management — all vital to the art of being a naval officer. The program has three interacting and equally important aspects. The first aspect consists of the professional academic subjects taught by the Office of Naval Science. The second aspect consists of the academic subjects taught by the Institute. These subjects comprise those outlined, as well as one year of calculus and physics. The third aspect consists of the professional training gained from leadership laboratories (one hour a week throughout the year), from voluntary 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.

All students in the Naval R.O.T.C. program, while completing degree requirements in one of the M.I.T. Courses, must take the following subjects prior to graduation.

First Year

| | |
|------------------|--|
| NS11 | Introduction to Naval Science (2-0-1) (no M.I.T. credit) |
| NS12* | Naval Ships Systems I (3-0-3) (no M.I.T. credit) |
| 13.013J NS51J | Water, Air and Interface Vehicles (3-0-9) (Optional, except for Engineering Duty candidates) |

Second Year

| | |
|------|---|
| NS21 | Naval Ships Systems II (2-2-2) (no M.I.T. credit) |
| NS22 | Seapower and Maritime Affairs (2-0-2) (no M.I.T. credit) |
| | A staff-specified M.I.T. subject on Military History/ International Relations |

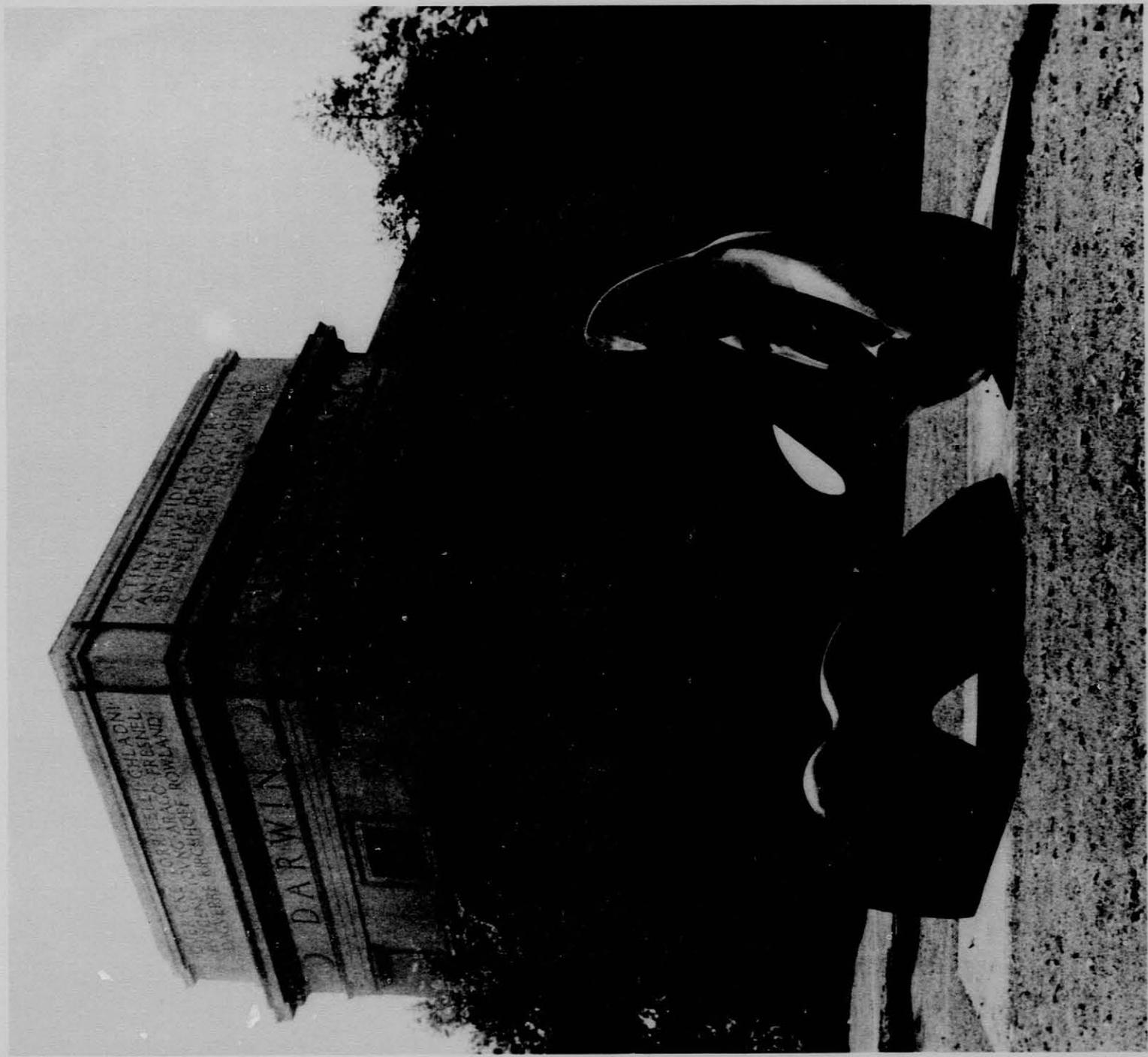
Third Year

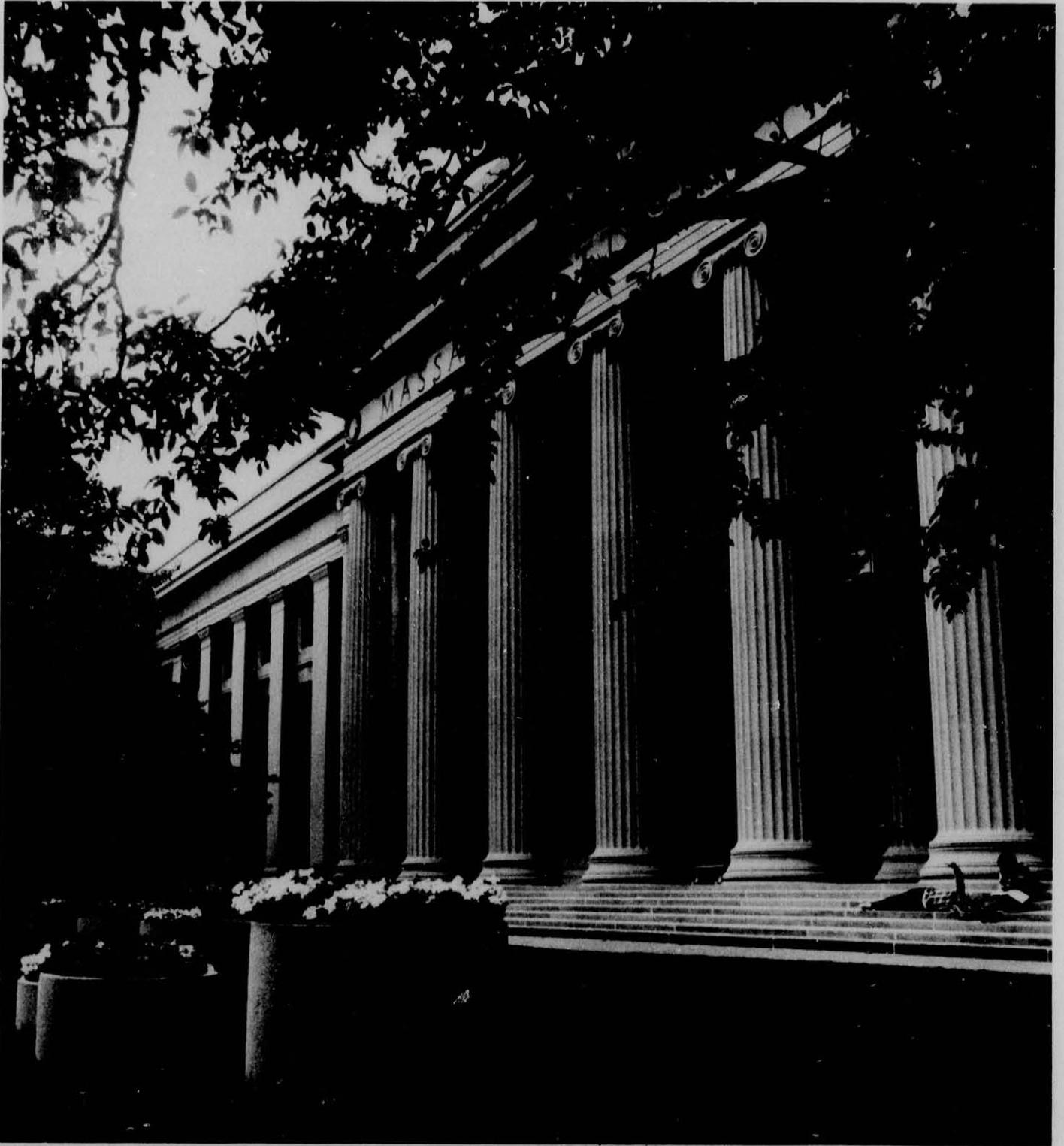
| | |
|-------|--|
| NS31 | Navigation and Naval Operations I (3-0-3) (no M.I.T. credit) |
| NS32* | Navigation and Naval Operations II (2-2-2) (no M.I.T. credit) |
| NS33 | Modern Warfare (2-0-2) (Marine option only, in lieu of NS31 and NS32) (no M.I.T. credit) |
| | A staff-specified M.I.T. subject on Defense Policy Formulation |

