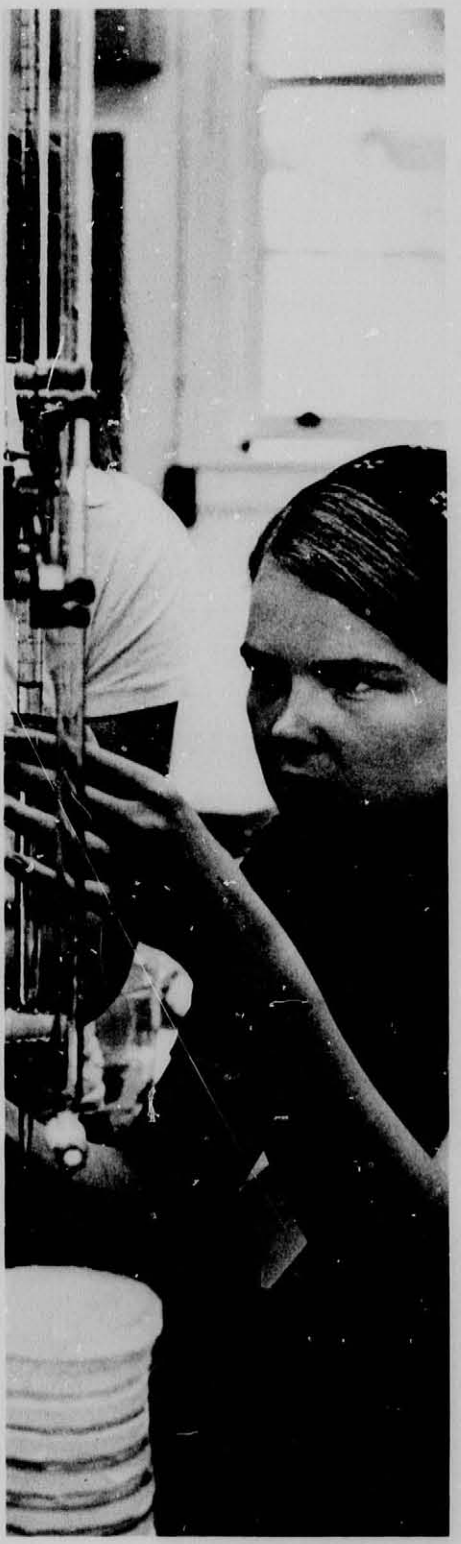
Bulletin 1974-75

Massachusetts Institute of Technology

General Catalogue Issue
September 1974







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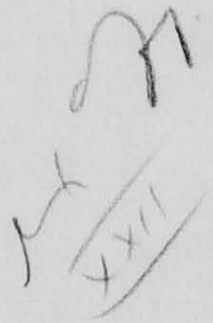
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Send undeliverable copies and changes of address to Room 7-111, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139.

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



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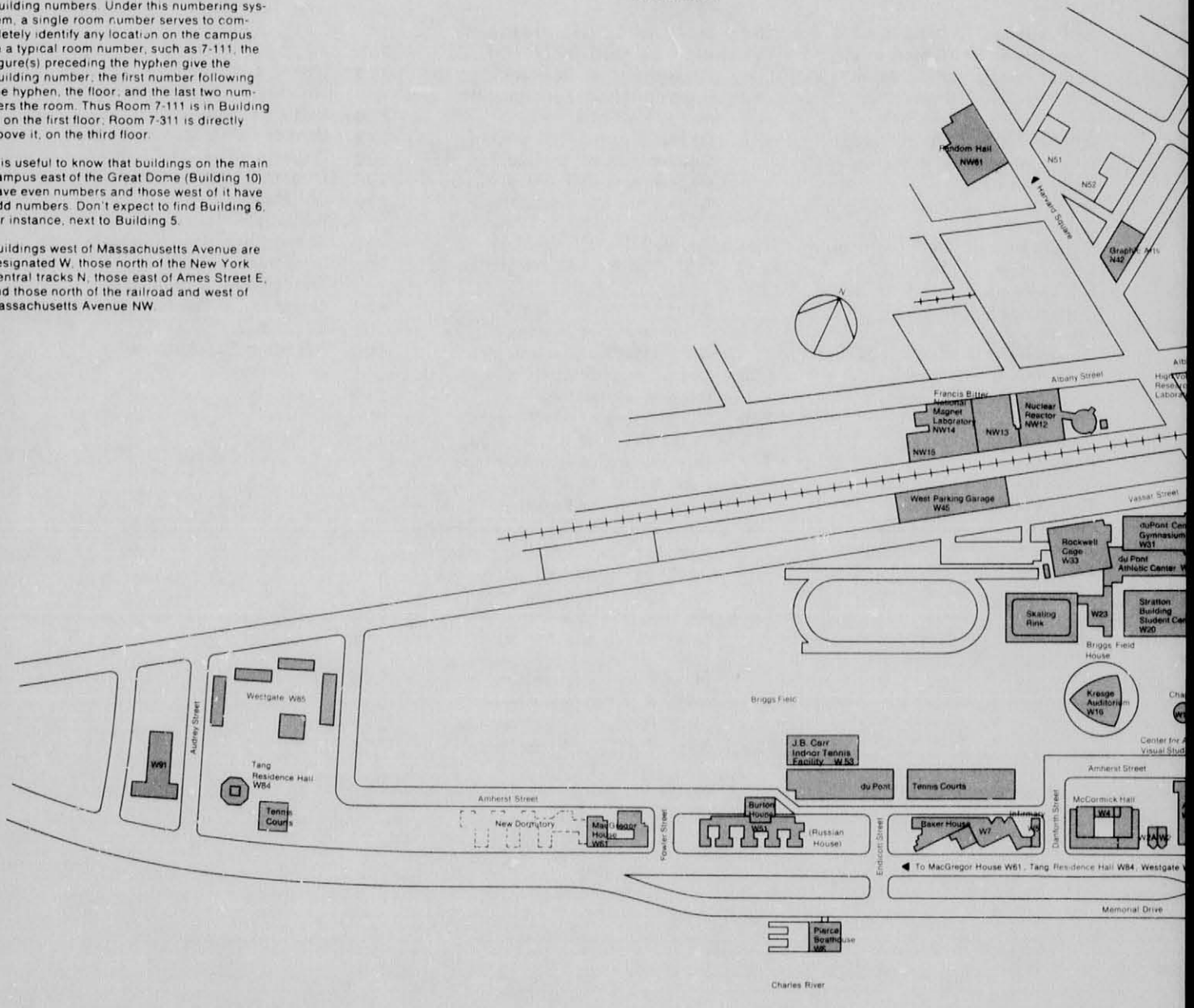
Massachusetts Institute of Technology

The numbers on this map refer to M.I.T.'s building numbers. Under this numbering system, a single room number serves to completely identify any location on the campus. In a typical room number, such as 7-111, the figure(s) preceding the hyphen give the building number; the first number following the hyphen, the floor; and the last two numbers the room. Thus Room 7-111 is in Building 7, on the first floor; Room 7-311 is directly above it, on the third floor.

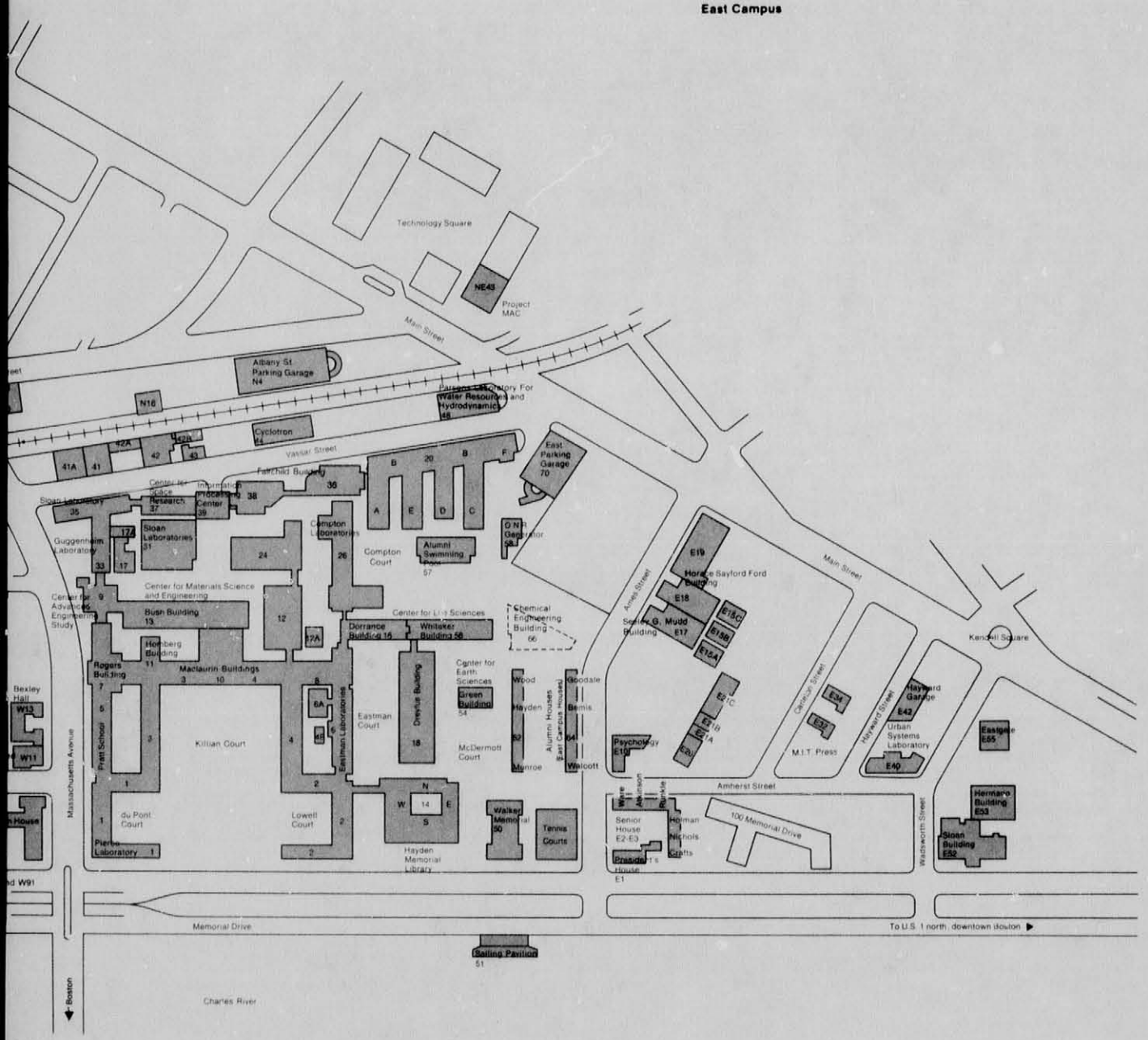
It is useful to know that buildings on the main campus east of the Great Dome (Building 10) have even numbers and those west of it have odd numbers. Don't expect to find Building 6, for instance, next to Building 5.

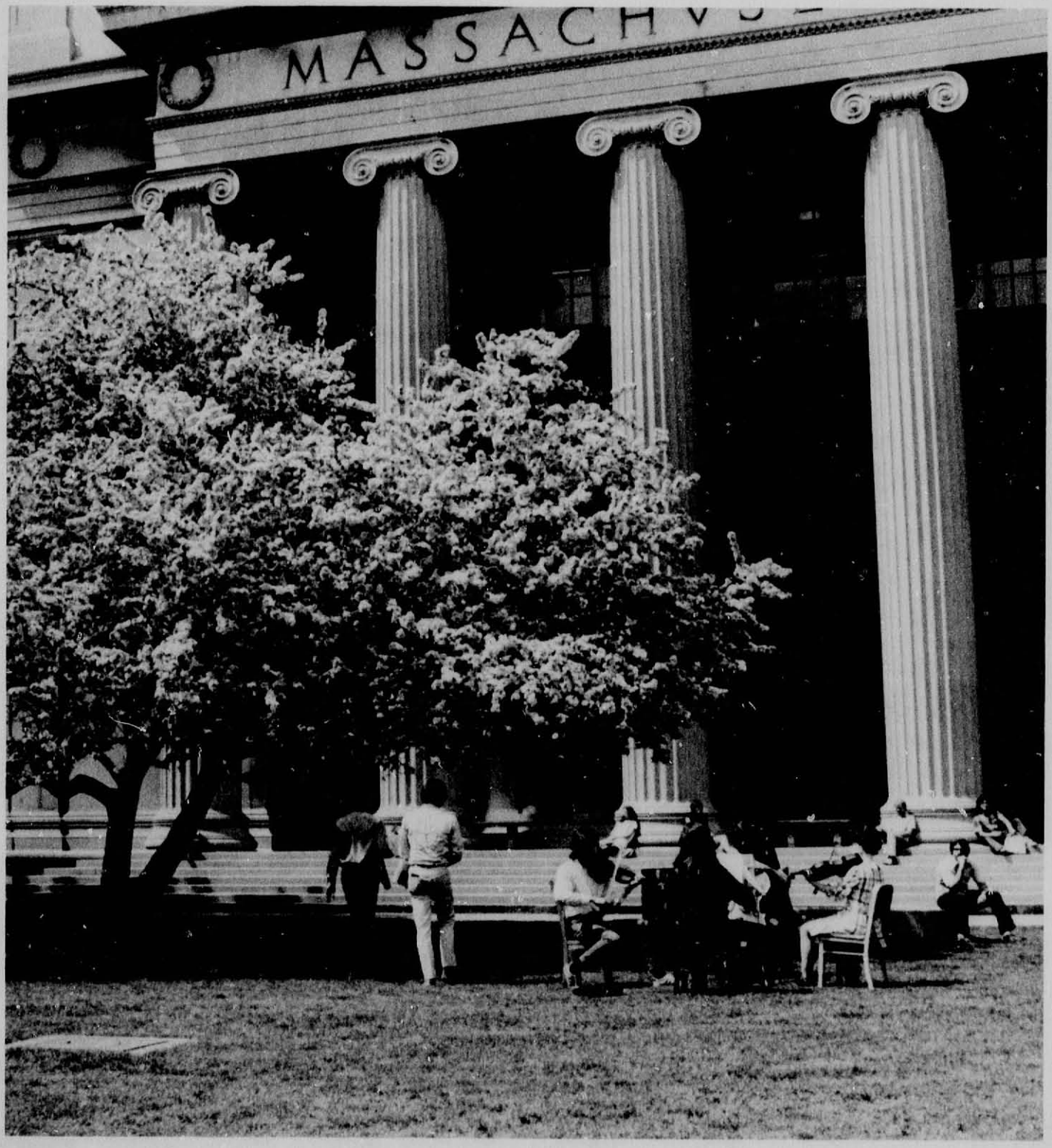
Buildings west of Massachusetts Avenue are designated W, those north of the New York Central tracks N, those east of Ames Street E, and those north of the railroad and west of Massachusetts Avenue NW.