Fourth Year

| | |
|------|---|
| NS41 | Leadership and Management (2-0-2) (no M.I.T. credit) |
| NS42 | Leadership and Management (2-0-2) (no M.I.T. credit) |
| NS43 | Amphibious Warfare (2-0-2) (Marine option only, in lieu of NS41 and NS42) (no M.I.T. credit) |

*These are normally given in conjunction with M.I.T. accredited seminars.





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Breene Mitchell Kerr
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Clint Williams Murchison, Jr.
Partner
Murchison Brothers

Gregory Smith
Former President and General
Manager
Eastman Gelatine Corporation

Louis Wellington Cabot
Chairman of the Board
Cabot Corporation

Richard Lee Terrell
Former Vice Chairman
General Motors Corporation

Helen Fisher Whitaker
Trustee
Whitaker Health Sciences Fund

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Ambassador to the United States
Republic of Colombia

Shirley Ann Jackson (1980)
Member, Technical Staff
Bell Telephone Laboratories,
Inc.

Vernon Eulion Jordan, Jr. (1980)
President
National Urban League, Inc.

Norman Bernard Leventhal
(1980)
President
The Beacon Companies

Allan Joseph MacEachen (1980)
Deputy Leader of the Opposition
House of Commons
Canada

Harold Jacob Muckley (1980)
Consultant

Mary Frances Wagley (1980)
Executive Director
Episcopal Social Services
Diocese of Maryland

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Arthur D. Little, Inc.

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President and Chief Operating
Officer
Motorola Inc.

Ellis Carl Littmann (1981)
President and Chairman
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Nixdorf Krein Industries, Inc.

William Harold Mills (1981)
President
Mills & Jones Construction
Company

James Albert Moody (1981)
Attorney-at-Law
Hogan & Hartson
Washington, D.C.

Kenneth Harry Olsen (1981)
Director and President
Digital Equipment Corporation

Howard Larsen Richardson (1981)
Corporate Director and Consultant

¹
Address correspondence to the
Massachusetts Institute of Technology,
Cambridge, Massachusetts 02139.

²
Terms expire on June 30 of the year
indicated.

William Gerald Austen (1982)
Chief of the Surgical Services,
Massachusetts General Hospital
Edward D. Churchill Professor
of Surgery,
Harvard Medical School

Yaichi Ayukawa (1982)
Chairman
CPC Japan Ltd.

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Operations Research Analyst
Goldman, Sachs & Co.

David Ross Clare (1982)
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William Van Alan Clark, Jr. (1982)
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Sippican Corporation

Charles G. Koch (1982)
Chairman
Koch Industries

Jerry McAfee (1982)
Chairman and Chief Executive
Officer
Gulf Oil Corporation

Denman Kittredge McNear (1982)
President
Southern Pacific Transportation
Company

F. Richard Meyer, III (1982)
Consultant
Corporate mergers and acquisitions

David Stephen Saxon (1982)
President
University of California Systemwide
Administration

William Henry Krome George (1983)
Chairman and Chief Executive
Officer
Aluminum Company of America

Paul Hotte (1983)
Former Vice President for Investor
Relations
P. R. Mallory & Co. Inc.

Brian Gordon Richard Hughes (1983)
Satellite Systems Analyst
Corroon & Black, Inc.
Washington, D.C.

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Chairman of the Executive
Committee
Morgan Guaranty Trust Company
of New York

leoh Ming Pei (1983)
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I. M. Pei and Partners

Stanley Matthew Proctor (1983)
Founder and President
Stanley M. Proctor Company

Edward Oswald Vetter (1983)
Edward O. Vetter
& Associates, Inc.

Emily Lippincott Wick (1983)
Dean of the Faculty and Professor
of Chemistry
Mount Holyoke College

Herman Russell Branson (1984)
President
Lincoln University

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Chairman of the Board
IBM Corporation

Paulette Coleman (1984)
Assistant Professor
University of Texas at Austin

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Associate

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Director

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Associate Director

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Astronautics
Chairman, Experimental Study
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Assistant Dean

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Business Advisor to Fraternities and
Independent Living Groups

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Staff Accountant
Undergraduate Finance Board

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International Students' Advisor
Associate Dean

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Assistant Dean

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Assistant Dean

Bonny Sue Kellermann, M.A.
Assistant Dean

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Director, Undergraduate Academic
Support Office

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Advisor on Preprofessional
Education

E. Jane Dickson
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on Academic Performance

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Associate Dean, Emeritus

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Carol K. Hulsizer, B.A.

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Helena Toksöz, B.S.

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Margaret B. Lettvin

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Doreen Beinart, M.Ed.

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Evelyn M. Houtsma, B.A.

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Margery Resnick, Ph.D.
Stephen K. Ault, A.M.

MacGregor House
Nathan Henry Cook, Sc.D.
Alice C. Cook, B.A.

William G. Thilly, Sc.D.
Diane F. Thilly, J.D.

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Karen Goodall, B.S.

Random Hall
(To be appointed)

Senior House
Borivoje Mikic, Sc.D.
Liba Mikic

Athletics

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Director of Athletics
Head of the Department

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Assistant Professor of Physical Education
Head Coach of Lacrosse and Soccer

John Gale Barry, B.S., M.S.
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Assistant Director of Athletics
Varsity Golf Coach

John A. Benedick, B.S., M.A.
Assistant Professor of Physical Education
Men's and Women's Swimming and Water Polo Coach

Jane Betts, B.A., M.S.
Associate Professor of Physical Education
Assistant Director of Athletics
Director of Women's Intercollegiate Athletics

Wilfred Raymond Chassey, B.S., M.Ed.
Associate Professor of Physical Education
Varsity Wrestling Coach

Edward Arthur Crocker, B.S.
Associate Professor of Physical Education
Director of Physical Education
Varsity Squash Coach
Varsity Tennis Coach

Jean A. Heiney, B.S., M.S.
Assistant Professor of Physical Education
Women's Basketball Coach
Assistant Softball Coach

Peter Anderson Holland, A.B., M.A.
Associate Professor of Physical Education
Head Rowing Coach

Gordon Victor Kelly, B.S., M.Ed.
Associate Professor of Physical Education
Head Track Coach

David Michael, B.S.
Associate Professor of Physical Education
Physical Education Swimming Program Director
Supervisor of Intramurals
Coach of Skiing

Francis Charles O'Brien, Jr., A.B., M.Ed.
Associate Professor of Physical Education
Varsity Basketball Coach
Varsity Baseball Coach

Manuel Weiss, B.S.
Assistant Professor of Physical Education
Women's Tennis Coach
Men's Freshman Squash Coach

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Varsity Sailing Coach

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Pasquale E. Melaragno
Rangemaster
Varsity Pistol Coach

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Assistant Sailing Master
Women's Sailing Coach

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Adele M. Severson
Women's Trainer
Instructor in Cardiac Pulmonary Resuscitation

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Head Coach of Fencing

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Women's Intercollegiate Athletics

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John H. Murphy
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Rosemary Viano
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Robert Shaw, B.S., LL.B.
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Assistant Counsel

Patent Marketing

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Donald Thomas Stevenson, Ph.D.
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Frederic John Epling, Ph.D.
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Director, Bates Linear Accelerator

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Director of Personnel

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Assistant Equal Opportunity Officer