West Campus



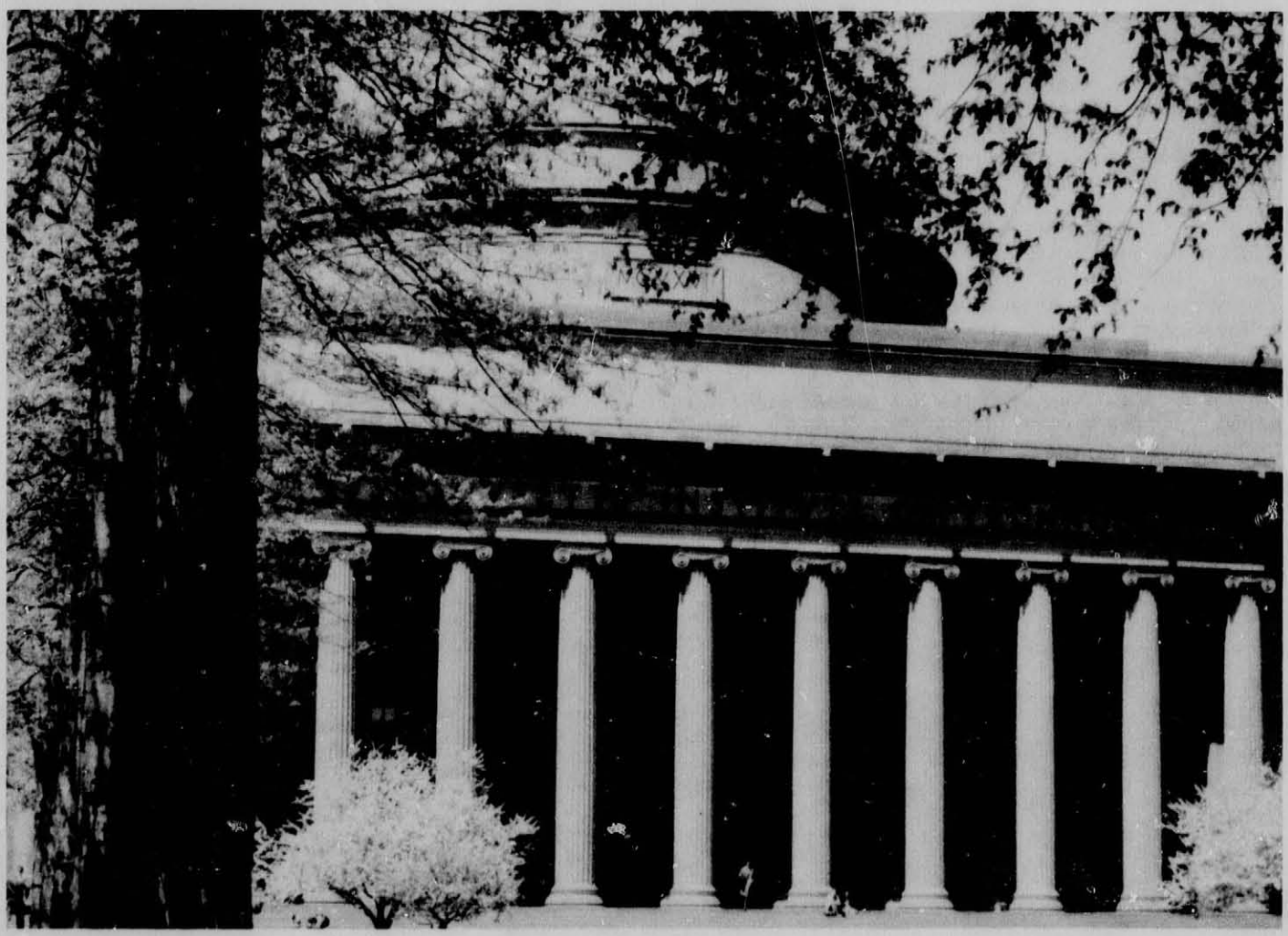
East Campus


Technology Square
NE43
Project MAC
Main Street
Albany St Parking Garage N4
N16
Cyclotron
Vassar Street
Fairchild Building
Center for Space Research
Information Processing Center
Sloan Laboratory
Guggenheim Laboratory
Sloan Laboratories
Compton Laboratories
Compton Court
Alumni Swimming Pool
ONR Generator
East Parking Garage 70
Center for Materials Science and Engineering
Center for Advanced Engineering Study
Bush Building
Hornberg Building
Rogers Building
Maclaurin Buildings
Center for Life Sciences
Dorrance Building 16
Whitaker Building 56
Chemical Engineering Building 66
Center for Earth Sciences
Green Building
Dreyfus Building
Eastman Laboratories
Eastman Court
Killian Court
McDermott Court
Wood
Hayden
Goodale
Bemis
Alumni Houses (East Campus Houses)
Walcott
Monroe
Pratt School
Bexley Hall
W13
W11
Massachusetts Avenue
du Pont Court
Pierce Laboratory
Lowell Court
Hayden Memorial Library
Walker Memorial 50
Tennis Courts
Ames Street
E19
Horace Sayford Ford Building
E18
Sanford G. Mudd Building E17
E15C
E15B
E15A
E21C
E21B
E21A
E23
Psychology E10
Wiesner
Atkinson
Burton
Senior House E2-E3
Holman
Nichols
Crafts
President's House E1
100 Memorial Drive
Amherst Street
Main Street
Kendall Square
Ogden Street
E34
E32
M.I.T. Press
Hayward Street
Hayward Garage E42
Urban Systems Laboratory
E40
Eastgate E55
Hermann Building E53
Sloan Building E52
Wadsworth Street
Memorial Drive
To U.S. 1 north, downtown Boston
Sailing Pavilion 51
Charles River
Boston


MASSACHV

I This Is M.I.T.





This Is M.I.T.

The Massachusetts Institute of Technology is an independent, co-educational, endowed university committed to the extension of knowledge through teaching and research. It is organized into five academic Schools — Architecture and Planning, Engineering, Humanities and Social Science, Management, and Science — and a number of interdisciplinary groups and activities. There are about 8,000 students, more than half of them studying for undergraduate degrees; about 950 members of the faculty; and a total teaching staff of 1,700. The Institute is located on a residential campus of 125 acres along the Charles River in Cambridge, Massachusetts, facing the city of Boston.

M.I.T. awards Bachelor's, Master's, professional (Engineer's), and doctoral degrees, and it provides several programs of postdoctoral and post-graduate study in management, engineering, urban studies, and the physical and life sciences. From modest beginnings in 1861 as an institution where students would "learn exactly and thoroughly the fundamental principles of positive science with their leading applications to the industrial arts," the Institute has grown to embrace teaching and research programs of distinction in engineering, the physical and life sciences, architecture and planning, management, and those of the humanities and social sciences most closely related by method or content to modern developments in engineering, science, and mathematics.

The central purpose of the academic program at M.I.T. is to give students a sound command of basic principles, a versatility of mind, insight, and perspective concerning natural 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 growth, especially in today's world of rapid technological change.

The Institute has a single campus and a single faculty serving both undergraduate and graduate students. Most of the classrooms and laboratories are in an interconnected group of buildings which facilitates informal interchange between departments and disciplines. Members of the faculty group themselves for teaching and research according to their interests. Most faculty appointments are in one or more of the Institute's 24 academic departments, but there are also many interdisciplinary laboratories, centers, and divisions which provide support in numerous fields that extend beyond the traditional boundaries of a single department. Most undergraduate students major in specific departments, focusing their work according to their interests. There are ample opportunities for students to share in the interdisciplinary activities of the faculty with whom they work and to major in fields which combine more than one discipline.

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.

Undergraduate subjects are offered by all of M.I.T.'s departments and Schools, and students' programs are generally made up of subjects from at least three of the Schools, some from all five. Graduate students frequently study in two or three of M.I.T.'s five academic Schools. Undergraduate upperclass students often register with graduate students for some of their classes; many undergraduates and almost all graduate students participate, often together, in advanced research.

M.I.T. students come from every state in the United States and from 90 foreign nations; the proportion of foreign students at the Institute (about 18 percent) is one of the highest in an American university. The intermixing of ages, disciplines, and nationalities which is characteristic of M.I.T. deeply influences the life and experience of every member of this academic community, bringing together students and teachers, metallurgists and physicians, 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.



Academic Calendar

In all universities, the academic calendar sets the framework of educational programs and cultural events and generally controls the ebb and flow of campus life. At M.I.T. the fall term starts in early September and ends before Christmas, and the spring term starts the first week in February and ends in late May. During January, an Independent Activities Period offers over 600 special activities including seminars, mini-courses, films, labs, workshops, and lectures on campus. There are also numerous off-campus activities including field trips and academic projects abroad.

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.

1974

August 30
Freshman Orientation

September 9
Registration Day, First Term

September 10
Classes Begin

October 14
Columbus Day *(holiday)*

October 28–29
Veterans Day, Vacation

November 28–29
Thanksgiving Vacation

December 11
Last Classes in Subjects with a Final Exam

December 13
Last Classes in Subjects with No Final Exam

December 16–19
Examination Period

December 20–January 5
Christmas Vacation

1975

January 6–29
Independent Activities Period

January 30–31
Vacation

February 3
Registration Day, Second Term

February 4
Classes Begin

February 17–18
Washington's Birthday, Vacation

March 22–30
Spring Vacation

April 21–22
Patriot's Day, Vacation

May 14
Last Classes in Subjects with a Final Exam

May 16
Last Classes in Subjects with No Final Exam

May 19–22
Examination Period

May 26
Memorial Day *(holiday)*

June 2
Commencement Day

June 9
Summer Session Begins









An M.I.T. Education for Our Times

Science has 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. 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 lost this hope and have become so frightened of future prospects that they would, if they could, stop technological change and the scientific discoveries on which the future depends.

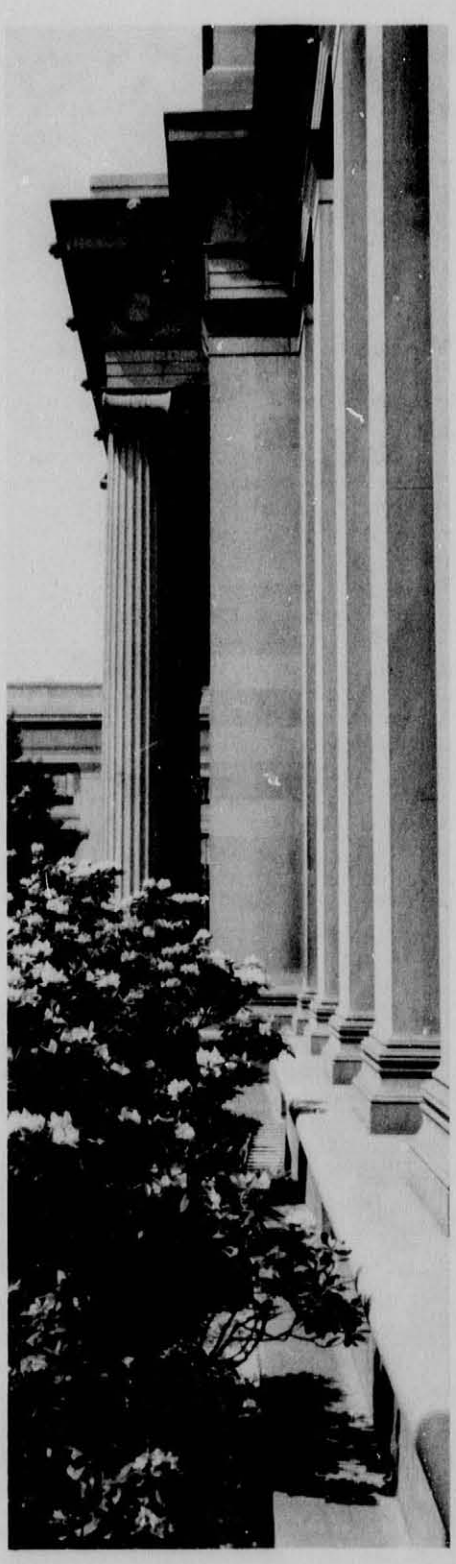
To me it is evident that without new technology, to enhance our muscle and brain power, we could not continue the quest for a free and decent society for everyone.

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 ache of 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. Taken together, the arts, sciences, and technology form a triple anvil on which to forge a new kind of apprenticeship for a complex world — an education in which the search for beauty is made real enough to take its place beside the university's ancient mission, the search for truth.

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 technology, social organization, and ecology. 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



The Academic Program

The primary organization of the academic program is along the lines of the traditional disciplines. Each of the 24 academic departments offers one or more degree programs, or Courses[1] of study. Most upperclass undergraduate and graduate students are registered in one of these Courses. Degrees are awarded on the basis of satisfactory completion of Courses.

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, computer science, health sciences, operations research, transportation, urban studies, and materials. Some of these programs involve guidance for the student by standing or special committees; others are associated with one of the interdepartmental activities.

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 Architecture in Advanced Studies (M. Arch. A.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 on the following pages shows Schools, departments, undergraduate and graduate Courses and degrees, and Course numbers. For most students, undergraduate Courses, including Courses which provide periods of on-the-job experience off campus, require four years of full-time study for the Bachelor of Science degree.

Undergraduate Courses and degree requirements are described in Chapter IV of this Catalogue; graduate degree programs and requirements are also described in Chapter IV. Individual departments should be consulted for more detailed information about the degrees offered.

In addition, three departments, Aerospace Studies, Military Science, and Naval Science, offer undergraduate instruction to all eligible students but are not part of any of the five Institute Schools. Their programs are described in Chapter IV.







1
At the Institute the word **Course** refers to an organized curriculum leading to a specified degree. The word **subject**, on the other hand, refers to the individual classes. Each Course is designated by a Roman numeral; individual subjects have 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.), Marine Mechanical Engineer (Mar. Mech. E.), Materials Engineer (Mat. E.), Mechanical Engineer (Mech. E.), Metallurgical Engineer (Met. E.), Mineral Engineer (Min. E.), Naval Architect (Nav. Arch.), Naval Engineer (Nav. E.), Nuclear Engineer (Nucl. E.), Ocean Engineer (Ocean E.).

Educational Resources

Teaching and research fulfill M.I.T.'s purpose of advancing the frontiers of knowledge. 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 by providing experience in theory and experiment for both students and faculty and by assuring that classroom teaching is up-to-date; thus research is viewed at M.I.T. as an essential partner to classroom and laboratory instruction.

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.

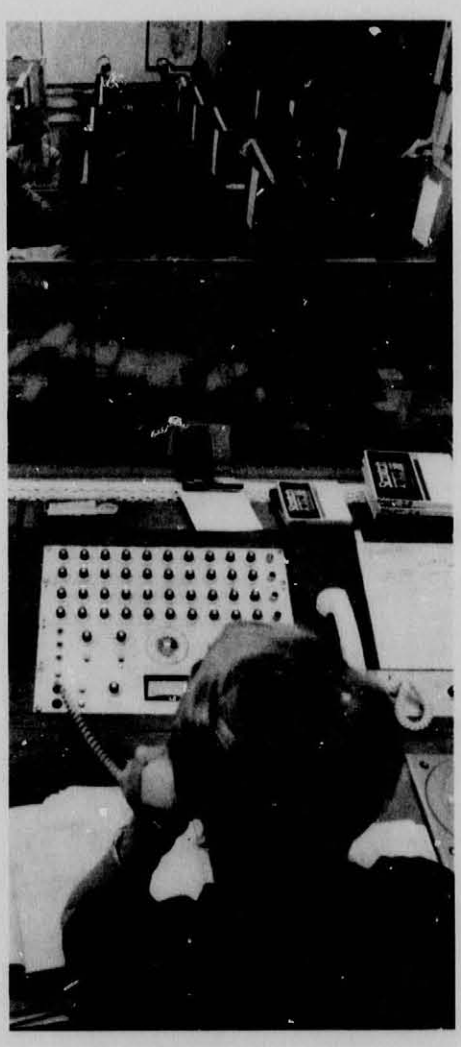
Many of these research facilities are described in this Catalogue by the departments which operate them. In addition to laboratories and facilities organized within departments, there is a large number of interdepartmental laboratories and centers, established to facilitate work in fields which cross the lines of traditional disciplines. Undergraduate opportunities in interdisciplinary areas are described in Chapter II. Graduate programs of an interdisciplinary nature, as well as the most important of M.I.T.'s interdisciplinary research facilities, are described in detail in Chapter III.

Libraries

Supporting both the teaching and research activities at the Institute are the M.I.T. Libraries, with holdings in excess of one and one-half million volumes. Over 17,000 current journals and serials and extensive back files provide comprehensive resources in all major fields. These are enriched by numerous special collections, including microfiche, slides, and maps.

The Library system, with headquarters in the Charles Hayden Memorial Library building, includes the five School libraries with several branches and reading rooms: the Rotch Library of Architecture and Planning; 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 Rare Books.

All of the services offered by a fine research library are available: reference and information, interlibrary loans, and microfilms, 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 Library Services, Room 14S-216, for a library privilege card.





Information Processing Services

The demonstrated and potential 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 totally new ways to process information and presents an opportunity to formulate and think through both old and current problems in wholly different ways. As a result of the application of the computer, new disciplines are emerging and established disciplines are being significantly transformed.

Students, both undergraduate and graduate, are involved in much of this activity. A majority of 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, whiere 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 provide somewhat specialized information processing requirements to meet specific needs. A detailed description of these resources appears under Research Facilities in Chapter III.

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 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 whose membership is limited by its Constitution to one hundred, 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. The Council's collective belief that the arts are a particularly significant element of a university based mainly on science and technology 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., including the visual and literary arts, dance, music, theater, cinema and photography, but not excluding other art forms. Its function is to act as a catalyst in a broadly based, highly participatory, wide-ranging program that is firmly founded on the intellectual tripod of teaching, practice, and research in the arts. 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.

In keeping with M.I.T.'s tradition of the pursuit of knowledge that is useful, the Council does not regard the arts as mere "enrichment" of a science and engineering curriculum but as active disciplines in their own right to be integrated in a truly modern undergraduate education. Nor are the arts only objects of study: they provide the student working experience with personal cognitive styles in a variety of disciplines; they confront him with practical esthetic choices and formal statements of value; they are, above all, alive.