Betty L. Hendricks
Supervisor, Faculty and Academic
Staff Records Office

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Assistant to the Vice President,
Administration and Personnel
Director of Personnel

Claudia Burroughs Liebesny, B.A.
(Absent)

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Benefits Officer

Donna Jeanne Taylor
Associate Benefits Officer

Nancy Rees Urquhart
Associate Benefits Officer

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Manager, Labor Relations

Michael Joseph Parr, B.A.
Assistant Manager, Labor Relations

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Wage and Salary Administrator

Therese M. Viohl
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Manager, Personnel Information
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Financial Aid

Dorothy Elizabeth Bowe
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Financial Aid

Stanley George Hudson, M.B.A.
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Financial Aid

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Financial Aid
Director of Student Employment

Lois B. Levine
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Financial Aid

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Philippa Warner
Family Day Care Program Developer

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Buyer

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Buyer

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of Laboratory Supplies

Danti Joseph Scarponi
Manager, Office of Laboratory
Supplies

James Joseph Sweeney
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Program Development

Yvonne L. Whitaker, B.A.
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Ronald Paul Smith
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Medical Director
Head of Department

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Emeritus

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Physician in Charge of
Environmental Medical Service

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Physician

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Assistant Medical Director
Physician

Samuel Wolf Stein, M.D.
Assistant Medical Director
Physician

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Associate Surgeon-in-Chief

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Psychiatrist-in-Chief

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Associate Psychiatrist-in-Chief

Peter Borie Jenney, M.D.
Associate Psychiatrist-in-Chief

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Frederic Garfield Worden, M.D.
Professor of Psychiatry

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Ronald C. Fleming, A.C.S.W.
Social Worker

Myra Aileen Rodrigues, M.S.S.
Social Worker

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Associate Director of Nurses
Supervisor of Nurses, M.I.T.
Infirmary

Ambulatory Service

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Supervisor of Nurses

Florence Dingle, R.N.
Nurse Coordinator, Obstetrics
and Gynecology

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Orthopedic Assistant

Nurse Practitioners

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Janice Marie McDonough, R.N.P.
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Lorraine G. Toher, R.N.P.
Marcia Cecilia West, R.N.P.
Susan Eva Wicks, R.N.P.

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Donald Bartlett, M.A., P.A.
Joyce Bishop, R.N., P.A.

Off-Hours Service

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Nurse Practitioners

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Colleen Ryan, R.N.P.
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Joyann Kay, R.N., B.S.
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Carolyn M. Leonard, R.N.
Catherine Theresa Marin, R.N.
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M.I.T. Health Plan

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M.I.T. Health Plan

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Health Planner

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Manager
Student Health Insurance

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Manager, Medical Records and Data
Processing

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Physician in Charge of
Environmental Medical Service

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Linear Accelerator

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Executive Director of Resource
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Director of Industrial Liaison

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Programs

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Director of Student Financial
Aid*
Director, Undergraduate
Academic Support Office*

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June L. Matthews (1981)
Marcus Karel (1982)
Judson R. Baron (1982)
Peter Elias**

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Academic Support Office*
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Discipline

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(Chairman)

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(To be appointed)**

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(Deputy Chairman)
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Associate Provost*
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Merton C. Flemings (1981)
Kenneth R. Manning (1981)
Margery Resnick (1981)
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Roy E. Welsch (1981)

Kathryn W. Lombardi
Secretary

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David Gordon Wilson (1981)
Amedeo R. Odoni (1982)
Edgar A. Schein (1982)

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Harold John Hanham
William F. Pounds
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Director of Admissions*
Associate Chairman of the Faculty*
Registrar*

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Services*
Director of Libraries*

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Director, Undergraduate Academic
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General Index

- Academic Calendar** 6
Academic Council 15
Academic Information, General 48, 88
Academic Program 5, 40
Academic Standards, Graduate 89
Accelerated Master of Science in Management 269
Accreditation by the Engineering Council for Professional Development 164, 169, 175, 183, 191, 199, 209, 223
Acoustics 108
Activities, Campus 22
Admissions, College Transfer 65
Admissions, Deferred 63
Admissions for O.S.P. Staff, Graduate School 92
Admissions, Foreign Graduate. See International Graduate Admissions
Admissions, Foreign Undergraduate. See International Undergraduate Admissions
Admissions, Freshman 61
Admissions, Regular Graduate 89
Admissions, Special Student 66, 91
Advanced Credit 66
Advanced Degrees, Undergraduate Requirements for 89
Advanced Engineering Study, Center for 120, 229
Advanced Placement 63
Advanced Standing Examinations 49, 63
Advanced Study Program 229
Advanced Study Program in Air Transportation 229
Advanced Visual Studies, Center for 120, 143, 146
Advising and Counseling 32
Advising and Education, Preprofessional 33, 46, 89
Advising, Office of Freshman 48
Aeroelasticity, Structures, Materials, and 168
Aeronautical and Astronautical Systems 168
Aeronautics and Astronautics, Bachelor of Science in 169
Aeronautics and Astronautics, Cooperative Program in 169
Aeronautics and Astronautics, Department of 166
Aeronautics and Astronautics Divisions of Instruction and Research Laboratories 170
Aeronautics and Astronautics, Doctor of Philosophy and Doctor of Science in 171
Aeronautics and Astronautics, Engineer in 171
Aeronautics and Astronautics, Master of Science in 171
Aeronautics and Astronautics, Subjects in 173
Aid for Foreign Study 97
Aid for Study in Various Fields 97
Air Force R.O.T.C. Program 318
Air Transportation, Advanced Study Program in 229
Alfred P. Sloan Fellows Program 272
Alfred P. Sloan School of Management 265
Alpha Phi Omega 26
Alumnae, Association of M.I.T. 15
Alumni Association 15
Alumni Fund 15
Alumni Placement 33
America-Mideast Educational and Training Services 64
American Studies 53
Ancient and Medieval Studies 248
Anthropology and Archaeology 53, 103, 244
Applications for Financial Aid 69, 95
Applied Biology 278, 298
Applied Mathematics 290
Applied Mechanics 224
Archaeology and Ancient Technology 103
Archaeology and Anthropology 53, 103, 244
Archaeology and Ethnology, Center for Materials Research in 123
Architecture and Planning, Laboratory of 132, 143
Architecture and Planning, School of 142
Architecture, Art, and Environmental Studies, Doctor of Philosophy in 150
Architecture, Department of 145
Architecture, Master of 84, 149
Architecture Studies, Master of Science in 149
Architecture, Subjects in 151
Army R.O.T.C. Program 320
Art and Architecture, History of 53
Art and Design, Bachelor of Science in 147
Art Collection, Environmental 11
Arteriosclerosis Center 118
Artificial Intelligence Laboratory 118
Arts at M.I.T., Council for the 9
Arts, Humanities, and Social Sciences Requirement 52, 232
Ashdown House, Avery Allen 31
Assistantships, Teaching and Research 96
Associates Program, M.I.T. 15
Association of M.I.T. Alumnae 15
Astronautical Systems, Aeronautical and 168
Astronomy and Astrophysics 103, 310
Athletics 23
Avery Allen Ashdown House 31
Awards and Prizes 75, 99
Bachelor of Science in Aeronautics and Astronautics 169
Bachelor of Science in Art and Design 147
Bachelor of Science in Chemical Engineering 176
Bachelor of Science in Chemistry 282
Bachelor of Science in Civil Engineering 182
Bachelor of Science in Computer Science and Engineering 192
Bachelor of Science in Earth and Planetary Sciences 286
Bachelor of Science in Economics 239
Bachelor of Science in Electrical Engineering 191
Bachelor of Science in Humanities and Engineering 249
Bachelor of Science in Humanities and Science 249
Bachelor of Science in Life Sciences 278, 298
Bachelor of Science in Management 268
Bachelor of Science in Materials Science and Engineering 199
Bachelor of Science in Mathematics 290
Bachelor of Science in Mechanical Engineering 209
Bachelor of Science in Nuclear Engineering 216
Bachelor of Science in Ocean Engineering, in Naval Architecture and Marine Engineering, or Without Designation 223
Bachelor of Science in Philosophy 254
Bachelor of Science in Physics 305
Bachelor of Science in Political Science 258
Bachelor of Science in Political Science: Public Policy 259
Bachelor of Science in Urban Studies 155
Bachelor of Science, Interdisciplinary Science Program 105, 307
Bachelor's and Master's Degree Program, Combined 209
Bachelor's and Master's Degrees, Simultaneous Award of 49, 85
Bachelor's Degrees, Program for Two 49
Ballroom Dancing Club 26
Bates Linear Accelerator 119
Behavioral Science in Management 268
Biochemical Engineering 299
Biochemistry 279
Bioelectrical Engineering Option 192
Biological Oceanography 111, 279, 309
Biology, Applied 278, 298
Biology, Department of 277
Biology, Doctor of Philosophy in 279
Biology, Subjects in 280
Biomedical Engineering 104, 171, 207
Biomedical Engineering at M.I.T., Summary of Graduate Degree Opportunities in 316
Biomedical Engineering, Doctor of Philosophy in 212
Biomedical Engineering, Doctor of Science or Doctor of Philosophy in 315
Biomedical Sciences 315
Biomedical Sciences Program, Doctor of Medicine in 315
Biophysics 279
Bitter National Magnet Laboratory 119
Black Student Union, M.I.T. 26
Board and Room 67, 93
Books and Materials 67, 94
Boston Environment 12
Boston Library Consortium 8, 79
Boston University 87
Brandeis University 87
Calculus Requirement 51
Calendar, Academic 6
Cambridge Humanities Seminar 248
Campus 10
Campus Activities 22
Campus Tours 11
Cancer Research, Center for 120
Career Opportunities in Ocean Engineering 221
Career Planning and Placement 33
Cell Biology, Virology, and Physiology 279
Cell Culture Center 119
Center for Advanced Engineering Study 120, 229
Center for Advanced Engineering Study Seminar Office 230
Center for Advanced Visual Studies 120, 143, 146
Center for Cancer Research 120
Center for Computational Research in Economics and Management Science 121
Center for Information Systems Research 122
Center for International Studies 122
Center for Materials Research in Archaeology and Ethnology 123
Center for Materials Science and Engineering 123
Center for Policy Alternatives 123
Center for Space Research 124
Center for Theoretical Physics 304
Center for Transportation Studies 117, 124, 184
Ceramics, Master of Science in 200
Chamber Players 24
Chapel 25
Charges for Late Changes in Registration 68, 94
Charles Stark Draper Laboratory 139
Chemical Engineer 177
Chemical Engineering, Bachelor of Science in 176
Chemical Engineering, Department of 174
Chemical Engineering, Doctor of Philosophy and Doctor of Science in 176
Chemical Engineering, Master of Science in 177
Chemical Engineering Practice, Master of Science in 177

- Chemical Engineering, Subjects in 178
 Chemical Oceanography 111
 Chemical Oceanography, Marine Geology, Marine Geophysics, and Physical Oceanography 309
 Chemistry, Bachelor of Science in 282
 Chemistry/Biology Requirement 51
 Chemistry, Department of 281
 Chemistry, Doctor of Philosophy and Doctor of Science in 282
 Chemistry, Master of Science in 282
 Chemistry, Subjects in 283
 Chinese Choral Society 24
 Choir, Gospel 24
 Choral Society 24
 Choral Society, Chinese 24
 Chorallaries 24
 City Planning, Master in 84, 156
 Civil Engineer 183
 Civil Engineering, Bachelor of Science in 182
 Civil Engineering, Department of 180
 Civil Engineering, Doctor of Philosophy and Doctor of Science in 183
 Civil Engineering, Master of Science in 183
 Civil Engineering, Subjects in 186
 Clinical Nutrition, Human and 299
 Clinical Research Center 125
 Coed Fraternity Residences 30
 Coastal Zone Development 224
 Cognitive Sciences 108
 College Transfer Admissions 65
 College Work-Study 97
 Combined Bachelor's and Master's Degree Program 209
 Combined Doctor of Medicine-Doctor of Philosophy Program in the Harvard-M.I.T. Division of Health Sciences and Technology 316
 Committee on Curricula 50
 Committee on Discipline 34
 Committee on Educational Policy 15
 Committee on Graduate School Policy 22, 79, 84, 88
 Committee on Preprofessional Advising and Education 33
 Committee on Privacy 36
 Commons Plans 29
 Communication Sciences and Engineering 136
 Community Development, Neighborhood and 156
 Community Fellows Program 142, 158
 Community Players, M.I.T. 25
 Compton Gallery, Margaret Hutchinson 27
 Computational Research in Economics and Management Science, Center for 121
 Computer Science and Engineering, Bachelor of Science in 192
 Computers, and Control, Systems, 207
 Concentration, Fields of 52
 Concert Band 24
 Concert Jazz Band 24
 Concourse Program 42, 104
 Consortium of Boston Libraries 8, 79
 Constructed Facilities 182
 Control, Instrumentation, Guidance, and 168
 Control, Systems, Computers, and 207
 Cooperative Living 30
 Cooperative Program in Aeronautics and Astronautics 169
 Cooperative Programs, with other Institutions 87
 Cooperative Programs 67, 93
 Corporation 15
 Costs for Graduate Students 93
 Costs for Undergraduate Students 67
 Council for the Arts at M.I.T. 9
 Counseling and Advising 32
 Creative Photography Gallery 26
 Creative Photography Laboratory 143
 Creative Writing 53
 Credits 48, 88
 Crossroads in Western Tradition. See Western Tradition: Issues and Texts.
 Curricula, Committee on 50
 Dance Workshop, M.I.T. 26
 Debate Society 26
 Decision Systems, Laboratory for Information and 130
 Deferred Admissions 63
 Deferred Payment Plan 68, 94
 Degree Programs in Engineering 164
 Degree Programs, Unspecified 107
 Degrees, Doctoral 86
 Degrees, Double 49, 85
 Degrees, Engineer's 85
 Degrees, Master's 84
 Degrees With and Without Specification 85
 Department of Aeronautics and Astronautics 166
 Department of Architecture 145
 Department of Biology 277
 Department of Chemical Engineering 174
 Department of Chemistry 281
 Department of Civil Engineering 180
 Department of Earth and Planetary Sciences 285
 Department of Economics 238
 Department of Electrical Engineering and Computer Science 188
 Department of Humanities 242
 Department of Linguistics and Philosophy 254
 Department of Materials Science and Engineering 197
 Department of Mathematics 289
 Department of Mechanical Engineering 204
 Department of Meteorology 293
 Department of Nuclear Engineering 214
 Department of Nutrition and Food Science 297
 Department of Ocean Engineering 220
 Department of Physics 302
 Department of Political Science 257
 Department of Psychology 262
 Department of Urban Studies and Planning 153
 Departmental Programs 40, 141
 Departmental Programs and Requirements 141
 Design, Environmental 156
 Design, Visual Arts and 54
 Developing Countries, Planning for 156
 Development, Neighborhood and Community 156
 Development, Regional Economic, 156
 Dining 29
 Disciplinary Committee Procedures, Statement of 34
 Discipline, Committee on 34
 Disclosure of Information about Students 35
 Distribution Subjects 52
 Division of Health Sciences and Technology, Harvard-M.I.T. 83, 312
 Division for Study and Research in Education 107, 113, 125
 Divisions of Instruction and Research Laboratories, Aeronautics and Astronautics 170
 Doctoral Degrees 86
 Doctor of Medicine-Doctor of Philosophy, Combined Program in the Harvard-M.I.T. Division of Health Sciences and Technology 316
 Doctor of Medicine in Biomedical Sciences Program 315
 Doctor of Philosophy and Doctor of Science, Aeronautics and Astronautics 171
 Doctor of Philosophy and Doctor of Science, Chemical Engineering 176
 Doctor of Philosophy and Doctor of Science, Chemistry 282
 Doctor of Philosophy and Doctor of Science, Civil Engineering 183
 Doctor of Philosophy and Doctor of Science, Earth and Planetary Sciences 286
 Doctor of Philosophy and Doctor of Science, Electrical Engineering and Computer Science 194
 Doctor of Philosophy and Doctor of Science, Materials Science and Engineering 200
 Doctor of Philosophy and Doctor of Science, Mathematics 291
 Doctor of Philosophy and Doctor of Science, Mechanical Engineering 210
 Doctor of Philosophy and Doctor of Science, Meteorology 295
 Doctor of Philosophy and Doctor of Science, Nuclear Engineering 218
 Doctor of Philosophy and Doctor of Science, Nutrition and Food Science 298
 Doctor of Philosophy and Doctor of Science, Ocean Engineering 224
 Doctor of Philosophy and Doctor of Science, Physics 305
 Doctor of Philosophy, Architecture, Art, and Environmental Studies 150
 Doctor of Philosophy, Biology 279
 Doctor of Philosophy, Biomedical Engineering 212
 Doctor of Philosophy, Economics 239
 Doctor of Philosophy, Linguistics 255
 Doctor of Philosophy, Management 269
 Doctor of Philosophy or Doctor of Science in Medical Engineering or Medical Physics 316
 Doctor of Philosophy, Philosophy 255
 Doctor of Philosophy, Political Science 259
 Doctor of Philosophy, Psychology 263
 Doctor of Philosophy, Urban Studies and Planning 156
 Doctor of Science or Doctor of Philosophy in Biomedical Engineering 315
 Doctor of Science or Doctor of Philosophy in Medical Engineering or Medical Physics 316
 Domestic Year Away 47
 Dormitory Council 22
 Double degrees 49, 85
 Drama Program 247
 Dramashop 25
 Draper Laboratory 139
 Dual Master's Degrees in Urban Studies and Architecture 157
 Dynamics of Management Systems 269
 Early Action in Admissions 63
 Early Music Society 24
 Earth and Planetary Sciences, Bachelor of Science in 286
 Earth and Planetary Sciences, Department of 285
 Earth and Planetary Sciences, Doctor of Philosophy and Doctor of Science in 286
 Earth and Planetary Sciences or Oceanography, Master of Science in 286
 Earth and Planetary Sciences, Subjects in 287
 Eastgate 31
 Economic Development, Regional 156
 Economics, Bachelor of Science in 239
 Economics, Department of 238