Schools, Departments, Courses, and Degrees*

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	Architecture[1] (IV)	S.B.	Architecture (IV)	M.Arch.
	Architecture[1] (IV-B)	S.B.		M.Arch.A.S.
Department of Urban Studies and Planning	Urban Studies (XI)	S.B.	Urban Studies and Planning (XI)	M.C.P. Ph.D.
School of Engineering				
Department of Aeronautics and Astronautics	Aeronautics and Astronautics (XVI)	S.B.	Aeronautics and Astronautics[2] (XVI)	S.M., E.A.A., Sc.D., Ph.D.
	Cooperative Course[1] (XVI-B)	S.B.		
Department of Chemical Engineering	Chemical Engineering (X)	S.B.	Chemical Engineering[2] (X)	S.M., Chem.E., Sc.D., Ph.D.
	Chemical Engineering[1] (X-C)	S.B.	Chemical Engineering Practice (X-A)	S.M.
Department of Civil Engineering	Civil Engineering[1] (I)	S.B.	Civil Engineering[2] (I)	S.M., C.E., Sc.D., Ph.D.
Department of Electrical Engineering	Electrical Engineering (VI)	S.B.	Electrical Engineering[2] (VI)	S.M., E.E., Sc.D., Ph.D.
	Electrical Engineering[3] (VI-A)	S.B.	Electrical Engineering (VI-A)	S.M.
Department of Mechanical Engineering	Mechanical Engineering (II)	S.B.	Mechanical Engineering[2] (II)	S.M., Mech.E., Sc.D., Ph.D.
	Mechanical Engineering[1] (II-A)	S.B.	Textile Technology	S.M.
	Cooperative Course[1] (II-B)	S.B.		
Department of Metallurgy and Materials Science	Metallurgy and Materials Science (III)	S.B.	Metallurgy[2] (III)	S.M., Met.E., Sc.D., Ph.D.
			Materials Engineering	S.M.
			Materials Science	S.M.
	Metallurgy and Materials Science[1] (III-A)	S.B.	Ceramics	S.M.
			Polymerics	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 Nuclear Engineering			Nuclear Engineering[2] (XXII)	S.M., Nucl. E., Sc.D., Ph.D.
Department of Ocean Engineering	Ocean Engineering[1] (XIII)	S.B.	Ocean Engineering[1] (XIII)	S.M., Ocean E., Sc.D., Ph.D.
	Naval Architecture and Marine Engineering[1] (XIII)	S.B.	Naval Architecture and Marine Engineering[1] (XIII)	S.M., Ocean E., Sc.D., Ph.D.
	Shipping and Shipbuilding Management[1,3] (XIII-B)	S.B.	Naval Construction and Engineering[1] (XIII-A)	S.M., Ocean E.
	Ocean Engineering[1, 3] (XIII-C)	S.B.	Shipping and Shipbuilding Management (XIII-B)	S.M.
	Naval Architecture and Marine Engineering[1, 3] (XIII-C)	S.B.	Ocean Engineering (XIII-C)	S.M.
			Naval Architecture and Marine Engineering (XIII-C)	S.M.
			Ocean Engineering[1,4] (XIII-W)	Ocean E., Ph.D., Sc.D.
School of Humanities and Social Science				
Department of Economics	Economics (XIV)	S.B.	Economics (XIV)	S.M., Ph.D.
Department of Foreign Literatures and Linguistics			Linguistics (XXIII)	Ph.D.
Department of Humanities	Humanities and Engineering (XXI-A)	S.B.		
	Humanities and Science (XXI-B)	S.B.		
Department of Philosophy	Philosophy (XXIV)	S.B.	Philosophy (XXIV)	Ph.D.
Department of Political Science	Political Science (XVII)	S.B.	Political Science (XVII)	S.M., Ph.D.
Department of Psychology			Psychology (IX)	S.M., Ph.D.

Schools and Departments	Undergraduate Courses (and Course Numbers)	Bachelor's Degrees	Graduate Courses (and Course Numbers)	Graduate Degrees
Alfred P. Sloan School of Management	Management (XV)	S.B.	Management (XV)	S.M., Ph.D.
School of Science				
Department of Biology	Life Sciences (VII)	S.B.	Biology[1] (VII)	Ph.D.
	Life Sciences[1] (VII-A)	S.B.		
	Life Sciences (VII-B)	S.B.	Biology[4] (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., Ph.D., Sc.D.
			Oceanography[4] (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., Ph.D., Sc.D.
			Oceanography[4] (XIX-W)	Ph.D., Sc.D.
Department of Nutrition and Food Science			Nutrition and Food Science[1] (XX)	S.M., Ph.D., Sc.D.
Department of Physics	Physics (VIII)	S.B.	Physics (VIII)	S.M., Ph.D., Sc.D.
School of Science	Interdisciplinary Science Program (XXV)	S.B.		

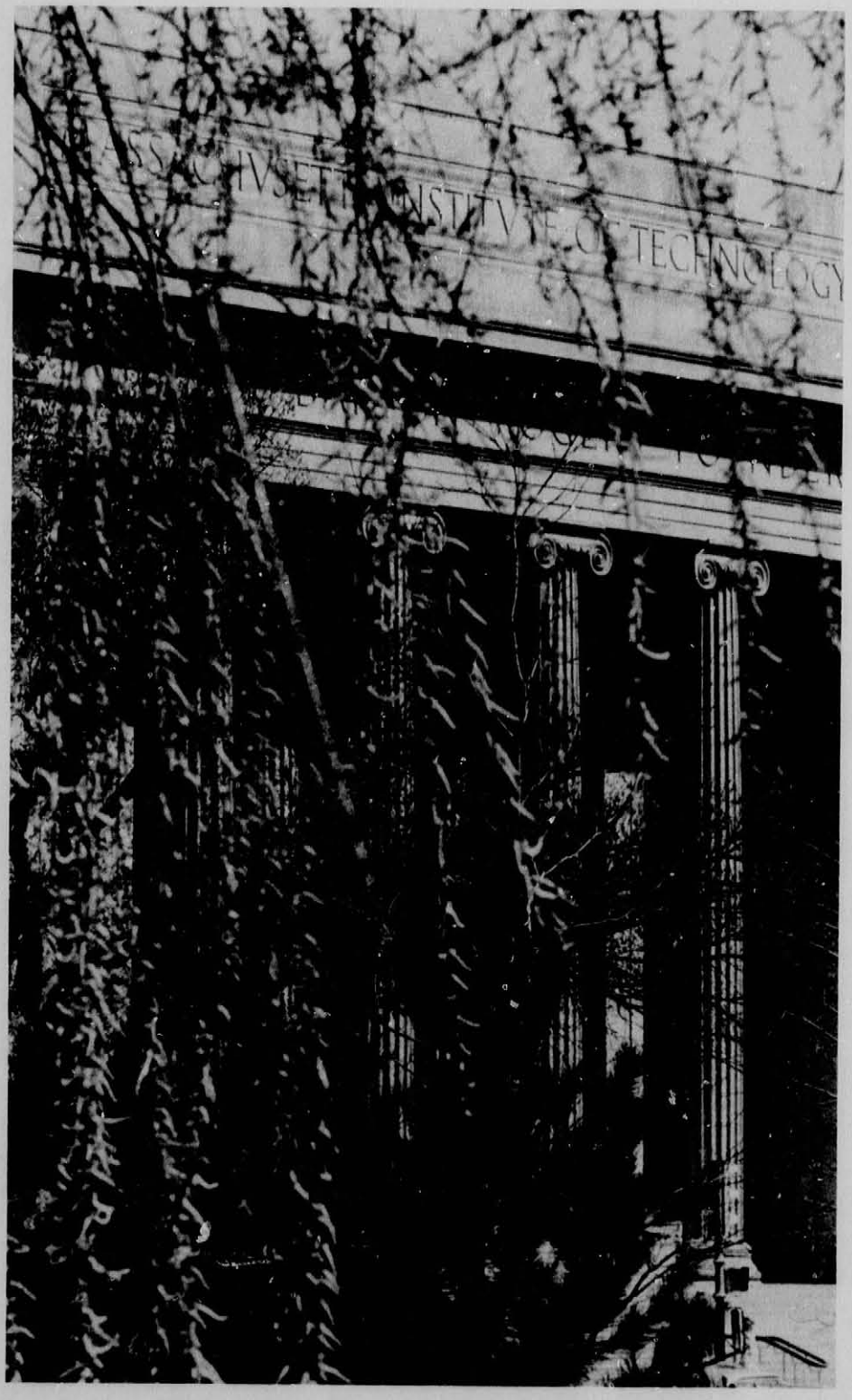
1
See the Department's statement for complete information about the specific degrees offered.

2
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.

3
Five-year Course leading to Bachelor of Science and Master of Science degrees awarded simultaneously at the end of the graduate year.

4
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.

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 interdisciplinary 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 against 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, and the Camille Edouard Dreyfus Chemistry Building.

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 prospect 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 Wnitaker 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 theater, 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.





Along Memorial Drive and facing out on the Charles River are additional student residences, among them the serpentine Baker House, which was designed by the Finnish architect Alvar Aalto. Westgate, an apartment complex for married students, and the Tang residence tower for graduate students are located at the westernmost end of the campus. Also on West Campus are playing fields for soccer, lacrosse, baseball, softball, touch football, rugby, cricket, track, and tennis. Here, too, are Rockwell Athletic cages, Briggs Field House, an outdoor skating rink, the J. B. Carr Indoor Tennis facility and the du Pont Athletic Center.

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 Sailing Pavilion provide means for extensive activity in crew and in sailing.

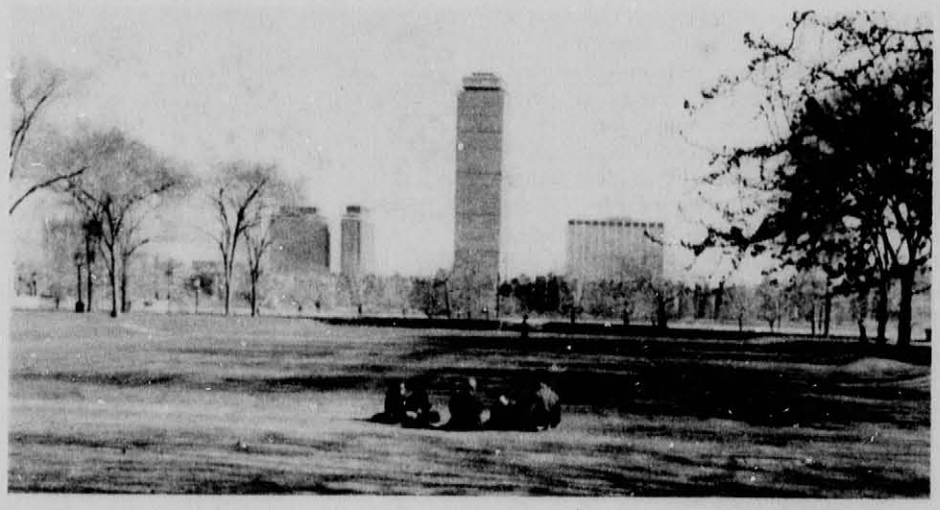


The Boston Environment

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, and the Boston Public Library. Students can easily travel 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. Among them are Harvard University, Radcliffe College, Boston University, Northeastern University, Brandeis 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 unsettled 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. 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 80 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 eight 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.

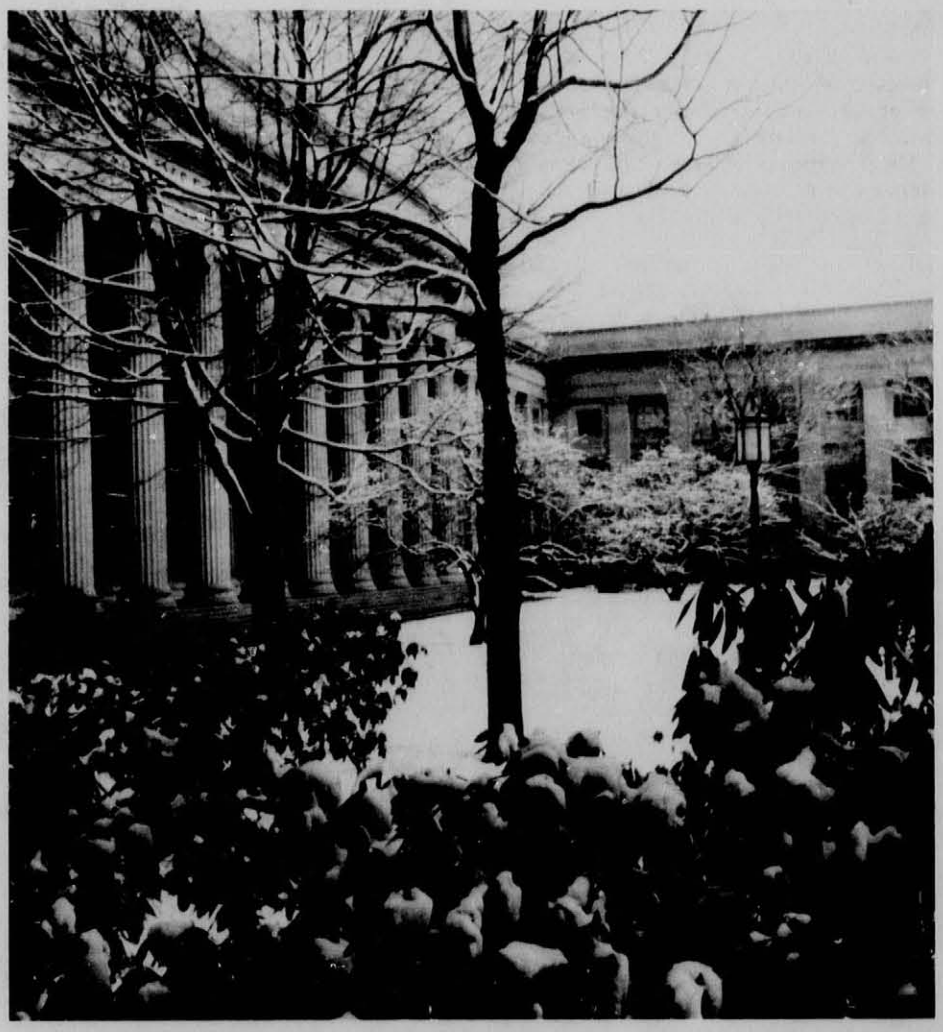
The President presides over the faculty of the Institute, which consists of all professors, certain professors emeriti, certain designated instructors and research associates and a number of administrative officers (ex officiis). Officers of the faculty are the President and the Chancellor of the Institute, 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 education 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 Office 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.



Alumni Association

The M.I.T. Alumni Association has a comprehensive program for keeping 59,000 former students informed of M.I.T. 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 highest. 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.



II Undergraduate Education at M.I.T.

Academic Programs



The undergraduate programs at M.I.T. are designed to assist students in developing the understanding, maturity, and capabilities needed to address the complex challenges of modern society. Founded on exceptional strengths in the basic—as well as applied—sciences and engineering, education at M.I.T. takes increasing recognition of the need to associate the pursuit and application of scientific and technological knowledge with a concern for human values and social goals. Building on a core of subjects in science, mathematics, and humanities, students may concentrate their studies in one of the engineering fields, the physical or life sciences, management, architecture or planning, humanities, or in one of a growing number of interdisciplinary fields. As undergraduates, students are encouraged to explore the intrinsic intellectual excitement of a discipline or field; to develop an active rather than a passive involvement in the subject matter; and to develop motivation for creative work and for continuing self-education.

Toward these goals, the Institute has strengthened its traditional academic fields, has explored new intellectual directions, and has provided an academic environment more adaptable to different learning and teaching styles. Among the special characteristics of undergraduate education at M.I.T. are the opportunities for students to participate with faculty in ongoing research projects. Such experiences, through the Undergraduate Research Opportunities Program, encourage intellectual commitment and self-direction and often provide a focus for students' undergraduate studies. The academic calendar includes an Independent Activities Period in January during which students can pursue interests and activities that do not fit into the normal academic calendar. With the development of interdepartmental and interdisciplinary activities in a wide range of disciplines, undergraduate students may arrange their academic programs to undertake work in areas such as environmental studies, biomedical engineering, communications, operations research, and transportation. In order to make it possible for most students to engage subject matter in the way that best suits their preparation and learning style, there have evolved a variety of routes through the core subjects. These include self-paced and tutorial options in the freshman subjects, as well as two distinctive freshman programs, Concourse and the Experimental Study Group. There is also the possibility of a degree without specification in several departments, which allows for greater flexibility in the individual planning of upper-class programs.

An undergraduate at M.I.T. may choose his or her major field of study from among many Courses or from a number of interdisciplinary fields. A complete list of undergraduate Courses* and degrees is given in Chapter I of this Catalogue. 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.

The General Institute Requirements consist of certain specific subjects in science, science distribution subjects in at least three fields, project-type laboratory subjects, and humanities, arts, and social science offerings. Among these offerings, each student may exercise a considerable range of choice.

* At the Institute the word **Course** refers to an organized curriculum leading to a specified degree. The word **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.

Selection of Major Course of Study

Each Departmental Program consists, in part, of a grouping of subjects in the department's areas of professional interest and, in part, of additional opportunities for students to take subjects of their choice. By Institute rule, considerable time for elective subjects is available to every student throughout the four years.

Students may use these elective opportunities 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 some professional field, such as medicine or law; for graduate study in some area in which M.I.T. gives no undergraduate degree, such as meteorology or psychology; or for advanced study in an interdisciplinary field such as astrophysics, communication science, or energy.

All students have considerable freedom in planning their academic program. Within limits imposed by subject prerequisites each student may schedule a sequence of subjects in consultation with the faculty counselor. Flexibility in the choice of electives and subjects fulfilling the Science Distribution and Laboratory Requirements and the opportunity to take examinations for advanced standing, all permit a student to design a program around his or her own particular background, interests, abilities, and future goals. Furthermore, in some cases, a student may substitute other subjects for certain of those specified by the selected Course.

To assure that such substitutions be well thought out and not haphazardly chosen, a student must obtain permission from his or her faculty counselor, during the junior year, to embark on a program involving a "major departure" from an approved curriculum. (The term "major departure" is understood to signify substitutions not-in-kind for more than one required subject, or substitutions of any sort for more than two required subjects.)