- Economics, Doctor of Philosophy in 239
 Economics, Master of Science in 239
 Economics, Subjects in 240
 Education, Division for Study and Research in 107, 113, 125
 Education for Public Management Program 229
 Education, Prelaw 46
 Education, Premedical 46
 Education Studies 46
 Educational Policy, Committee on 15
 Educational Resources 8
 Elective Subjects 55
 Electives 44
 Electives in Engineering, School-Wide 163
 Electric Power Systems Engineering Laboratory 126
 Electrical Engineer 194
 Electrical Engineering and Computer Science, Department of 188
 Electrical Engineering and Computer Science, Doctor of Philosophy and Doctor of Science in 194
 Electrical Engineering and Computer Science, Master of Science in 194
 Electrical Engineering and Computer Science, Subjects in 195
 Electrical Engineering, Bachelor of Science in 191
 Elements of Ocean Engineering 222
 Employment, Student 69, 96
 Energy Conversion, Propulsion and 168
 Energy Laboratory 127
 Engineer, Aeronautics and Astronautics 171
 Engineer, Chemical 177
 Engineer, Civil 183
 Engineer, Electrical 194
 Engineer, Environmental 177, 183, 211, 224
 Engineer, Materials 177, 200, 211
 Engineer, Mechanical 210
 Engineer, Metallurgical 200
 Engineer, Nuclear 217
 Engineer, Ocean 224
 Engineering Council for Professional Development, Accreditation by the 164, 169, 175, 183, 191, 199, 209, 223
 Engineering, Degree Programs in 164
 Engineering, Naval Construction and 224
 Engineering Internship Program 162, 170, 183, 192, 200, 209, 217
 Engineering, Medical or Medical Physics, Doctor of Science or Doctor of Philosophy in 316
 Engineering, School of 160
 Engineering, School of, Interdepartmental Centers, Projects, and Laboratories in the 163
 Engineering, School-Wide Electives in 163
 Engineer's Degrees 85
 English. See Literature
 Entrance Examinations 62
 Entrance Examinations for Foreign Applicants 64
 Environmental Art Collection 11
 Environmental Design 156
 Environmental Engineer 177, 183, 211, 224
 Environmental Engineering 109, 206, 224
 Environmental Engineering, Water Resources and 182
 Environmental Planning and Policy 156
 Environmental Studies 104, 109
 Ergo 24
 Ethnology and Archaeology, Center for Materials Research in 123
 Evening Classes 9
 Examinations, Final 49, 88
 Examinations for Advanced Standing 49
 Examinations, Graduate Record 90
 Exchange Programs 47, 87
 Executive Development in Management, Programs for 272
 Experimental Study Group 42, 104
 Faculty Council 15
 Fees and Tuition 67, 93
 Fees, Miscellaneous 67, 94
 Fellowships 95
 Festival Jazz Band 24
 Fields for Graduate Study 80
 Fields of Concentration 52
 Fieldwork and Internships in Urban Studies 157
 Film Section 143
 Films, Lectures, and Seminars 24
 Final Examinations 49, 88
 Financial Aid, Applications for 69, 95
 Financial Aids 69, 95
 Flight Transportation 172
 Fluid Mechanics 224
 Fluids, Mechanics and Physics of 168
 Folk Dance Club 26
 Food Science and Technology 298
 Foreign Graduate Admissions. See International Graduate Admissions
 Foreign Languages 53
 Foreign Study for Graduate Students 88
 Foreign Undergraduate Admissions. See International Undergraduate Admissions
 Francis Bitter National Magnet Laboratory 119
 Fraternities 30
 Freshman Admissions 61
 Freshman Advisory Council. See Office of Freshman Advising
 Freshman Grading 43
 Freshman Handbook 43
 Freshman Year 41
 Full-time Study at Other Universities 47
 Fusion Center, Plasma 135
 Gallery, Margaret Hutchinson Compton 27
 General Academic Information 48, 88
 General Institute Requirements 40, 50
 General Physics 136
 General Requirements for Graduate Degrees 80
 George R. Wallace, Jr., Astrophysical Observatory 138
 George R. Wallace, Jr., Geophysical Observatory 138
 Geotechnical Engineering Research Laboratory 185
 Gospel Choir 24
 Government, Graduate Student 22
 Government, Undergraduate Student 22
 Grade Reports and Transcripts 49, 89
 Grading, Freshman 43
 Grading, Pass-Fail 43
 Graduate Academic Standards 89
 Graduate Admissions, Foreign. See International Graduate Admissions
 Graduate Admissions, Regular 89
 Graduate Education at M.I.T. 77
 Graduate Living Costs 94
 Graduate Program in Medical Radiological Physics, Harvard-M.I.T. 316
 Graduate Record Examinations 90
 Graduate School Admission for O.S.P. Staff 92
 Graduate School, Organization of the 79
 Graduate School Policy, Committee on 22, 79, 84, 88
 Graduate Single Student Housing 31
 Graduate Student Government 22
 Graduate Student Organization 22
 Graduate Students, Costs for 93
 Graduate Students, Special 91
 Graduate Study, Fields for 80
 Graduate Study, Resources for 79
 Graduate, The 24
 Guidance, and Control, Instrumentation, 168
 Hart Nautical Museum, Francis Russell 27
 Harvard-M.I.T. Division of Health Sciences and Technology 83, 312
 Harvard-M.I.T. Division of Health Sciences and Technology, Combined Doctor of Medicine-Doctor of Philosophy Program in 316
 Harvard-M.I.T. Graduate Program in Medical Radiological Physics 316
 Harvard University 47, 87
 Hayden Gallery 27
 Health Program, Student 32
 Health Sciences and Technology, Combined Doctor of Medicine-Doctor of Philosophy in the Harvard-M.I.T. Division of 316
 Health Sciences and Technology, Harvard-M.I.T. Division of 83, 312
 Health Sciences, Technology, and Management, Whitaker College of 311
 Health Service Fee 67, 93
 Historical Collections 8
 History 53
 History of Art and Architecture 53
 History of Science and Technology 235
 Hobby Shop 26
 HoToGAMIT 24
 Housing 28, 31
 Housing, Real Estate, and Land Development 156
 Human and Clinical Nutrition 299
 Humanities and Engineering 105
 Humanities and Engineering, Bachelor of Science in 249
 Humanities and Science 105
 Humanities and Science, Bachelor of Science in 249
 Humanities and Social Science, School of 231
 Humanities, Arts, and Social Sciences Requirement 52, 232
 Humanities, Department of 242
 Humanities, Subjects in 250
 Hydrodynamics 224
 Hydrodynamics, Ralph M. Parsons Laboratory for Water Resources and 185
 I.A.P. (Independent Activities Period) 6, 154
 Industrial Liaison Office 15
 Information about Students, Disclosure of 35
 Information and Decision Systems, Laboratory for 130
 Information Processing Services 8
 Information Systems Research, Center for 122
 Innovation Center 129
 Innovation Program 172
 Institute House Rentals and Meals 68, 94
 Institute Houses 29
 Institute, Organization of the 15
 Institute Requirements, General 40, 50
 Instrumentation, Guidance, and Control 168
 Intercollegiate Athletics 23
 Interdepartmental Centers, Projects, and Laboratories in the School of Engineering 163
 Interdepartmental Graduate Opportunities 108
 Interdepartmental Laboratories in the School of Science 275

- Interdepartmental Organizations and Research Facilities 118
 Interdepartmental Study and Research 101
 Interdepartmental Undergraduate Opportunities 103
 Interdisciplinary Research Opportunities 105
 Interdisciplinary Science Program 105, 109, 307
 Interdisciplinary Science Program, Bachelor of Science in the 105, 307
 Interdisciplinary Science Program, Master of Science in 109, 307
 Interfraternity Conference 22, 30
 International Graduate Admissions 91
 International Nutrition Program 129, 300
 International Students' Council 22
 International Studies, Center for 122
 International Undergraduate Admissions 64
 Internship Program, Engineering 162, 170, 183, 192, 200, 209, 217
 Internships and Fieldwork in Urban Studies 157
 Internships in Political Science 258
 Internships, Summer, in Science and Technology Policy 236
 Interphase, Project 61
 Interview 61
 Intramural Athletic Program 23
- J**
 January Independent Activities Period 6, 154
 Jazz Band, Festival 24
 Joint Center for Urban Studies of M.I.T. and Harvard University 143
 Joint Degree Programs in Humanities and Engineering and Humanities and Science 105, 249
 Joint Program in Oceanographic Engineering with Woods Hole Oceanographic Institution 176, 185, 193, 202, 211, 225, 227
 Joint Programs in Oceanography with Woods Hole Oceanographic Institution 279, 286, 295, 308
- L**
 Laboratory for Computer Science 130
 Laboratory for Information and Decision Systems 130
 Laboratory for Manufacturing and Productivity 131, 207
 Laboratory for Nuclear Science 132
 Laboratory for Water Resources and Hydrodynamics, Ralph M. Parsons 185
 Laboratory, Nuclear Reactor 134, 218
 Laboratory of Architecture and Planning 132, 143
 Laboratory Requirement 58
 Land Development, Housing, Real Estate, and 156
 Language Laboratory 244
 Language Proficiency 86
 Law and Ocean Engineering 224
 Law-Related Studies 106, 110
 Lecture Series Committee 24
 Lectures, Seminars, and Films 24
 Letters of Recommendation 36
 Libraries 8, 79
 Life Sciences, Bachelor of Science in 278, 298
 Libraries, Boston Consortium of 8, 79
 Lincoln Laboratory 133
 Linguistics and Philosophy, Department of 254
 Linguistics and Philosophy, Subjects in 256
 Linguistics, Doctor of Philosophy in 255
 Literature 53, 245
 Loan Funds, Special 74, 98
 Loan Plan, Parent 68, 69, 94
 Loans 69, 96
 Logarithms 24
 Lowell Institute School 9
- M**
 Major Course of Study 44
 Management, Accelerated Master of Science in 269
 Management, Alfred P. Sloan School of 265
 Management, Bachelor of Science in 268
 Management, Behavioral Science in 268
 Management, Doctor of Philosophy in 269
 Management, Master of Science in 269
 Management, Mineral Resources Engineering and 110, 201
 Management, Programs for Executive Development in 272
 Management Science 269
 Management, Special Program in 268
 Management, Subjects in 273
 Management Systems, Dynamics of 269
 Manufacturing and Materials Processing 207
 Manufacturing and Productivity, Laboratory for 131, 207
 Margaret Hutchinson Compton Gallery 27
 Marine Acoustics 224
 Marine Data Systems Engineering 224
 Marine Engineering 224
 Marine Geology 111
 Marine Geology, Chemical Oceanography, Marine Geophysics, and Physical Oceanography 309
 Marine Geophysics 111
 Marine Geophysics, Chemical Oceanography, Marine Geology, and Physical Oceanography 309
 Marine Systems 224
 Married Student Housing 31
 Master in City Planning 84, 156
 Master of Architecture 84, 149
 Master of Science 84
 Master of Science Degrees for Students from Other Departments, Simultaneous Award of 202
 Master of Science in Aeronautics and Astronautics 171
 Master of Science in Architecture Studies 149
 Master of Science in Ceramics 200
 Master of Science in Chemical Engineering 177
 Master of Science in Chemical Engineering Practice 177
 Master of Science in Chemistry 282
 Master of Science in Civil Engineering 183
 Master of Science in Earth and Planetary Sciences or in Oceanography 287
 Master of Science in Economics 239
 Master of Science in Electrical Engineering and Computer Science 194
 Master of Science in Management 269
 Master of Science in Management, Accelerated 269
 Master of Science in Materials Engineering 200
 Master of Science in Materials Science 200
 Master of Science in Mathematics 291
 Master of Science in Mechanical Engineering 210
 Master of Science in Metallurgy 200
 Master of Science in Meteorology or in Oceanography 295
 Master of Science in Nuclear Engineering 217
 Master of Science in Ocean Engineering, in Naval Architecture and Marine Engineering, or Without Specification 224
 Master of Science in Physics 305
 Master of Science in Political Science 259
 Master of Science in Polymerics 200
 Master of Science in Psychology and Brain Science 263
 Master of Science in Science Communication 307
- Master of Science in Shipping and Shipbuilding Management 225
 Master of Science in Technology and Policy 171, 177, 184, 201, 210, 217, 224
 Master of Science in Textile Technology 210
 Master of Science in Transportation 117, 185
 Master of Science in Visual Studies 150
 Master of Science, Interdisciplinary Science Program 109, 307
 Master of Science: Nutrition and Food Science 298
 Master's and Bachelor's Degree Program, Combined 209
 Master's and Bachelor's Degrees, Simultaneous Award of 49, 85
 Master's Degrees 84
 Master's Degrees, Simultaneous Award of Two 85
 Materials, and Structures, Aeroelasticity, 168
 Materials Engineer 177, 200, 211
 Materials Engineering 200
 Materials Engineering, Master of Science in 200
 Materials Research in Archaeology and Ethnology, Center for 123
 Materials Science 200
 Materials Science and Engineering, Bachelor of Science in 199
 Materials Science and Engineering, Center for 123
 Materials Science and Engineering, Department of 197
 Materials Science and Engineering, Doctor of Philosophy and Doctor of Science in 200
 Materials Science and Engineering, Subjects in 203
 Materials Science, Master of Science in 200
 Mathematics, Applied 290
 Mathematics, Bachelor of Science in 290
 Mathematics, Department of 289
 Mathematics, Doctor of Philosophy and Doctor of Science in 291
 Mathematics, Master of Science in 291
 Mathematics, Pure 290, 291
 Mathematics, Subjects in 291
 Mechanical Engineer 210
 Mechanical Engineering, Bachelor of Science in 209
 Mechanical Engineering, Department of 204
 Mechanical Engineering, Doctor of Philosophy and Doctor of Science in 210
 Mechanical Engineering, Master of Science in 210
 Mechanical Engineering, Research Laboratories and Programs in 207
 Mechanical Engineering, Subjects in 212
 Mechanics and Physics of Fluids 168
 Medical Engineering or Medical Physics, Doctor of Science or Doctor of Philosophy in 316
 Medical Physics or Medical Engineering, Doctor of Science or Doctor of Philosophy in 316
 Medical Radiological Physics, Harvard-M.I.T. Graduate Program in 316
 Medical Services 32
 Medieval Studies, Ancient and 248
 Metabolism and Nutritional Biochemistry 299
 Metallurgical Engineer 200
 Metallurgy 201
 Metallurgy, Master of Science in 200
 Meteorology, Department of 293
 Meteorology, Doctor of Philosophy and Doctor of Science in 295
 Meteorology or Oceanography, Master of Science in 295
 Meteorology, Subjects in 296