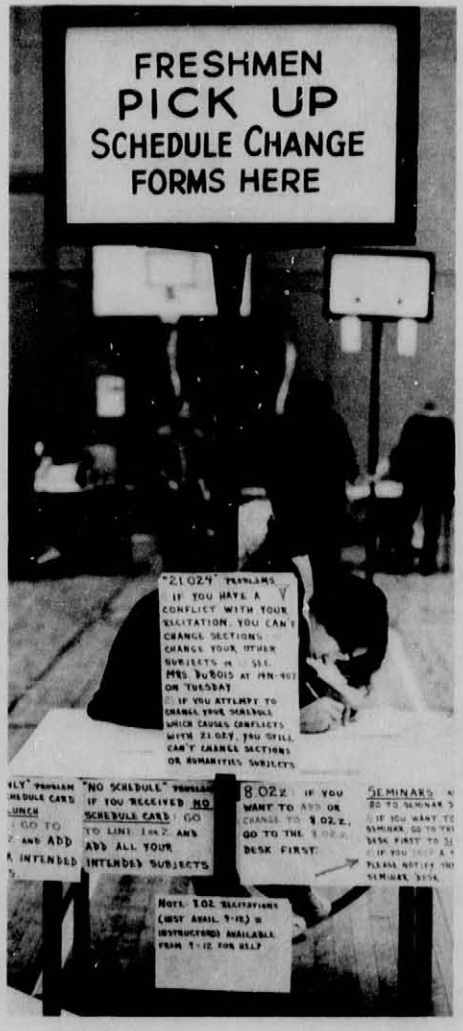
Each undergraduate Course offers the degree of Bachelor of Science with the field of the degree specified, for example Bachelor of Science in Electrical Engineering. The School of Science and some departments in the other Schools also offer an undesignated degree of Bachelor of Science. The purpose of this arrangement is to provide further flexibility by making available curricula which may cross disciplinary and departmental lines. While the undergraduate curriculum for an undesignated Bachelor of Science degree, as listed by a department, may have its own unique features, each program must be laid out in consultation with a departmental representative to assure that it is meaningful in structure and challenging in content.

In the first year, most students concentrate on a program centered around mathematics, physics, chemistry or biology, and humanities. During the second year, studies are ordinarily continued with subjects meeting the Science Distribution, Laboratory, and Humanities, Arts, and Social Sciences Requirements and with the beginning subjects in the Departmental Programs. In the third and fourth years, students concentrate on their Departmental Programs.

The curricula for all the Courses are given in Chapter IV of this Catalogue, where descriptions of the departments in each School are arranged alphabetically by School. The General Institute Requirements are given in this Chapter.



Many entering students have a well-defined preference for a specific field, while others have interests in several areas and have not yet decided upon 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, and 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

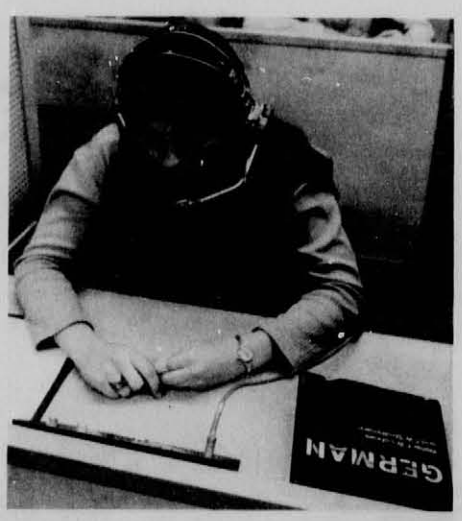


many students this consideration of available possibilities will reinforce existing convictions, while for others it will open up new avenues of interest.

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.

A student may enroll in a Course as early as the end of the first year, but he or she must do so by the end of the second year. This arrangement affords the opportunity for early concentration by a student who has settled on a Course and, at the same time, provides time for others to explore their interests, assess their abilities, and choose a Course which satisfies both.

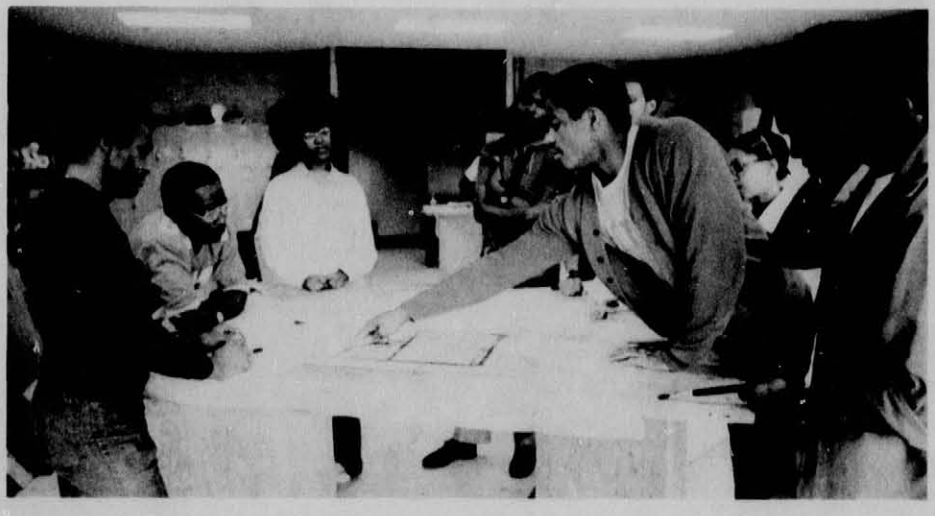
Each student entering M.I.T. is assigned an advisor, a member of the faculty or staff who assists the student in designing an effective program of study appropriate to individual interests and aspirations. The selection of electives is one of the important problems on which all students should work in 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.

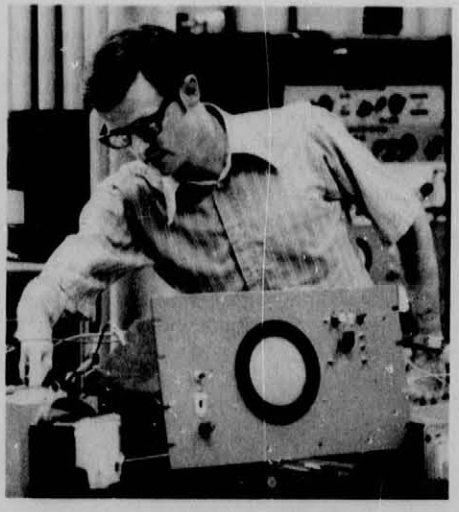


Electives

Any subject offered by the Institute is open to first year students, provided they can satisfy the prerequisites. In addition to Undergraduate Seminars, there are more than 100 subjects without prerequisites and an additional 20 to 30 with prerequisites or corequisites that most freshmen can satisfy at least by the second term.

Electives can be used for several different purposes. For example, many students who are undecided about their eventual course 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.





The Freshman Year

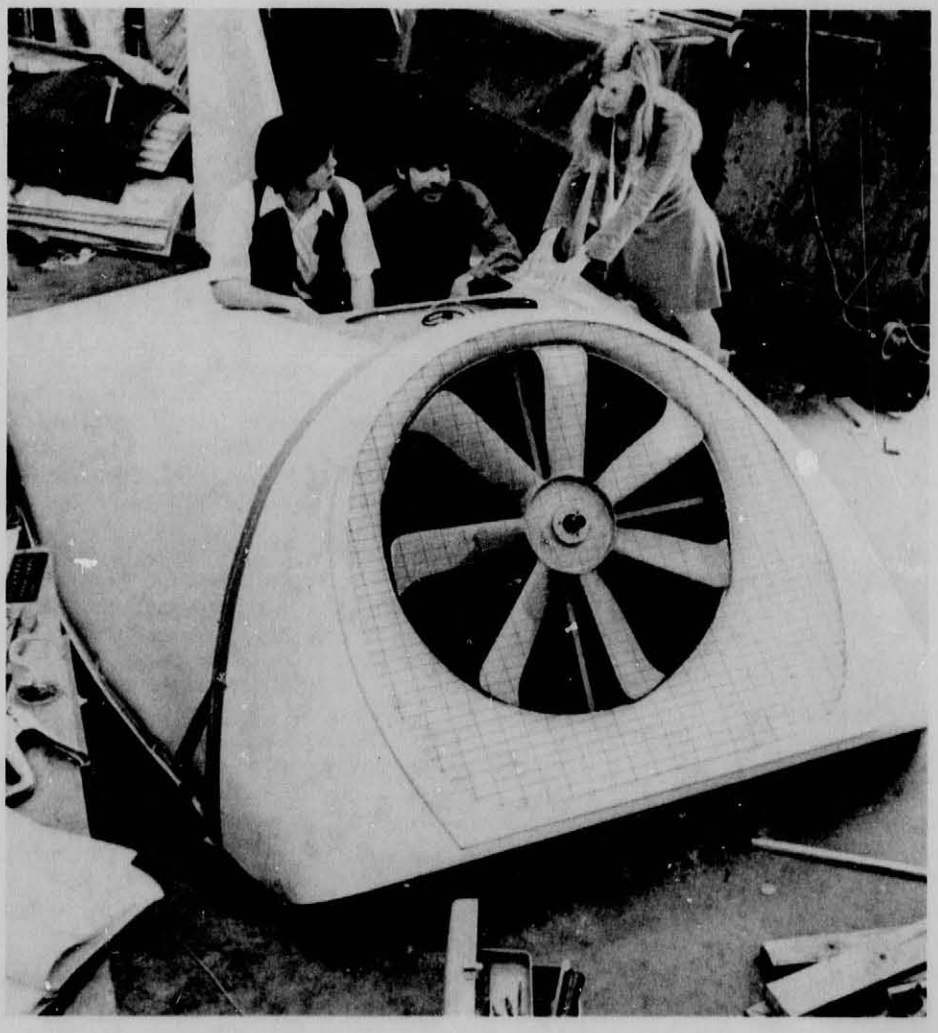
During the first year at M.I.T., most students take a program which includes, among its subjects, mathematics, physics, chemistry or biology, and humanities. There are a variety of ways in which a student may fulfill the first year Institute Requirements and prepare for further undergraduate study. Students may choose from a range of specific subjects, or may enroll in one of the special freshman programs — Concourse or the Experimental Study Group. The provision of these different modes allows students to engage subject material in a manner best suited to their interests, learning styles, and preparation.

In order to fulfill the Institute Requirements, those freshmen following the more traditional subject-by-subject format may choose between two sequences in mathematics, from among four subjects in the chemistry/biology area, from among four sequences in physics, and from an especially 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 and method of organization. Some of the subjects are given in a self-paced format. 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 and perhaps an undergraduate seminar. Entering students with degree credit in one or more of the first-year subjects may substitute more advanced subjects in the same areas or may use the time thus 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 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 35-50 freshmen working with a team of 5-7 faculty members in an integrative program of study which emphasized interactions of ideas and methods from engineering, science, social science, and humanities. The Program has as its central focus an exploration of the unity and conflict of humanistic and technical viewpoints and ideas. Each term the work of the Program is organized around a theme. For the fall term of 1974 the general theme is "Man, Machine, and Meaning," a study designed to illuminate the interdisciplinary relevance of freshman calculus, physics, chemistry, biology, and humanities in the context of topics such as artificial intelligence, computers, neurophysiology, information theory, perception, and the mind-body problem.

The Concourse faculty members, representing widely different professional disciplines, collaborate closely in the planning and teaching of the curriculum which embraces the subject matter of Institute Requirements while employing a variety of teaching and learning styles. These programs include regularly scheduled class sessions as well as 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. A detailed description of the program may be found in the Freshman Handbook or may be obtained by writing to Concourse, Room 35-433, M.I.T., Cambridge, Massachusetts 02139.

Experimental Study Group

The Experimental Study Group (E.S.G.) is a group of about 30-50 freshmen, 10 staff members, and a number of upperclassmen (many of them currently or formerly enrolled in the E.S.G.) who believe that individual responsibility in learning is best acquired through taking on such responsibility as early as possible in one's education. The E.S.G. offers freshmen and sophomores the opportunity to approach their studies in a way that is largely free of constraints on time, methods of study and evaluation, and subject matter.

Once a freshman decides to join E.S.G., he or she is asked to choose one of the E.S.G. faculty members as an advisor. The only formal requirement is that the freshman and the advisor meet at least every two weeks. Although essentially a full-time activity for freshmen (and half-time for sophomores), students may take some subjects in the regular curriculum, usually in fields in which the E.S.G. staff does not have expertise (such as foreign languages and computer science). Each freshman usually gets 50 units of free elective credit per term, which is turned into credit for specific subjects as he or she demonstrates adequate knowledge of an appropriate subject or completes a subject in the regular curriculum. All undergraduate students must satisfy the General Institute Requirements before obtaining their degrees. First-year students in E.S.G. usually organize their programs to include much, if not all, of the subject matter of the first-year requirements.

The day-to-day life of E.S.G. students is in some ways similar to that of students in the regular curriculum. E.S.G. students participate in seminars, talk with staff or other students, or work in the lab for much of the day. However, no student is required to study any particular subject, or to use any particular method of study. E.S.G. students also use the E.S.G. facilities to read, to socialize and to eat together. The E.S.G. does not draw sharp lines between academic and non-academic work or between upperclassmen, freshmen, and faculty. In such an atmosphere students see the limits as well as the extent of the faculty's knowledge and are able to regard members of the staff as colleagues and friends, rather than simply as teachers. For more information, see the Freshman Handbook or write to Experimental Study Group, Room 24-612, M.I.T., Cambridge, Massachusetts 02139.



Freshman Grading

Freshmen presently receive grades of either pass or fail in all subjects they take; grades of F will not appear on the permanent record of the freshman year, beginning with the Class of 1977. 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 in each subject. This process usually provides the student with a more comprehensive and useful evaluation of his or her work 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). Compared to an A–F grading system, pass/fail offers freshmen more choice of how to spend their time, often permitting them to take an additional subject for credit. Freshmen are limited, however, to 60 units of credit in the fall and 63 in the spring, exclusive of Advanced Standing credit.

Freshman Handbook

This relatively 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, housing, the advisory system, and an outline of Residence/Orientation Week. Distributed also to the freshman advisors, the Handbook is a primary reference document for the first year.





Departmental Programs

All undergraduate and graduate academic programs, as well as faculty and subject listings, for each of the Institute's 24 Courses are described fully in Chapter IV, Departmental Programs and Requirements.





Undergraduate Research Opportunities Program

U.R.O.P. invites and encourages students 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 the 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 are some of the returns students can expect. Students will come to have a better understanding of the intellectual process of inquiry, while providing an opportunity for personal and professional growth.

Ground rules for participating in U.R.O.P. are contained in the U.R.O.P. directory published every term. 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 U.R.O.P. experience will be unlike any other; its benefits and rewards are great, but expectations and standards are commensurately demanding. Call or visit the U.R.O.P. office at any time: advice, consolation, or congratulations await.

Undergraduate Seminars

The Undergraduate Seminar Program was begun in 1961 in order to provide students with an opportunity for close association with a faculty member in smaller and less formal groups and to provide an opportunity for a high degree of student responsibility and freedom in planning and executing a selected program. Since 1961, the Program has grown steadily and has continued to provide both freshmen and upperclassmen with unique opportunities for student-faculty interaction. Seminars cover a wide range of topics and many include laboratory work, discussion groups, or field trips.

A new effort has begun this year to present seminars of a "How-to-. . ." nature. These seminars will give students an opportunity to get their hands dirty while studying a problem with real academic significance. Sample titles are: The How and Why of Electroplating, The Life Cycle of a Slime Mold, and Aluminum Bicycles.

All seminars carry six units of credit and faculty generally restrict the number of students in a seminar. Titles of seminars and their descriptions are printed in the Freshman Handbook for first term subjects and in the Undergraduate Seminar Booklet for second term subjects. These publications are available from the Undergraduate Seminar Office, Room 7-105. Application for admission to all Undergraduate Seminars should be made to this office.

Undergraduate Policy Seminars

Undergraduate Policy Seminars, offered by a number of departments, provide undergraduates, particularly those in the third year or above, an opportunity to explore with a faculty member and in small groups, specific issues with clear policy implications. The goals are to provide experience in addressing public policy questions and to relate such decision making to the students' own value structures and to their future participation as professionals in their fields. For further information, contact Professor J. D. Nyhart, 3-1582, Room 10-219.



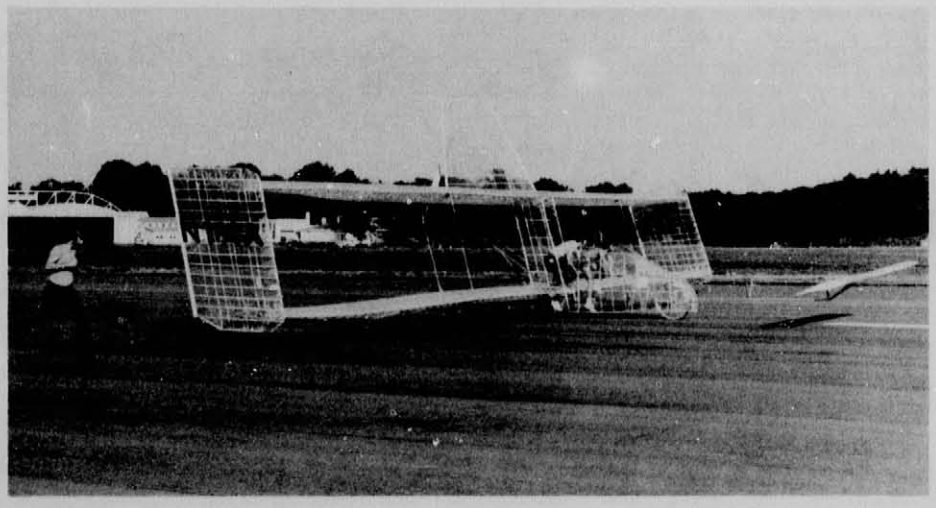
Independent Activities Period

The January Independent Activities Period, established at M.I.T. four years ago, continues to provide a new dimension to educational activities through the freedom it offers students between the first and second term of each year. The time during I.A.P. may be devoted to research, study in a field of the student's interest, travel, relaxation and exploration of Boston and New England, or investigation of new fields. During this time over 500 special activities, individual projects, intensive subjects, and exploratory programs, which do not fit into the normal academic calendar, are offered both at M.I.T. and at numerous off-campus locations. Among the range of options available this past January were: a field trip to the Port Authority of New York and New Jersey; design and construction of the world's largest yoyo; jazz and rock musical improvisation; numerous film series; a residential German House; biomedical engineering projects; development of speed and comprehension in reading; introductory programming; recycling of municipal refuse; and writing and television.

Preprofessional Advising and Education

The Office of Preprofessional Advising and Education serves students in the fields of medicine, law, public administration, education and/or related fields. The Office supports three faculty/student entities, the Committee on Preprofessional Advising and Education, the Premedical Advisory Council, and the Prelaw Advisory Council. The Executive Officer to the Committee on Preprofessional Advising and Education acts as liaison between students and members of 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, 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. By proper selection of electives, medical school entrance requirements can be met; 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. *A Premedical Handbook for M.I.T. Students* has been prepared by the Committee on Preprofessional Advising and Education to provide general information to students interested in medical education and a medical career.

Copies of the Handbook are available through the Office of Preprofessional Advising and Education.



Education Studies

The profession of education, including teaching at high school levels, has interested an increasing number of students. M.I.T. students may receive certification in teaching in the Commonwealth of Massachusetts by taking a prescribed series of subjects. A teaching program in one of the Cambridge high schools, available as a credit seminar, provides the practical teaching experience necessary for certification. 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.

Copies of catalogues of graduate programs in education are available in the Preprofessional Advising and Education Office.

Some of the coursework offered at the Institute gives academic support to several voluntary activities conducted by students. These activities include the M.I.T. Educational Studies Program, Tutoring Programs, and other student-initiated programs. *A Handbook for M.I.T. Students Interested in a Career in Education* tells of these as well as other opportunities at M.I.T. Copies of the Handbook are available through the Preprofessional Advising and Education Office.

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 but prefer applicants who have completed a degree program. Students from every Institute School — Engineering, Science, Humanities and Social Science, Architecture and Urban Planning, and Management — have been admitted to law school. Prelaw students may wish to 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. It 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 III for a further discussion of opportunities and programs in this area.



Professional and Honorary Societies

Phi Beta Kappa

Chartered in 1970 as the first chapter of the Society to be established in an institute of technology, XI of Massachusetts encourages the development of scholarly, collegial, and cultural interests on campus and recognizes and rewards outstanding accomplishment. Eligibility rests primarily on achievement in the liberal arts and the social, humane, and theoretical sciences. Only seniors are elected, normally from the Schools of Science and Humanities and Social Science, under a quota determined as a set percentage of the number of seniors enrolled.

American Institute of Aeronautics and Astronautics

Members of all classes who are interested in aeronautics and astronautics find it well worth their while to join the A.I.A.A. The society offers an excellent way of meeting others of similar interests; the Student Branch at M.I.T. presents films on aircraft topics, speakers, and field trips in the Boston area, as interests of the members dictate.

American Society of Mechanical Engineers

Membership in the A.S.M.E. is open to all students in good standing in any engineering curriculum. Joining the A.S.M.E. provides the student with a broader perspective of the engineering profession than he or she would receive in class; at the various seminar meetings, the student has the opportunity to meet professors and members of the profession on an informal basis.

Eta Kappa Nu

Eta Kappa Nu is the only honorary fraternity associated exclusively with the field of electrical engineering. Because of this unique position it serves as a medium by which professional members may communicate on topics relevant to their work. Only juniors and seniors in Electrical Engineering with sufficiently high class standing and a record of extracurricular service may be considered for membership.

Institute of Electrical and Electronics Engineers

The I.E.E.E. is the world's largest professional engineering society, and M.I.T. has one of the largest student branches with over 300 members. Any graduate or undergraduate student in engineering or science is eligible for student membership and may join any of the 32 Professional Technical Groups, including the groups on Information Theory, Biomedical Electronics, Nuclear Science, and Electronic Computers.

Phi Lambda Upsilon

Phi Lambda Upsilon is the national honorary chemical society, encompassing the fields of chemistry, including metallurgy, biology, chemical engineering, geology, and food science. The objective of the society is the promotion of high scholarship and original investigation in all branches of pure and applied chemistry. Membership is limited to students in the chemical fields, elected because they have shown outstanding academic achievement.

Pi Tau Sigma

Pi Tau Sigma is the national honorary fraternity for mechanical engineers. Any juniors or seniors in mechanical engineering who are in the top 30 percent of their class are eligible to apply for membership. The fraternity acts as a liaison between faculty and students and promotes good faculty-student relations.

Society of Physics Students

The Society of Physics Students provides a structure for the free exchange of ideas, controversial as well as academic, between the Society members and the Institute as a whole. It also acts as a medium through which students may learn viewpoints and current techniques of physics which are not otherwise available to them.

Tau Beta Pi

Tau Beta Pi is an all-engineering honorary. Men and women whose scholarship places them in the highest one-eighth of the junior class or in the highest one-fifth of the senior class are further considered for membership on the basis of character, integrity, and unselfish activities. The primary function of Tau Beta Pi is to serve as a means for social and technical communication between engineers in different fields. Further, this group presents the annual Outstanding Freshman Award and provides financial aid to its members through a graduate fellowship and a student loan program.

Zeamer Squadron (Arnold Air Society)

The Arnold Air Society is a national honorary society of Air Force R.O.T.C. cadets. Membership in the Society, which has recently become coed, is restricted to cadets enrolled in A.F.R.O.T.C. Cadets may join after successful completion of a four- to six-week pledge program.

Exchange Programs



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 in the curricula and environments 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*.

New issues of the *Guide* are mailed to all undergraduates 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 Office and the Wellesley-M.I.T. Exchange Office. Bus transportation between Wellesley and M.I.T. for academic purposes is provided to cross-registered students without cost. Deadlines for cross-registration are in May for the following September and in December or January for the spring term.

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 Department of Humanities prior to or at the regular M.I.T. registration periods.







Full-time Study at Other Universities

Overseas Study

Many opportunities are open for study in foreign countries through participation in one of the excellent programs administered by non-profit educational organizations or through an individually arranged program. Plans for the study abroad should be worked out by each student with his Faculty Advisor. 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 major learning experience.

Effective working command of the language of the host country is vital. Even a student without prior study frequently can, by conscientious work in language subjects here, 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.

Because of differences in academic practices in foreign universities there is no general rule for obtaining academic credit toward an M.I.T. degree. Credit is usually obtained, however, especially after advance consultation with faculty advisors.

Domestic Year Away

A "domestic year away" for study at another U.S. 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;

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.

I.A.P. Student Exchanges

During the January Independent Activities Period it is sometimes possible to arrange tuition free, one-for-one student exchanges between M.I.T. and other schools which have January programs.

Those students interested in these programs should consult the Foreign Study Office, Room 7-133, extension 3-5243.





General Academic Information

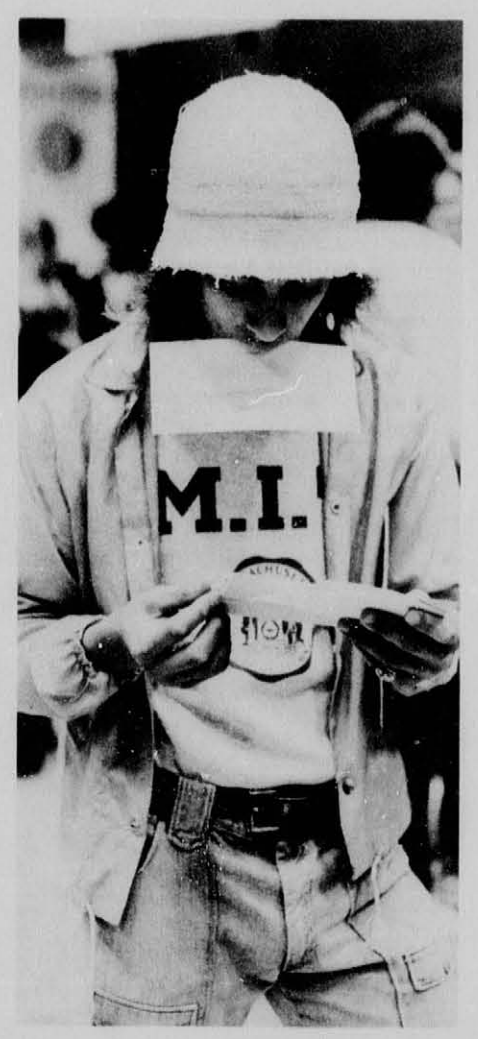
Registration

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 is mailed early in August to regular students whose home address is in the U.S. or Canada and should be returned by the last week in August. Second-term registration material is available at the Registrar's Office late in the first term. 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.

In the last two weeks of a regular term, registration in any subject may not be cancelled by a student without the additional approval of the Committee on Academic Performance. The final date for cancelling subjects without this approval will be posted outside Room 7-111 (Information Center).

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. All freshmen have as their advisors members of the Freshman Advisory Council. 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.







Program for the Bachelor's and Master's Degrees

Any regular undergraduate student may undertake a program of study leading to the simultaneous award of the Bachelor's and Master's degrees, provided his or her departments recommend him or her to the Dean of the Graduate School as a candidate for the Master's degree. The student must be enrolled at least one term as a graduate student and complete the requirements for both the Bachelor's and Master's degrees, including a Master's thesis. A student wishing to pursue this program should submit a petition approved by the undergraduate Faculty Counselor and the graduate Registration Officer. The requirements for the various honors and other designated five-year Courses leading to the S.B. and S.M. degrees are specified under the appropriate department statements.

Program for Two Bachelor's Degrees

A student may work for a second Bachelor's degree to be received separately or concurrently. A petition which describes the planned academic program must be 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 S.B. requirements of each department must be satisfied and the combined program must contain at least 450 units. From the time the petition is approved until the student receives the first of the two S.B. degrees, the student must register in both departments and the program and all changes in it must be approved by both Faculty Counselors.

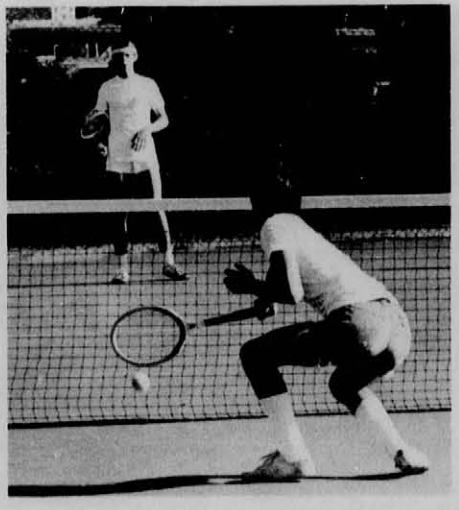
Credits

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.









Examinations for Advanced Standing

Undergraduate students may take examinations for advanced standing during the scheduled examination periods, provided that they have never been registered for or attended classes 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 shall be given only after the approval of the member of the Faculty in charge of the subject. The faculty member in charge 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.

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 7-111), 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.

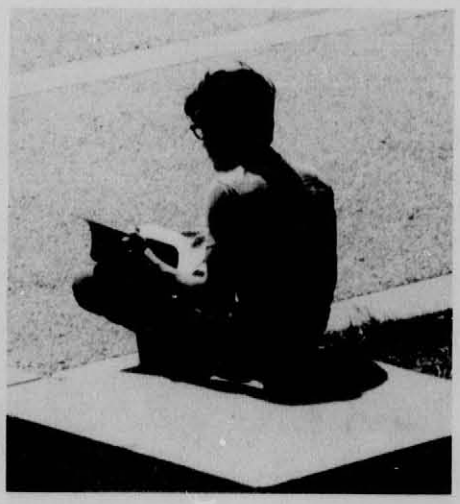
No member of the instructing staff is empowered to grant excuse from a scheduled final examination. Absence from any final examination is equivalent to complete failure except on presentation of adequate evidence of sickness or other valid reason for the absence. The Dean for Student Affairs may permit 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.

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 $1 per copy.







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 IV.



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

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

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 important, 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, in engineering, and in other professions, is a central objective of the Institute's educational programs.

Chemistry/Biology Requirement

The requirement that students take a term of chemistry has been broadened so that it can be satisfied in four rather different ways. The alternatives are 3.091 Introduction to Solid State Chemistry; 5.41 Introduction to Structure, Bonding and Mechanism; 5.60 Chemical Equilibrium; and 7.01 General Biology. 3.091 is designed for students who are particularly interested in the chemistry of the solid state. 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 or in advance. The faculty responsible for 7.01 prefer 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. 8.011–8.021 is a one-year sequence especially designed for students who do not expect to take more than one year of physics in all. It treats most of the topics covered in the full two-year sequence of introductory physics (8.01–8.04), though in less depth and detail. 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. 8.013–8.023 constitutes the first two terms of a new four-term physics program developed under the auspices of the joint M.I.T.–Harvard Program in Health Sciences and Technology. This sequence is 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.

Advanced placement for one or two terms of physics may be obtained through advanced standing examinations given in September upon prior request. If the student has taken the College Board Advanced Placement Physics C test, he or she may qualify for advanced placement of one term of M.I.T. physics.

Calculus Requirement

The Department of Mathematics currently offers two basic calculus sequences: 18.001–18.002 Calculus (two versions); and 18.01–18.02 Calculus (three 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 a new book, *Calculus, An Introduction to Applied Mathematics* by Professors Greenspan and Benney — 18.01–18.02 uses *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 six self-paced repeatable 40-minute 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.



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 way 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** in the humanities, arts, and social sciences, normally at the rate of one subject each term.

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 in or closely related to that Field. An individual's program of Concentration is arranged in consultation with a designated advisor in the Field. A maximum of one appropriate Distribution subject may be counted as part of the program of Concentration. 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** are currently offered:

Anthropology and Archaeology
Creative Writing
Economics
Foreign Languages and Literature
History
History of Art and Architecture
Labor in Industrial Society
Linguistics
Literature
Music
Philosophy
Political Science
Psychology
Urban Studies
Visual Arts and Design

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.

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. It should be noted that each of the three groups of subjects listed under Interdisciplinary Studies (Crossroads in the Western Tradition, American Studies, and Black Studies) is for this purpose to be regarded as a separate Field; i.e. students may, if they wish, take one subject from one or more of these three groups.

All of these subjects, with the exception of the French, German, and Russian language subjects, are without prerequisites and are intended to be available to students at all levels. Students are encouraged, though not required, to take one or two Distribution subjects in their freshman year, both so as to get an early start toward satisfying the Institute requirement and in order to sample the offerings in fields that might later be selected for further intensive study.

It should be kept in mind that 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 be counted toward both Distribution and Concentration.

Students enrolled before the 1974–75 academic year will automatically be given Distribution credit for any subjects already taken and credited toward the previous freshman and sophomore humanities requirement; including those for which appropriate transfer credit was given. Any three such subjects, regardless of the fields in which they were taken, will be accepted in fulfillment of the Distribution component of the Requirement.

The list of **distribution subjects** is as follows:

	Anthropology and Archaeology
21.025	An Introduction to Anthropology
	Creative Writing
21.023	Writing and Experience I
21.024	Writing and Experience II
	Foreign Languages and Literature
23.011	The Greek Tradition
23.021	The Judaeo-Christian Tradition
23.13	German III
23.14	German IV
23.143	German Civilization I (1848–1945)
23.53	French III
23.54	French IV
23.543	French Civilization II
23.93	Russian III
23.94	Russian IV
23.951	Russian Civilization
	History
21.013	The Northern Renaissance and the Reformation
21.027	Modern World History I
21.028	Modern World History II
21.04	Revolution in the Twentieth Century
21.041	Rationalism and Radicalism: The Dilemma of Liberal Society from Cromwell to Hitler
21.051	American Intellectual History
21.473	Rome, Reality and Idea
21.522	Marx, Darwin and Freud
21.552	The Soviet Union: A Communist Society in Historical Perspective
	History of Art and Architecture
4.601	Topical Studies in the History and Theory of Art I
4.606	Introduction to the History of Architecture I
4.607	Introduction to the History of Architecture II
4.641	Painting in the Nineteenth Century
4.642	Modern Art from Post-Impressionism to Cubism
4.651	Painting in the Twentieth Century
	Labor in Industrial Society
14.63	Labor in Industrial Society
	Literature
21.03	Approaches to Literature: Criteria for Judgment
21.031	Approaches to Literature: Structure and Technique in Literature
21.032	Approaches to Literature: The Adolescent in Literature
21.033	Approaches to Literature: Introduction to Literary Analysis
21.034	Approaches to Literature — Brave New Worlds: Modern America and Russia
	Music
21.07	Introduction to Music
	Philosophy
24.01	Contemporary Moral Issues
24.03	Logic, Language and Science
24.05	Science and Philosophy
24.101	Problems of Philosophy
	Political Science
17.05	The Quest for Equality and Development in Third World Countries
17.06	Modernization of Industrial Societies
17.07	Aggression, War and Civilization
17.08	American Politics and Social Change
17.21	Introduction to the American Political Process
	Urban Studies
11.05	Urban Social Structure and Process
11.09	Technology and the City
11.18	The Writer and the City
11.591J	American Urban History
	Visual Arts and Design
4.01	Creative Seeing
4.056	Evaluating Photography
4.062	Art and the Environment

Interdisciplinary Subjects

	Crossroads in the Western Tradition
21.011	The Greeks
21.012	The Bible and Western Values
21.013	The Northern Renaissance and the Reformation
21.014	The Enlightenment: Reason and Religion
21.015	Romanticism and Ideas of Revolution
21.016	Ideology and the Modern Age
	American Studies
21.019	Culture and Society in America: The Rise of a Technological Civilization
21.020	Culture and Society in America: The Technological Society
	Black Studies
21.021	Identity and Purpose in Black America
21.022	Myth, Legend and Science: The Dilemma of the Black Bourgeoisie

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 virtually all 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. A listing of eligible subjects is given below. Appropriate subjects taken by cross-registration at Harvard University or Wellesley College may also be counted toward the Requirement.