- Microbiology 279
 Mideast-America Educational and Training Services 64
 Mineral Resource Studies 106
 Mineral Resources Engineering and Management 110, 201
 Minerals Resources Research Institute, Mining and 106, 110, 133
 Mining and Minerals Resources Research Institute 106, 110, 133
 Minority Group Programs 61
 Minor Program 86
 Miscellaneous Fees 67, 94
 M.I.T. Associates Program 15
 M.I.T. Black Student Union 26
 M.I.T. Community Players 25
 M.I.T. Dance Workshop 26
 M.I.T. Press 9
 M.I.T. Shakespeare Ensemble 25
 M.I.T. Student House 30
 M.I.T. Urban Action Program 26
 M.I.T.-Wellesley Upward Bound Program 46
 Music 24, 54, 246
 Music Society, Early 24
 Musical Theatre Guild 24

National Fellowships for Graduate Study 97
 Nautical Museum, Francis Russell Hart 27
 Naval Architecture and Marine Engineering, Ocean Engineering, or Without Specification, Master of Science in 224
 Naval Construction and Engineering 224
 Naval Engineering 224
 Naval R.O.T.C. Program 322
 Neighborhood and Community Development 156
 Neural and Endocrine Regulation 299
 Neurosciences Research Program 133
 Night School 9
 Nonresident Student Association 22, 30
 Nuclear and Particle Theory 304
 Nuclear Engineer 217
 Nuclear Engineering, Bachelor of Science in 216
 Nuclear Engineering, Department of 214
 Nuclear Engineering, Doctor of Philosophy and Doctor of Science in 218
 Nuclear Engineering, Master of Science in 217
 Nuclear Engineering, Subjects in 218
 Nuclear Reactor Laboratory 134, 218
 Nuclear Science, Laboratory for 132
 Nursery School, Technology 31
 Nutrition and Food Science, Department of 297
 Nutrition and Food Science, Doctor of Philosophy and Doctor of Science 298
 Nutrition and Food Science, Master of Science 298
 Nutrition and Food Science, Subjects in 300
 Nutrition, Human and Clinical 299
 Nutrition Program, International 129, 300
 Nutritional Biochemistry and Metabolism 299

Ocean Engineer 224
 Ocean Engineering and Oceanographic Engineering 227, 308
 Ocean Engineering and Law 224
 Ocean Engineering, Career Opportunities in 221
 Ocean Engineering, Department of 220
 Ocean Engineering, Doctor of Philosophy and Doctor of Science in 224
 Ocean Engineering, Elements of 222
 Ocean Engineering, Naval Architecture and Marine Engineering, or Without Designation, Bachelor of Science in 223
 Ocean Engineering, Naval Architecture and Marine Engineering, or Without Specification, Master of Science in 224
 Ocean Engineering, Subjects in 226
 Ocean Transportation 224
 Oceanographic Engineering and Oceanography 111
 Oceanographic Engineering, Joint Program in, with Woods Hole Oceanographic Institution 176, 185, 193, 202, 211, 225, 227
 Oceanography 295
 Oceanography and Oceanographic Engineering 111
 Oceanography, Joint Programs in, with Woods Hole Oceanographic Institution 279, 286, 295, 308
 Oceanography or Earth and Planetary Sciences, Master of Science in 287
 Oceanography or Meteorology, Master of Science in 295
 Off Campus Housing Service 30
 Office of Freshman Advising 48
 Office of Sponsored Programs 15, 92
 Offshore Engineering 224
 Operations Research 111, 224
 Operations Research Center 111, 134
 Organization of the Graduate School 79
 Organization of the Institute 15
 Organizations and Research Facilities, Interdepartmental 118
 O.S.P. Staff, Graduate School Admission for 92
 Outing Club 26

Parent Loan Plan 68, 69, 94
 Parsons, Ralph M., Laboratory for Water Resources and Hydrodynamics 185
 Pass-Fail Grading 43
 Payment Plan, Deferred 68, 94
 Payments 68, 94
 Personal Conferences 61, 64
 Personal Files 36
 Philosophy 54
 Philosophy, Bachelor of Science in 254
 Philosophy, Doctor of Philosophy in 255
 Philosophy of Science and Technology 235
 Physical Education Requirement 59
 Physical Oceanography 111
 Physical Oceanography, Chemical Oceanography, Marine Geology, and Marine Geophysics 309
 Physics, Bachelor of Science in 305
 Physics, Department of 302
 Physics, Doctor of Philosophy and Doctor of Science in 305
 Physics, General 136
 Physics, Master of Science in 305
 Physics, Medical or Medical Engineering, Doctor of Science or Doctor of Philosophy in 316
 Physics, Medical Radiological, Harvard-M.I.T. Graduate Program in 316
 Physics Requirement 51
 Physics, Subjects in 306
 Physiology, Cell Biology, and Virology 279
 Ping Yuan Tang Residence Hall 31
 Placement, Career Planning and 33
 Planning and Policy, Environmental 156
 Planning for Developing Countries 156
 Planning, Transportation 157
 Plasma Dynamics 136
 Plasma Fusion Center 135
 Policy Alternatives, Center for 123
 Policy and Planning, Environmental 156
 Policy, Public and Ocean Use 224
 Political Science, Bachelor of Science in 258
 Political Science, Department of 257
 Political Science, Doctor of Philosophy in 259
 Political Science, Internships in 258
 Political Science, Master of Science in 259
 Political Science: Public Policy, Bachelor of Science in 259
 Political Science, Subjects in 260
 Polymeric Materials 112
 Polymerics 201
 Polymerics, Master of Science in 200
 Power Engineering 112
 Prelaw Advisory Council 46, 106
 Prelaw Education 46
 Premedical Advisory Council 46
 Premedical Education 46
 Preprofessional Advising and Education 33, 46, 89
 Professional Development, Engineering Council for, Accreditation by the 164, 169, 175, 183, 191, 199, 209, 223
 Privacy, Committee on 36
 Privacy of Student Records 35
 Prizes and Awards 75, 99
 Processing Charges for Late Charges in Registration 68, 94
 Program, Academic 5, 40
 Program for Senior Executives, M.I.T. 272
 Program for Two Bachelor's Degrees 49
 Program in Science, Technology and Society 54, 106, 113, 234
 Programs, Cooperative 67, 93
 Programs, Cooperative, with other Institutions 87
 Programs, Departmental 40, 141
 Programs for Executive Development in Management 272
 Project Interphase 61
 Propulsion and Energy Conversion 168
 Psychology and Brain Science, Master of Science in 263
 Psychology, Department of 262
 Psychology, Doctor of Philosophy in 263
 Psychology, Subjects in 264
 Public Policy and Ocean Use 224
 Public Policy, Bachelor of Science in Political Science 259
 Publications, Student 24
 Pure Mathematics 290, 291

Ralph M. Parsons Laboratory for Water Resources and Hydrodynamics 185
 Reactor Laboratory, Nuclear 134, 218
 Real Estate, and Land Development, Housing, 156
 Recommendation, Letters of 36
 Records, Privacy of 35
 Records, Student, Review of 35
 Regional Economic Development 156
 Registration 48, 88
 Registration, Charges for Late Changes in 68, 94
 Regular Graduate Admissions 89
 Regulations and Rules 34
 Religious Organizations 25
 Religious Studies 54
 Requirement, Calculus 51
 Requirement, Chemistry/Biology 51
 Requirement in the Humanities, Arts, and Social Sciences 52, 232
 Requirement, Laboratory 58
 Requirement, Physical Education 59
 Requirement, Physics 51
 Requirement, Science 50
 Requirement, Science Distribution 56

- Requirements for Advanced Degrees, Undergraduate 89
- Requirements for Graduate Degrees, General 80
- Requirements, General Institute 40, 50
- Requirements, Residence 84
- Research and Reading Seminars, Undergraduate 55
- Research and Teaching Assistantships 96
- Research Facilities, Interdepartmental Organizations and 118
- Research Laboratories, Aeronautics and Astronautics Divisions of Instruction and 170
- Research Laboratories and Programs in Mechanical Engineering 207
- Research Laboratory of Electronics 136
- Residence/Orientation Week 30
- Residence Requirements 84
- Resource Studies, Mineral 106
- Resources, Educational 8
- Resources for Graduate Study 79
- Review of Student Records 35
- Review, The* 24
- Room and Board 67, 93
- R.O.T.C. Programs 318
- Rules and Regulations 34
- Rune* 24
- Russian Studies 247
- Scholarships and Fellowships for Graduate Students 97
- Scholarships for Undergraduates 70
- School of Architecture and Planning 142
- School of Engineering 160
- School of Humanities and Social Science 231
- School of Management, Alfred P. Sloan 265
- School of Science 275
- School-Wide Electives in Engineering 163
- Science and Technology, History of 235
- Science and Technology, Philosophy of 235
- Science and Technology Policy, Summer Internships in 236
- Science and Technology, Sociology of 235
- Science Communication, Master of Science in 307
- Science Distribution Requirement 56
- Science, Master of 84
- Science Program, Interdisciplinary 105, 109, 307
- Science Requirement 50
- Science, School of 275
- Science, School of, Interdepartmental Laboratories in the 275
- Science, Technology, and Society, Program in 54, 106, 113, 224
- Sciences, Biomedical 315
- Seafloor Engineering 224
- Sea Grant Program 136
- Self-Study Subject Development Program 230
- Seminar Office, Center for Advanced Engineering Study 230
- Seminars, Lectures, and Films 24
- Seminars, Undergraduate 45, 107
- Senior Executives, M.I.T. Program for 272
- Services, Student 32
- Shakespeare Ensemble, M.I.T. 25
- Ship and Offshore Rig Dynamics 224
- Shipping and Shipbuilding Management, Master of Science in 225
- Ship Propulsion 224
- Ship Systems 224
- Simultaneous Award of Bachelor's and Master's Degrees 49, 85
- Simultaneous Award of Two Master of Science Degrees for Students from Other Departments 202
- Simultaneous Award of Two Master's Degrees 85
- Single Student Housing, Graduate 31
- Single Student Housing, Undergraduate 28
- Sloan Fellows Program, Alfred P. 272
- Sloan School of Management, Alfred P. 265
- Social Coordinating Committee 22
- Social Science, School of Humanities and 231
- Social Sciences, Humanities, and Arts Requirement 52, 232
- Sociology of Science and Technology 235
- Solid-state, Laser, Plasma, and Atomic Physics 304
- Space Research, Center for 124
- Special Graduate Students 91
- Special Interdisciplinary Programs in Humanities 107
- Special Loan Funds 74, 98
- Special Program for Urban and Regional Studies 142, 158
- Special Program in Management 268
- Special Student Admissions 66, 91
- Spectroscopy Laboratory 137
- Statement of Disciplinary Committee Procedures 34
- Structural Mechanics 224
- Structures Laboratory 185
- Structures, Materials, and Aeroelasticity 168
- Student Art Association 26
- Student Employment 69, 96
- Student Government, Graduate 22
- Student Government, Undergraduate 22
- Student Health Program 32
- Student House, M.I.T. 30
- Student Publications 24
- Student Records, Privacy of 35
- Student Records, Review of 35
- Student Services 32
- Study and Research in Education, Division for 107, 113, 125
- Study at Other Universities, Full-time 47
- Subjects, Distribution 52
- Subjects, Elective 55
- Subjects in Aeronautics and Astronautics 173
- Subjects in Architecture 151
- Subjects in Biology 280
- Subjects in Chemical Engineering 178
- Subjects in Chemistry 283
- Subjects in Civil Engineering 186
- Subjects in Earth and Planetary Sciences 287
- Subjects in Economics 240
- Subjects in Electrical Engineering and Computer Science 195
- Subjects in Humanities 250
- Subjects in Linguistics and Philosophy 256
- Subjects in Management 273
- Subjects in Materials Science and Engineering 203
- Subjects in Mathematics 291
- Subjects in Mechanical Engineering 212
- Subjects in Meteorology 296
- Subjects in Nuclear Engineering 218
- Subjects in Nutrition and Food Science 300
- Subjects in Ocean Engineering 226
- Subjects in Physics 306
- Subjects in Political Science 260
- Subjects in Psychology 264
- Subjects in Urban Studies and Planning 158
- Summary of Graduate Degree Opportunities in Biomedical Engineering at M.I.T. 316
- Summer Internships in Science and Technology Policy 236
- Summer Session 6
- Symphony Orchestra 24
- Systems, Computers, and Control 207
- Systems Research, Center for Information 122
- Talbot House 27
- Tang Residence Hall, Ping Yuan 31
- Teaching and Research Assistantships 96
- Tech, The* 24
- Tech Squares 26
- Technique* 24
- Technology Adaptation Program 114, 137
- Technology and Food Science 298
- Technology and Policy 115, 224
- Technology and Policy, Master of Science in 171, 177, 184, 201, 210, 217, 224
- Technology and Society, Program in Science 54, 106, 113, 234
- Technology Community Association 25
- Technology Nursery School 31
- Technology Review* 15
- Technology Studies. See Program in Science, Technology, and Society
- Technology Wives Organization 26
- Test of English as a Foreign Language (TOEFL) 64, 91
- Textile Technology, Master of Science in 210
- Theatre 25
- Theoretical Physics, Center for 304
- Thesis 86
- Tours of the Institute 11
- Toxicology 299
- Traineeships 95
- Transcripts and Grade Reports 49, 89
- Transfer Admissions, College 65
- Transportation, Master of Science in 117, 185
- Transportation Planning 157
- Transportation Studies, Center for 117, 124, 184
- Transportation Systems 182
- Tufts University 88
- Tuition and Fees 67, 93
- Tutoring Programs 46
- Two Bachelor's Degrees, Program for 49
- Two Master of Science Degrees for Students from Other Departments, Simultaneous Award of 202
- Two Master's Degrees, Simultaneous Award of 85
- Undergraduate Admissions, Foreign. See International Undergraduate Admissions
- Undergraduate Association 22
- Undergraduate Education at M.I.T. 39
- Undergraduate Interdepartmental Opportunities 103
- Undergraduate Students, Costs for 67
- Undergraduate Requirements for Advanced Degrees 89
- Undergraduate Research and Reading Seminars 55
- Undergraduate Research Opportunities Program (UROP) 40, 45, 105
- Undergraduate Seminars 45, 107
- Undergraduate Single Student Housing 28
- Undergraduate Student Government 22
- Unspecified Degree Programs 107
- Upward Bound Program, M.I.T.-Wellesley 46
- Urban Action Program, M.I.T. 26
- Urban Legal Studies Program 106
- Urban Studies and Architecture, Dual Master's Degrees in 157

-
- Urban Studies and Planning, Department of 153
Urban Studies and Planning, Doctor of Philosophy
in 156
Urban Studies and Planning, Subjects in 158
Urban Studies, Bachelor of Science in 155
Urban Studies, Fieldwork and Internships in 157
Urban Studies, Joint Center for, of M.I.T. and
Harvard University 143
UROP (Undergraduate Research Opportunities
Program) 40, 45, 105
- V**
Virology, Cell Biology, and Physiology 279
Visible Language Workshop 143, 146
Visiting Committees 15
Visual Arts Activities 27
Visual Arts and Design 54
Visual Studies, Master of Science in 150
- W**
Wallace Astrophysical Observatory 138
Wallace Geophysical Observatory 138
Washington Internship Program 258
Water Resources and Environmental
Engineering 182
Water Resources and Hydrodynamics, Ralph M
Parsons Laboratory for 185
Wellesley College 47, 60, 87
Wellesley-M.I.T. Exchange Program 47, 60, 87
Wellesley-M.I.T. Upward Bound Program 46
Western Tradition: Issues and Texts 248
Westgate 31
Whitaker College of Health Sciences, Technology,
and Management 311
White Water Club 26
WIMX 26
WMBR 26
Woods Hole Oceanographic Institution 87, 111,
227, 308
Woods Hole Oceanographic Institution, Joint
Program in Oceanographic Engineering with
176, 185, 193, 202, 211, 225, 227
Woods Hole Oceanographic Institution, Joint
Programs in Oceanography with 279, 286, 295,
308
Work-Study, College 97
Writing, Creative 53
Writing Program 246
WTBS. See WMBR
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