It should be noted that two categories of subjects are **not** routinely acceptable for credit as electives under the terms of the Requirement: 1) graduate subjects (designated "Year: G") and 2) undergraduate research and reading seminars, and other similar subjects whose content is not specified in the catalogue description of the subject. These two categories of subjects may be used to meet the terms of the Requirement only by petition, which must contain the signature of the instructor and a description of the subject content (if unspecified in the catalogue).

Subjects in the School of Humanities and Social Science Except as noted above, virtually all **undergraduate** subjects offered by the School of Humanities and Social Science may be used as elective subjects to complete the Requirement. Listed prerequisites must have been met or the instructor's permission obtained to waive the prerequisites. The following subjects are **not eligible for credit** under the terms of the Requirement.

9.04	From the Mammalian Visual and Oculomotor Systems to Sensory Neurophysiology
14.11	Mathematical Economics
14.30	Introduction to Statistical Method in Economics
14.31	Econometrics
17.01	Political Science Laboratory

Subjects in the School of Architecture and Planning The following subjects may be used as electives in fulfillment of the Institute Requirement:

	Department of Urban Studies and Planning
11.05	Urban Social Structure and Process
11.06J	Politics, Planning and Public Policy
11.09	Technology and the City
11.15	The Political Economy of Urban Poverty
11.18	The Writer and the City
11.19	The Urban Neighborhood
11.401	Introduction to Urban Planning and Development
11.402	Urban and Regional Development Theory
11.540	The Sociology of Medical Care
11.543	Policies and Politics of Health Planning
11.546	The Human Life Cycle: Institutions, Agencies and Unmet Needs
11.551	Urban Institutions and Social Change
11.552	Seminar on Urban Institutions
11.553	Law and Social Change: Application of the Fourteenth Amendment to Selected Public Policy Issues
11.571	Human Resource Development and the Helping Professions
11.591J	American Urban History

	Department of Architecture
4.01	Creative Seeing
4.021	Visual Design Problems I
4.022	Visual Design Problems II
4.051	Creative Photography I
4.052	Creative Photography II
4.056	Evaluating Photography
4.062	Art and the Environment
4.091	Introduction to Film Making
4.092	Advanced Film Making I
4.096	Movies: An Introduction I
4.097	Movies: An Introduction II
4.601	Topical Studies in the History and Theory of Art I
4.602	Topical Studies in the History and Theory of Art II
4.606	Introduction to the History of Architecture I
4.607	Introduction to the History of Architecture II
4.611	Selected Topics in Greek Art
4.612	Selected Topics in Etruscan and Roman Art
4.616	Selected Topics in Architecture of the Ancient World
4.621	Selected Topics in Medieval Art
4.626	Selected Topics in Architecture in the Middle Ages
4.631	Selected Topics in Renaissance and Baroque Art
4.636	Selected Topics in Architecture 1400–1750
4.641	Painting in the Nineteenth Century
4.642	Modern Art from Post-Impressionism to Cubism
4.647	Selected Topics in Architecture 1750 to the Present
4.651	Painting in the Twentieth Century
4.652	Sculpture in the Nineteenth and Twentieth Centuries

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

3.17	Understanding the Discovery Process — An Historical Approach
3.80J 21.643J	Comparative Ancient Technologies
3.81J 21.641J	Art Materials and Culture
7.09J 21.941J 24.116J	Seminar in Technology and Society: Ethical and Social Issues in Bio-Medicine
4.683J 8.202J 21.956J	Science, Technology and Ritual

Subjects Taken by Cross-registration at Wellesley and Harvard Relevant subjects taken at these institutions are acceptable as electives under the Requirement. A petition must be submitted.

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. 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 are normally 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.

1.00	Information Systems (3–2–7)
1.02J	Materials of Construction (3–3–6)
1.07	Analysis of Uncertainty (3–1–8)
1.08	Geotechnology (3–3–6)
1.09J	Ecology (3–3–6)
1.11J	Introduction to Systems Analysis (3–0–9)
1.13	Behavior of Physical Systems (6–0–6)
1.86	Cycling of Material in the Environment (3–0–9)
2.01	Mechanics of Solids (4–0–8)
2.02	Engineering Modeling and Analysis (4–0–8)
2.101	Computer Models of Physical and Engineering Systems I (3–3–6)
2.19J	Introduction to Systems Analysis (3–0–9)
2.20	Fluid Mechanics (4–0–8)
2.40	Thermodynamics (4–0–8)
2.901	Polymer Materials Science (3–0–9)
3.00	Thermodynamics of Materials I (4–0–8)
3.07	Introduction to Ceramics (4–0–8)
3.095	Materials Processing, an Engineering and Historical Approach (3–4–5)
3.10	Chemical Physics of Materials (3–0–5)
3.11	Mechanics of Materials I (4–0–8)
3.141	Engineering Materials Laboratory (1–6–5)
3.143J	Materials of Construction (3–3–6)
4.30	Basic Structural Theory (3–3–6)
4.43	Environmental Control-Acoustics (3–0–5)
5.121J	Planetary Physics and Chemistry I (3–0–9)
5.122J	Planetary Physics and Chemistry II (3–0–9)
5.41	[1]Introduction to Structure Bonding and Mechanism (5–0–7)
5.60	[1]Chemical Equilibrium (4–0–8)
5.61	Physical Chemistry (4–0–8)
6.011	Introductory Network Theory (4–0–8)
6.030	Introduction to Computation (4–3–5)
6.034	Introduction to Artificial Intelligence (4–0–8)
6.041	Probabilistic Systems Analysis (4–0–8)
6.071	Introduction to Electronics (4–2–6)
6.083	Programming Small Scale Computers (3–3–6)
6.502J	Musical Acoustics (3–0–6)
6.503	Animal Communication Systems (3–0–6)
6.521	Electrocardiography (2–0–4)
7.01	[1]General Biology (4–0–8)
7.05	General Biochemistry (5–0–7)
8.03	Physics III (5–0–7)
8.033	Physics III (5–0–7)
8.04	Principles of Quantum Physics I (5–0–7)
8.20	Introduction to Special Relativity (3–0–3)
8.211	Introduction to Quantum Physics (5–0–7)
8.263J	Physics of Fluids (3–0–9)
8.281	Introduction to Astrophysics (4–0–8)
8.291J	Planetary Physics and Chemistry I (3–0–9)
8.292J	Planetary Physics and Chemistry II (3–0–9)
10.07	Introduction to Polymer Chemistry (4–0–8)
10.10	Process Synthesis (3–0–6)
10.13	Mass and Energy Processing (4–0–8)
10.17	Combustion and Air Pollution (2–0–4)
11.04	Models and the Metropolis (4–0–8)
12.00	Evolution of the Earth (3–0–3)
12.001	Introductory Oceanography (2–0–4)
12.002	The Earth and the Planets (2–0–4)
12.003	Environmental Ecology I (2–0–4)
12.004	Environmental Ecology II (2–0–4)
12.01	Earth Surface Processes (2–3–4)
12.02	Physics and Chemistry of Geological Materials (3–4–5)
12.111	Survey of Astronomy I (2–0–4)
12.112	Survey of Astronomy II (2–0–4)
12.113	Astronomy I (3–0–6)
12.116	Astronomy II (3–0–6)

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

Laboratory Requirement

12.131J	Planetary Physics and Chemistry I (3-0-9)
12.132J	Planetary Physics and Chemistry II (3-0-9)
12.21	Physical Oceanography (3-0-9)
13.001	Introduction to Marine Applied Mechanics (4-0-8)
13.64J	Water, Air and Interface Vehicles (3-0-9)
14.30	Introduction to Statistical Method in Economics (4-0-8)
15.053	Introduction to Management Science (4-0-8)
15.852	Principles of Dynamic Systems I (3-0-9)
16.001	Unified Engineering I (4-3-5)
16.006	Thermodynamics (4-0-8)
16.57J	Physics of Fluids (3-0-9)
16.811J	Introduction to Systems Analysis (3-0-9)
18.03	Differential Equations (4-0-8)
18.031	Introduction to Linear Algebra and Differential Equations (4-0-8)
18.05	Introduction to Probability and Statistics (3-0-9)
18.051	Surveys of Higher Mathematics (3-0-9)
18.303	Probability and Random Variables (3-0-9)
18.312	Statistics for Applications (3-0-9)
18.313	Probability (3-0-9)
18.420	Introduction to the Mathematical Theory of Computation (3-0-9)
18.700	Linear Algebra (3-0-9)
18.703	Modern Algebra (3-0-9)
18.710	Abstract Linear Algebra (3-0-9)
19.02	Descriptive Meteorology (2-2-5)
19.43	Synoptic Meteorology I (3-3-6)
19.83	Physical Oceanography (3-0-9)
20.30	Physiological and Nutritional Biochemistry (4-0-8)
20.48J	Ecology (3-3-6)
22.02	Physics of Nuclear Energy (3-0-9)
22.03	Engineering of Nuclear Power Reactor Systems (3-0-9)
22.04	Radiation Effects and Uses (2-1-9)
22.06	Nuclear Engineering in Society (3-0-6)
NS51J	Water, Air and Interface Vehicles (3-0-9)

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, but some students may choose to postpone it. The Laboratory Subjects must be approved by the student's Faculty Counselor.

Typically, a Laboratory Subject consists of an experimental investigation, including an analysis of the problem and evaluation of results. Assumptions based on book knowledge or intuition are experimentally tested against the real world. A student analyzes the results, relating them to assumptions and methods, and a faculty member participates in the evaluation of the experiment. 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)
1.103	Geotechnical Engineering Laboratory Projects (0-3-3)
1.104	Materials of Construction Laboratory Projects (0-3-3)
1.105	Structural Engineering Laboratory Projects (0-3-3)
1.106	Water Resources Laboratory Projects (0-3-3)
1.107	Water Quality Laboratory Projects (2-6-4)
2.671	[1]Measurement and Instrumentation (2-3-4)
2.672	Project Laboratory (1-3-2)
2.673	Projects in Mechanical Engineering (Arr. Minimum 6 units
2.86	[1]Manufacturing Projects Laboratory (3-3-3)
3.081	Materials Laboratory I (1-6-5)
3.172	Critical Experiments in Materials Science (3-5-4)
4.71J	Laboratory in Urban Technology (3-6-3)
5.31	Introduction to Chemical Experimentation (2-8-2)
6.101	Introductory Electronics Laboratory (3-8-1)
6.111	Introductory Digital Systems Laboratory (3-7-2)
6.112	Digital Systems Project Laboratory (2-8-2)
6.121	Bioelectronics Project Laboratory (2-8-2)
6.131	Control Systems Project Laboratory (2-8-2)
6.141	Power Systems Project Laboratory (2-8-2)
6.151	Semiconductor Devices Project Laboratory (2-8-2)
6.161	Modern Optics Project Laboratory (2-8-2)
6.162	Image Transmission Systems Project Laboratory (0-12-0)
6.163	Strobe Project Laboratory (2-8-2)

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

6.181	Audio Frequency Communications Project Laboratory (2-8-2)
6.182	Psychoacoustics Project Laboratory (3-4-5)
7.011	Introduction to Experimental Biology (1-8-3)
7.021	Experimental Immunology (2-16-6)
7.031	Experimental Microbial Genetics (2-16-6)
7.041	Experimental Cell Biology (2-16-6)
7.051	Experimental Biochemistry (2-16-6)
7.061	Experimental Behavioral Genetics (2-16-6)
7.211	Experimental Microbiology (2-16-6)
8.11	Physics Project Laboratory I (1-6-5)
8.12	Physics Project Laboratory II (1-6-5)
9.50	Research in Psychology (Arr. — minimum 6 units)
10.91	Experimental Research Problem (Arr. — minimum 6 units)
11.391J	Laboratory in Urban Technology (3-6-3)
13.90	Ocean Engineering Laboratory (0-12-0)
14.31	Econometrics (3-4-5)
15.301	Managerial Psychology Laboratory (2-6-4)
15.307	Behavior Science Research Practicum (2-8-8)
16.62	Experimental Projects (2-6-4)
16.675	Invention Development Laboratory (Arr. — minimum 6 units)
16.676	Internship in New Enterprise Development (Arr. — normal load 6 units)
17.01	Political Science Laboratory (2-6-4)
20.02	Laboratory in Applied Biology (2-8-4)
20.41	Microbiology Laboratory (2-6-4)

Physical Education Requirement

The Institute expects each student to gain experience in recreational athletics during his or her first two years at M.I.T. By the end of this period each student must have compiled at least 8 points of athletic credit. These points may be acquired by participation in physical education classes, by active membership on one of the freshmen or varsity teams. In addition, a student may elect to take an advance credit exam in one or more of the nineteen 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 September to end of October: archery, ballet, development class, golf, touch football, lacrosse, sailing, self-designed fitness, beginning swimming, pistol, beginning tennis, intermediate tennis, modern dance, folk dance, sculling, karate, rock climbing, scuba diving, bicycling, yoga, partner dancing, square dancing, and frisbee.

Second quarter End of October through fall term: badminton, development class, fencing, judo, scuba diving, self-designed fitness, beginning skating, figure skating, skiing, squash, pistol, beginning swimming, intermediate swimming, Red Cross senior life saving, modern dance, folk dance, gymnastics, rock climbing, and partner dancing.

I. A. P. January: badminton, dance, diving, fencing, figure skating, women's gymnastics, hockey, karate, pistol, precision air rifle, scuba, skating, skiing, squash, beginning trampoline, intermediate trampoline, and yoga.

Third quarter February through March: development class, fencing, judo, scuba diving, self-designed fitness, beginning skating, figure skating, skiing, squash, beginning swimming, rifle, volleyball, Red Cross water safety instructors' course, Part I, modern dance, folk dance, trampoline, women's gymnastics, and ballet.

Fourth quarter April through May: archery, ballet, development class, beginning golf, intermediate golf, karate, sailing, self-designed fitness, softball, beginning swimming, synchronized swimming, scuba diving, beginning tennis, intermediate tennis, rifle, sculling, Red Cross water safety instructors course, Part II, modern dance, folk dance, rock climbing, bicycling and yoga.

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.



Undergraduate Interdisciplinary Opportunities

Interdisciplinary Degree Programs

Advances in knowledge and concern with the functioning of industrial societies 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 discipline. 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 disciplinary lines. Out of these common research undertakings there are also emerging several educational programs ranging from those which can be accommodated within certain departments to others which involve faculty from several Schools.



Humanities and Engineering and Humanities and Science

These two undergraduate programs allow students to devote more than half of their studies to humanities and the remainder to science or engineering, developing special interests in any combination of the two subject areas. Built on the base provided by the Institute's general requirements in mathematics, physics, humanities and chemistry or biology, each of these programs provides a curriculum of unusual diversity. Both programs lead to a Bachelor's degree at the end of the senior year. More detailed descriptions of both of these programs, including outlined programs of study, are included in the Department of Humanitites description in Chapter IV.

Interdisciplinary Science Program

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, also will help students to find a suitable advisor.

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 IV. The faculty member in charge of this Program is Professor Louis N. Howard; the office is Room 6-219 (253-5723).

Simultaneous Award of Two Degrees

It is possible for a student to undertake a program of study in more than one field and obtain two degrees simultaneously, either two Bachelor's degrees or the Bachelor's and Master's degrees, depending on the program. Examples of fields in which students have earned two degrees include computer science and management, mathematics and electrical engineering, civil engineering and economics, and physics and chemistry. For more information about these programs, refer to the descriptions in Chapter II under General Academic Information.

Unspecified Degree Programs

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 interdisciplinary study.

Interdisciplinary Program in the Freshman Year

Concourse Program

For freshmen who wish to have the experience of extensive interdisciplinary study in the first year, the Concourse Program offers team-taught curricula expressly designed to explore the possibilities (and limits) of integrative study and thought. The program employs a closely comparative and relational treatment of ideas and techniques from the sciences, engineering, social thought, and humanistic inquiry, viewed in various unifying contexts both thematic and historical. The Concourse Program spans, and provides credit for, all of the freshman Institute Requirements (Chemistry/Biology, Physics, Mathematics, and Humanities, Arts and Social Sciences).



Interdisciplinary Programs in the Upperclass Years

Archaeology and Ancient Technology

Through a combination of archaeological field work, laboratory studies, and subjects, this program attempts to improve the understanding of how pre-modern man adapted his material environment to his needs, and how cultural conditioning and the physical properties of materials interacted in the hands of man to produce technological systems which, in turn, helped to shape man's culture. 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 field work is aimed at examining the same technologies worked within the laboratory in their original ecological and cultural settings with the goal of elucidating not only the technology itself, but also of understanding 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 Anthrolopogy/Archaeology Program) and in the Department of Metallurgy and Materials Science, 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-Colombian metalworking in Peru and Colombia and a study of the ancient copper industry of the island of Cyprus. Interested students should contact Professor Heather Lechtman (Room 16-401) or Professor Arthur Steinberg (Room 14N-308).

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 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 IV.

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 artificial organs, 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. Graduate study in biomedical engineering is open to students with appropriate undergraduate background in either the engineering or biological sciences. The Committee on Biomedical Engineering serves as an advisory body which can assist students in setting up interdepartmental programs.

Interdisciplinary Study Opportunities Involving Fieldwork

Environmental Studies

Environmental studies for undergraduates at M.I.T. are available through a variety of departmental and interdepartmental subjects and laboratories which are growing in number. Although there is no separate degree program at the undergraduate level, many departments offer educational and research opportunities in those aspects of the environment which are closely related to their own disciplinary interests. Undergraduate students 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 wish 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 sample programs of studies on environmental issues are available through the Office of the Provost, Room 3-234.



Study and Research in Education

The Division for Study and Research in Education is beginning its second year of operation. Activities in the Division have an interdisciplinary focus involving the research of several faculty members on fundamental questions of how learners learn. The scope of these inquiries span learning at different ages and in different educational settings. They are based, in large extent, upon current perceptions of social processes, recent developments in cognitive sciences — particularly from an information processing point of view — and emerging technologies. Different paradigms for education research are being developed which question old assumptions and which actively inter-relate cognitive theory, learning content and context, and social process. Parallel with these developments are beginning efforts to investigate reliable processes for institutional change and organizational learning. (For additional information about research projects, see the D.S.R.E. research facilities section under Research Facilities at M.I.T.)

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. Students should also explore possibilities available through the Teaching Intern Program.

Teaching Intern Program

M.I.T.'s undergraduate Teaching Intern Program, a combined practicum and seminar involving teaching experience in urban secondary education, is offered this year. It is primarily intended for students considering careers as high-school teachers, and through it, students can satisfy the teaching experience requirements for teacher certification. For details, contact Michael Efron (253-5126), Room 20-C-004.

Undergraduate Research Opportunities Program

This broad program has been developed to provide 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. While the program was not primarily designed to provide experience in interdisciplinary areas, it has worked out that way in many cases. Students are encouraged to participate in ongoing interdisciplinary research, or to find a faculty sponsor for interdisciplinary projects initiated by the students themselves. The U.R.O.P. Directory, published each term, has more detailed information on the program. If students have any questions, contact the U.R.O.P. office, Room 20B-141, 253-5049.



Interdisciplinary Subject Offerings

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 field-work opportunities. Among the more than 20 law-centered subjects in ten 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.

In recent years, an increasing 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 a more regulated one. 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 Services Program.

The Office of Preprofessional Advising and Education 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.

Special Interdisciplinary Programs in Humanities

The School of Humanities and Social Sciences 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 IV.

Undergraduate Seminars

The Undergraduate Seminar Program offers subjects on a wide range of topics, many of which are interdisciplinary in nature. 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.



Undergraduate Opportunities in Interdisciplinary Research

The Institute provides a number of interdisciplinary research opportunities for undergraduates, many of which are listed below. Students interested in research opportunities of an interdisciplinary nature may contact the U.R.O.P. office or may directly contact faculty in the various laboratories or centers. For further information about the facilities listed here, please see the more extensive descriptions under Interdisciplinary Research Facilities at M.I.T. which appears in Chapter III.

Bitter National Magnet Laboratory

The Francis Bitter National Magnet Laboratory provides opportunities for undergraduate research through the Undergraduate Research Opportunities Program as well as for senior thesis projects. In the spring term, the Laboratory organizes an undergraduate seminar in which students are introduced to the current basic and applied research programs.

Center for Cancer Research

The Center for Cancer Research offers opportunities for undergraduate research in the fields of cancer immunology and virus research. A program of research in the Center, if acceptable to the Department of Biology, can satisfy the requirements for a project laboratory for biology majors. Openings for undergraduate research in the Center for Cancer Research are limited to a small number of students.

Center for Space Research

The Center for Space Research offers an opportunity for undergraduates to participate in a broad program of space related research through the Undergraduate Research Opportunities Program, direct employment, undergraduate seminars, or attendance at frequent seminars.

Clinical Research Center

The Clinical Research Center is a 12-bed research hospital located on the campus. Although its size limits the number of opportunities available, there are openings each year for a few undergraduates to work on projects in medical research. These may include such diverse topics as medical biochemistry, medical laboratory

automation, computer assisted diagnosis, diagnostic instrumentation and assisting physicians in medical research. Inquiries should be made at the Office of the Director.

Commodity Transportation and Economic Development Laboratory

The Commodity Transportation and Economic Development Laboratory of the School of Engineering offers opportunities to undergraduates for interdisciplinary study of problems in energy transport, ports and terminals, commodity distribution, regulation and control of goods transportation, transportation economics, and related areas, either independently or as participants in ongoing research.

Electric Power Systems Engineering Laboratory

Associated with its graduate research program, the Electric Power Systems Engineering Laboratory generally has available a number of projects appropriate for either laboratory or undergraduate thesis credit. Most problems are in an electric power systems context and can be either experimental or theoretical. For additional information, contact Professors G. L. Wilson, J. L. Kirtley, or J. G. Kassakian.

Laboratory of Architecture and Planning

The Laboratory of Architecture and Planning is a new center for research activities in the School of Architecture and Planning. The Laboratory fosters research which contributes to the understanding, the education and the practice of architecture, planning, and closely related fields. Concerns of projects currently in the Laboratory include: the human quality of the environment; the distributional effects of environmental change among groups and institutions in society; and the openness and accountability of processes associated with environmental change. Most projects are also concerned with developing new methods of research and practice.

Laboratory for Nuclear Science

The Laboratory for Nuclear Science encourages the participation and involvement of M.I.T. undergraduate students in its programs of nuclear and elementary particle research. Possibilities include: nuclear instrumentation, elementary particle physics, nuclear structure physics, and theoretical physics. A detailed itemization of current topics and a listing of M.I.T. faculty and staff who have indicated a willingness to supervise undergraduate projects in L.N.S. are listed in the most recent Directory of M.I.T. Undergraduate Research Opportunities.

Project MAC

Project MAC, which is a large interdepartmental laboratory for computer research and development, offers many opportunities to undergraduate students for participation in research with faculty, graduate students, and research staff in small groups, either for credit in special subjects or for money under the Undergraduate Research Opportunities Program. Last year 29 undergraduate students were involved in software, hardware, and theoretical research at Project MAC.

Research Laboratory of Electronics

Faculty members and students from approximately ten academic departments participate in the research activities of the Research Laboratory of Electronics. A variety of projects are under way in the broad categories of general physics, plasma dynamics and communication sciences. The research activities of faculty members and graduate students provide numerous opportunities for special laboratory projects and student theses.

Sea Grant Program

Undergraduates interested in the technology of and concepts in ocean utilization and coastal zone development can participate in several of the educational and research activities sponsored by the Sea Grant Program. An interdisciplinary systems design subject and a student summer laboratory provide practical experience in planning for marine and coastal resource use, in oceanography, and in ocean engineering.

Spectroscopy Laboratory

Opportunities for undergraduate research in the Spectroscopy Laboratory include studies of the spectra of crystals and small polyatomic molecules, conformations of biopolymers by laser-Raman spectroscopy, infrared and Raman spectra of inorganic molecules, optical double-resonance spectroscopy, and ultra high resolution spectroscopy with tunable lasers. It is expected that undergraduates will have had basic laboratory training in physics or physical chemistry, but consultation with a staff member may show that previous specialized experience is sufficient for acceptance in the undergraduate research program.

Urban Systems Laboratory

The Urban Systems Laboratory has a variety of opportunities for students to work in the fields of engineering, management, architecture, planning, and the social sciences. Students may receive credit for course related work.

Wallace Astrophysical Observatory

The George R. Wallace, Jr. Astrophysical Observatory is available for use by undergraduates. Several subjects (12.111, 12.112, 12.113, 12.116, 12.143) make extensive use of the facility for training students in methods of astronomy and operation of telescopes. Individual students are encouraged to apply for observing time to carry out special problem research under the U.R.O.P. program, as a special problem course project, or for senior thesis research. Projects available include observations, instrument development and computer telescope automation.

Campus Activities

Undergraduate Student Government

The M.I.T. Undergraduate Association, to which all undergraduates belong, is the major undergraduate governmental body. A variety of committees are 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 administers the Student Center, including building improvements and Center activities. The Student Committee on Environment tries to improve classroom and building design and atmosphere, obtain better living conditions in the dorms, and implement coed living in more living groups. The Student Committee on Educational Policy proposes educational reforms such as a pass/fail system or an independent study calendar. It also sponsors feed-back programs and attempts to involve more students in academic departmental decision processes. 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 activities and tries to improve their facilities and settle disputes among various activities. The Foreign Opportunities Committee publicizes and arranges for work or study abroad. Its Nominations Committee recommends student representatives for M.I.T. faculty and administrative committees (of which there are over 40).

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

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 also 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 intra-House judicial problems.

The elected officers of the Non-Resident Student Association run a program of tutorial, athletic, and social events for commuting students which centers around 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.

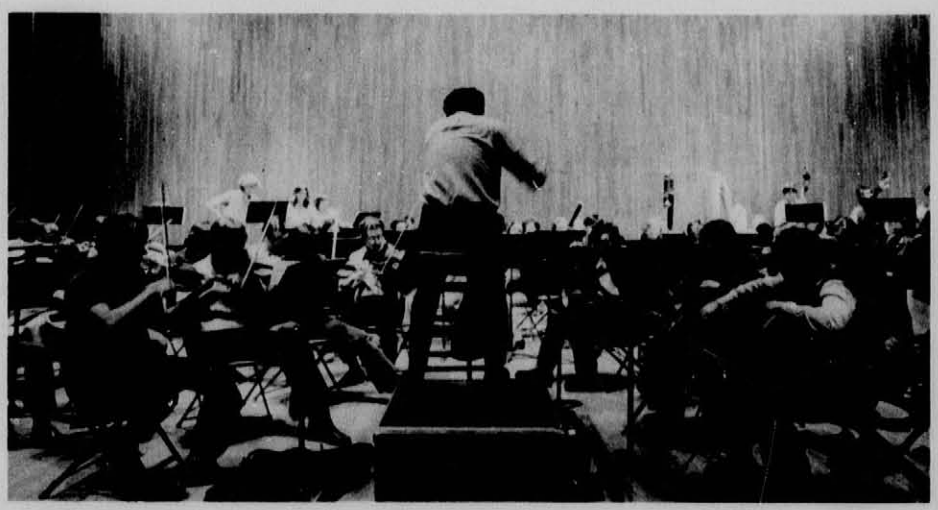
Theater

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

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

The Musical Theatre Guild produces *Tech Show*, an annual 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 each year.



Student Publications

Student publications at M.I.T. include *The Tech,* a student newspaper published twice each week; weeklies, *Thursday* and *Ergo; Technique,* the senior yearbook; *Tech Engineering News,* a monthly student magazine of science and engineering; *How To Get Around M.I.T.* (HoToGAMIT), the M.I.T. community guide; and *Rain,* a literary magazine. There are less formal outlets for journalism talents in the newspapers of the Institute Houses and in departmental newsletters of many kinds.



Athletics

A major purpose of the athletic program at the Institute is to encourage all students to develop interests leading to participation 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 1,000 men and women for competition in 26 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 including sailing privileges for their families.

M.I.T. has varsity and freshman intercollegiate teams in 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 and fencing with club teams in field hockey, tennis, swimming, gymnastics, softball and volleyball. Competition includes traditional New England colleges and Ivy League schools.

The Intramural athletic program is noteworthy; last year over 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, softball, volleyball, swimming, track, tennis, table tennis, sailing, badminton, hockey, golf, squash, water polo, wrestling, rifle, and bowling. Club sports, with intercollegiate competition but less formal organization than varsity teams, include badminton, bicycling, rugby, cricket, judo, white water, and weightlifting. Undergraduate and graduate students participate in both intramural and club programs.

Excellent facilities for these sports are provided by the du Pont Athletic Center, Rockwell Cage, the du Pont Gymnasium, Briggs Field, the Alumni Swimming Pool, indoor and outdoor tennis courts, an outdoor skating rink, and the Sailing Pavilion and Pierce Boathouse on the Charles River.





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 Glee Club, Symphony Orchestra, Concert Band, Woodwind and Brass ensembles, Schola Cantorum, Festival Jazz Band, Concert Jazz Band, and a barbershop group — the Logarhythms; there is also a Choral Society, which draws its members from the entire M.I.T. community. 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 employing faculty and students are regularly scheduled throughout the year. Other professional musical events are sponsored at the Institute by various campus organizations.

Lectures, Seminars and Films

The Lecture Series Committee, an all-student group independently financed by its popular program of classic and current films, brings outstanding and controversial speakers to the campus. Such men as U Thant and Buckminster Fuller have recently delivered talks to the M.I.T. community. L.S.C. has also co-sponsored, with M.I.T. departments or other campus groups, events of cultural, entertainment, or educational significance.



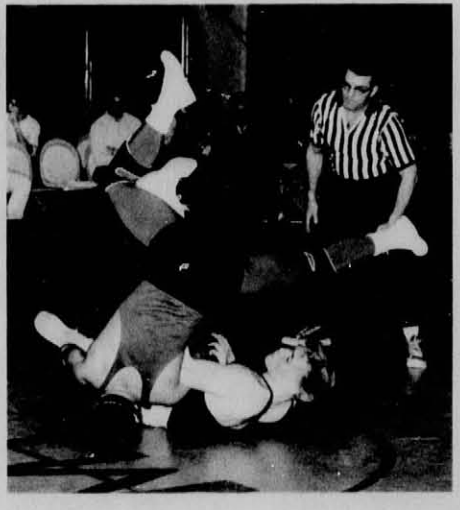
Visual Arts Activities

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 Department of Naval Architecture and Marine Engineering, maintains a fine collection of paintings, prints, photographs, ship plans, and working drawings of yachts and small craft by well-known twentieth century designers.

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





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, within this environment, to provide opportunity for the development of spiritual maturity and the exercise of 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, WTBS (the FM local broadcasting station), and the Student Art Association.

More than 500 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 Council 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' problems. Numerous nationality clubs sponsor programs for foreign students from various nations, including discussions and social events. The wives of M.I.T. students, both undergraduate and graduate, form the Technology Wives Organization (TWO). A social and service organization that begins activities in mid-October, the group sponsors a variety of monthly programs.

Smaller interest groups include bridge, folk and square dance, model rocket, and railroad clubs.

Technology Community Association

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

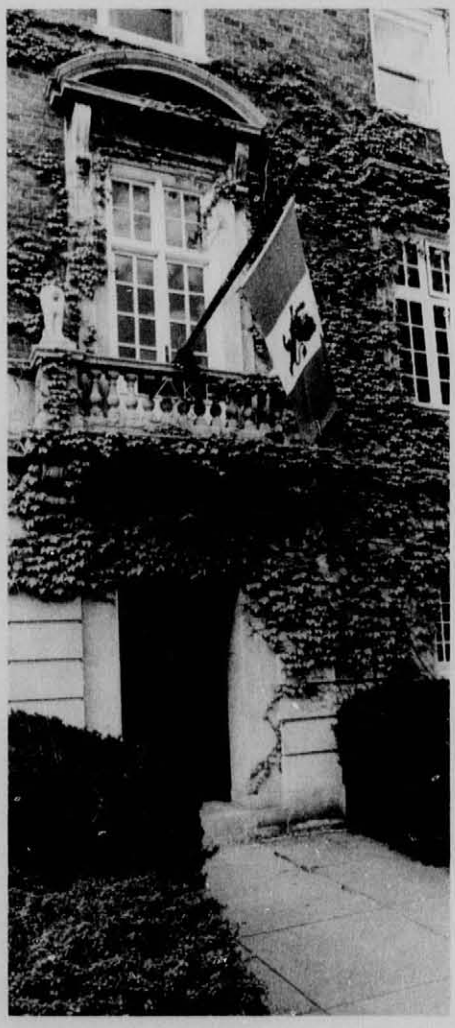




Undergraduate Residence

Single Student Housing





At the undergraduate level, M.I.T. is essentially a residential university. Of the total undergraduate student body of about 4,100, about 2,000 single men and women live in the eight Institute houses on the campus and about 1,300 single men and women live in 29 fraternity chapters and the cooperative M.I.T. Student House.

The central purpose of the residential system is to provide environment and programs conducive to personal development as well as to academic achievement, and in this way to extend the experience of higher education which M.I.T. offers its undergraduates. Great reliance is placed by the Institute 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.

Many responsibilities are delegated to student governing groups for establishing and administering House regulations and for maintaining 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 taxes 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 29 fraternities, or the M.I.T. Student House. Freshmen particularly gain from associations with upperclassmen 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 areas are required to live "on campus." Exceptions to this "on campus" living requirement are made only with the approval of the Dean for Student Affairs.



Institute Houses

The Everett Moore Baker House, located on the river front at 362 Memorial Drive, on the west campus, accommodates 350 men and women in single, double, or triple rooms. The House has its own dining facilities, where residents may choose to take Commons meals.

Bexley Hall, an apartment house at 46-48-50-52 Massachusetts Avenue, directly across from the main entrance to the Institute, has been furnished as an apartment dormitory for men. There are suites for two, three, and four students, each with bath and kitchenette. A total of 126 men are accommodated. Residents may, if they wish, take their meals at any of the Institute's dining facilities.

Burton-Conner, located on the Charles River at 410 Memorial Drive, on West Campus, houses 344 men and women in single and double rooms grouped in suites for three to eleven students. Each suite has its own living room, kitchen, and bath, and the suites are arranged in floor groups of 30 or 50 students. Residents of Burton House may prepare their own meals in the suite kitchens or purchase Commons meals in any of the nearby House dining halls.

The East Campus Houses — Munroe, Hayden, Wood, Goodale, Bemis, and Walcott — on the east side of the campus near Walker Memorial, house about 380 undergraduate men and women, mostly in single rooms. Residents of East Campus may take their meals in nearby Walker Memorial. The Walker dining room offers both Commons meals and a la carte service and the Pritchett Lounge offers sandwiches, beverages, and other snacks.

The German/French House, located next year on one floor of Ashdown House, is a new cooperative living group where the French and German languages are spoken and the cultures of each nation are studied by two groups of people. Each group will have a distinct identity. Members of the House will share some housekeeping duties, including preparing their own meals. The House will move to the new Institute House currently under construction, upon completion.

The Frank S. MacGregor House, located on the Charles River at 450 Memorial Drive on the west campus, houses 324 men in singles arranged in six- or eight-man suites. Each suite has its own living room, bath, and galley kitchen. The suites are arranged in entries of about 40 men. The House has its own dining hall, where residents may choose to take Commons meals.

Stanley McCormick Hall, located at 320 Memorial Drive overlooking the Charles River on the west campus, has accommodations for 220 undergraduate women in single and double rooms. Half of the House is arranged in suites with nine single rooms, a bath, and a kitchen-lounge. The other half is arranged in floor groups of 20 students in single and double rooms with baths and a kitchen-lounge shared by the residents of each floor. Residents may prepare their own meals in the suite and floor kitchens or take Commons meals in nearby dining halls.

The Russian House, located on one floor of Burton House, offers a unique opportunity for undergraduate men and women interested in Russian to obtain a speaking knowledge of that language. The 20 residents prepare their meals and eat as a group and converse primarily in Russian while in the House.

The Senior House — Ware, Atkinson, Runkle, Holman, Nichols, and Crafts — on the east side of the campus at the corner of Ames Street and Memorial Drive, houses about 195 undergraduate men and women. The accommodations consist of one-, two- and three-person rooms and suites. Residents of Senior House may take their meals in nearby Walker Memorial. The Walker dining room offers both Commons meals and a la carte service and the Pritchett Lounge offers sandwiches, beverages, and other snacks.

For the 1974–75 academic year a group of 30 undergraduate students will live in Ashdown House, a residence for single graduate students located on the corner to Massachusetts Avenue and Memorial Drive. Upon completion in September 1975, these students will be the first to move to a new undergraduate house now under construction on Memorial Drive.

Rooms in the Institute Houses are engaged for the full academic year. For the year 1974–75, the residence fees range from $396 to $503 per term.

The Commons Plans available for 1974–75 are as follows:

1
The 19-Meal Plan with breakfast, lunch, and dinner Monday through Friday and brunch and dinner on Saturday and Sunday.
2
The 15-Meal Plan which is the same as the 19-Meal Plan but with no Saturday or Sunday meals.
3
The 25-Day Plan which consists of 25 breakfasts, 25 lunches, and 25 dinners which may be eaten anytime during the term. (This covers one-third of the meals in the 15-Meal Plan).

Commons contract prices for 1974–75 are as follows (the prices for I.A.P. and spring term will be reviewed during the fall term and I.A.P. respectively):

	Fall Term	I.A.P.	Spring Term
19-Meal Plan	$480	$105	$520
15-Meal Plan	370	80	400
25-Meal Plan	145	45	155

Fraternities

Recognized fraternities at the Massachusetts Institute of Technology include 27 chapters of national fraternities and two local residential groups with no off-campus affiliation. 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 and is responsible for management of all its operations and maintenance and for development of its academic, social, membership, recreational and external relations 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 college 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 sponsored by a group of House alumni. The 30 undergraduate members maintain the residence and do all the work except for cooking and major repairs. Cooperation by the students extends to the management of the House and to the academic, recreational, and social aspects of student life. Savings per member are about $400 a year.





Non-Resident Student Association

Those unmarried undergraduate men and women 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 Non-Resident Student Association (the N.S.R.A.). A small fee is charged members to help support the social and cultural programs undertaken by this student organization. The focus for N.S.R.A. activities is a house on the campus which provides social and study facilities for commuting students and limited overnight accommodations. The student governing group has responsibilities similar to those of student governing bodies in the residences.

Additional Information

Additional information on undergraduate housing and application procedures is contained in the publication *Undergraduate Residence at M.I.T.* Each new first-year student and each new college transfer 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 may also 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.

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 lease basis.

A nursery school, with one classroom in Westgate and two in Eastgate, is operated by Technology Nursery School, Inc., a non-profit 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 Campus Housing Office, Room E18-307, M.I.T. Since accommodations in Eastgate and Westgate are limited, married students are well advised to contact the Community Housing Office regarding off-campus housing.

Westgate

This five-building complex, located at the west end of the M.I.T. Campus, provides 210 apartments for married student families. The West Campus location near Memorial Drive and the Charles River is within ten minutes' walk of the Institute's main buildings.

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 60 two-bedroom apartments. Community facilities are available and free parking is provided for a majority of the residents. Rents in Westgate range from $155 to $220 per month, including utilities and heating.

Eastgate

Located adjacent to Kendall Square at the east end of the M.I.T. campus is Eastgate, a 30-story apartment tower with 204 family units for married students and faculty. The site adjoins the Sloan School of Management and the Departments of Economics and Political Science. It is convenient to the main campus and public transportation.

The tower building contains 96 one-bedroom apartments, 84 large one-bedroom apartments, and 24 two-bedroom apartments. About 80 percent of the apartments are allotted to married students; the remainder are available to faculty members. Rents in Eastgate range from $158 to $251 per month including utilities and heating. Community facilities are available and free parking is provided for a majority of the residents.

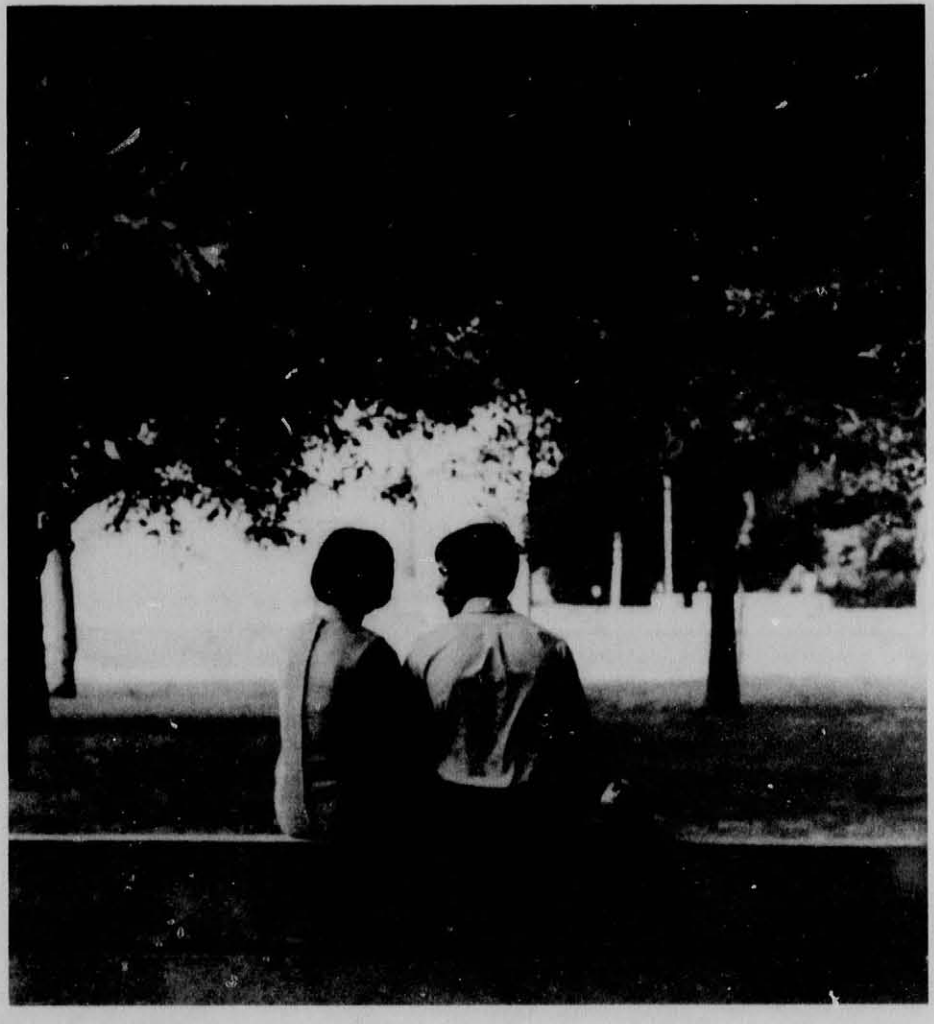






Community Housing Service

Students who do not live on campus will find help in locating accommodations in the Community Housing Service. Listings of available rentals in the Greater Boston area are maintained, and the staff attempts, on an individual basis, to help students locate the type of accommodations that will best suit individual preferences and financial resources and to advise on many additional aspects of off-campus living. All correspondence should be addressed to Community Housing Service, Box 42, M.I.T. Branch Post Office, Cambridge, Massachusetts 02139.





Student Services

Counseling

The Institute offers a variety of 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 likely to be of help and to state his or her situation or problem in the student's own terms. Counseling, as the word is used here, refers to casual conversations and to scheduled appointments; it runs from the providing of information to skilled psychotherapy.

The Freshman Handbook and *How to Get Around MIT* list in detail the counseling resources at M.I.T. Only a short summary is given here. Each student has a faculty advisor. Housemasters and tutors are available in the Institute houses, and some fraternities have graduate tutors. Frequently a student is able to get help he or she wants from a fellow student or from an instructor who is not officially a faculty advisor. Coaches and activity advisors can also often be helpful. Several offices specialize in particular areas, such as the Student Financial Aid Office which includes student employment, the Office of the Foreign Student Advisors, the Religious Counselors, and the Career Planning and Placement Office. The Campus Patrol is frequently of help to students. There is a Premedical Advisory Council, a Prelaw Advisory Council, a Foreign Study Advisor, and an Education Advisory Council for those students considering these fields.

The office of the Dean for Student Affairs has several members whose time is almost entirely devoted to student counseling, whether the situation is academic or personal or both.

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 Services

The Institute maintains a well-equipped Medical Department staffed by specialists, centrally located in the Homberg Memorial building, a wing of M.I.T.'s main buildings. In addition to general medical care given by specialists in internal medicine and surgery, the Medical Department provides consultants in allergy, dentistry, dermatology, gynecology, obstetrics, neurology, ophthalmology, orthopedics, otolaryngology, pediatrics, psychiatry and urology. Except in emergencies, visits are by appointment. The Infirmary, with 28 beds, is located on the campus between Baker House and McCormick Hall. Facilities of the Boston and Cambridge hospitals are used in cases involving major operations or critical illnesses, after which students may return to the Infirmary for convalescence.

The Student Health Program consists of two parts. The first part covers ambulatory and infirmary care provided by the M.I.T. Medical Department and is required for full-time students at an annual cost of $130. This does not cover dental services, eye refractions or pediatric clinic visits which are on a fee for service basis. The second part covers hospitalization (other than in the M.I.T. Infirmary) due to accidents or illness at an annual cost of $60. This portion of the program is required for foreign students and optional for American students. However, all students are urged to purchase this coverage unless they have equivalent insurance as hospital care is very expensive. A medical insurance plan for the spouse of a student and for their children is also available. The additional cost of coverage for the spouse, which includes care in the M.I.T. Medical Department and outside hospital care with a $300 maternity benefit, is $245. Hospital coverage for one or more children may be purchased for $55.

	M.I.T. Medical Department	Outside Hospital	Both
Student	$130	$60	$190
Student Spouse	$130	$115	$245
Children, one or more	Fee for Service	$55	—

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, nor is it underwritten by the Student Health Program. Students requiring such treatment will be referred to private psychiatrists or psychiatric clinics in the area.

A dental service which offers complete dental treatment for students and their spouses is available on a fee for service basis, but because of limited space, not all student dental needs can be met. A pediatric clinic is also available on a fee for service basis. They are located in the M.I.T. Infirmary building at 350 Memorial Drive.

Prior to matriculation, every student, undergraduate or graduate, is required to submit a report from his own physician recorded on an Institute medical form, which is to be mailed by the physician to the Associate Medical Director stating that he or she is free from active tuberculosis as evidenced by an intradermal skin test or chest x-ray or both. This is a public health measure and cannot be waived. Immunization against tetanus is also required before entrance.



Career Planning and Placement

The Career Planning and Placement Office serves students seeking information and advice on employment, opportunities of further study and careers. It works in close cooperation with the Office of the Dean for Student Affairs, the Office of the Dean of the Graduate School, the Foreign Study Advisor, the placement counselors in the departments, and the faculty advisors on careers in education, law, and medicine.

The Office staff are happy to talk with students on an individual basis about career plans. The Office also arranges seminars at which alumni 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 of work and study abroad.

Over 200 companies, government agencies, and graduate schools make recruiting visits to the Career Planning and Placement Office each year. Their 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 continuous 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, Room 10-186, extension 3-4158, serves students who are interested in entering medicine, education, law, and related fields in public administration. The director of the Office also 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 advising in these areas may be found in Chapter II.



Foreign Study Advising

The Foreign Study Office assists those seeking foreign study and research opportunities on various levels. Files are maintained on opportunities all over the world. In addition to helping undergraduates plan a "junior year abroad" or "domestic year away," the Foreign Study Advisor is the M.I.T. representative for such foreign fellowship and scholarship programs as Churchill, Marshall, and Fulbright. Many other less well known sources of support exist for graduate and postdoctoral study and research overseas. Since deadlines for the following year are in the summer or early in the fall, planning should begin in the spring. Interested students are encouraged to consult the Foreign Study Office, Room 7-133, extension 3-5243.



Admissions

Freshman Admission

The great majority of undergraduate men and women enter M.I.T. as members of the freshman class, directly following completion of secondary school studies. Each year a limited number of students whose previous studies at other colleges and universities entitle them to advanced standing are accepted for entrance.





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

Students who have not completed one of these subjects by graduation should be prepared to meet the requirement through a summer school program.

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.

It is recommended that the elective subjects include one or more years' study of history. While there is no language requirement for admission, the study of modern foreign languages in secondary school is obviously desirable and is recommended. The choice of languages should be guidnd 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. Much flexibility is used in interpreting C.E.E.B. test scores, wherever there is evidence of disadvantaged education or cultural background. 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. In addition, financial aid for minority group students is adjusted to reflect background conditions, both in terms of calculation of need and in terms of the amount of self-help expected. 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.

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 and submit a non-returnable fee of $20 (this may be waived in cases of extreme financial hardship) by January 1 of the year of intended entrance.

Candidates who have submitted all the required material and have completed the entrance examinations by January will be notified early in April.

Personal Conferences (Interview)

Each applicant for admission to the freshman class is required to have a personal conference either in the Admissions Office or 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 personal conference to a member of the Council at the time of receipt of the referral card in the Admissions Office. This personal 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, except during February. Appointments are available and are suggested for the months of August through January. Visitors should try to plan their time to include a student-guided tour of the campus, available at 10 and 2 each day 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, 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 Formosa should apply to the College Entrance Examination Board, Box 1025, Berkeley, California 94701.

Candidates for admission for September 1975 must take the S.A.T.'s by the December 1974 test date. Achievement tests must be taken by the January 1975 test date. The closing dates for registration are usually four to six weeks before the test date. The required series of tests must be completed by the January test date of a candidate's senior year. Applicants outside the United States should note that the latest date on which the S.A.T. will be offered this year is December 7, 1974; the closing date for registration is October 17, 1974. The latest date for the Achievement Tests is January 11, 1975; the closing date for registration is November 29, 1974. 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 in May 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 before the senior year 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 December 15. 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. 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 colleges' common reply date, May 1. This is therefore not an "early decision" plan in the usual sense.

Early Evaluation

The colleges and universities of the Ivy Group have agreed to adopt an early evaluation procedure for U.S. and Canadian citizens. Beginning after December 15 and continuing until March 1, an early evaluation will be sent by M.I.T. to an applicant after the application and all supporting documents are received. This preliminary evaluation will state whether an applicant's chances of admission are "likely," "possible," or "unlikely." Formal admissions decisions will be sent to applicants early in April, as in the past.

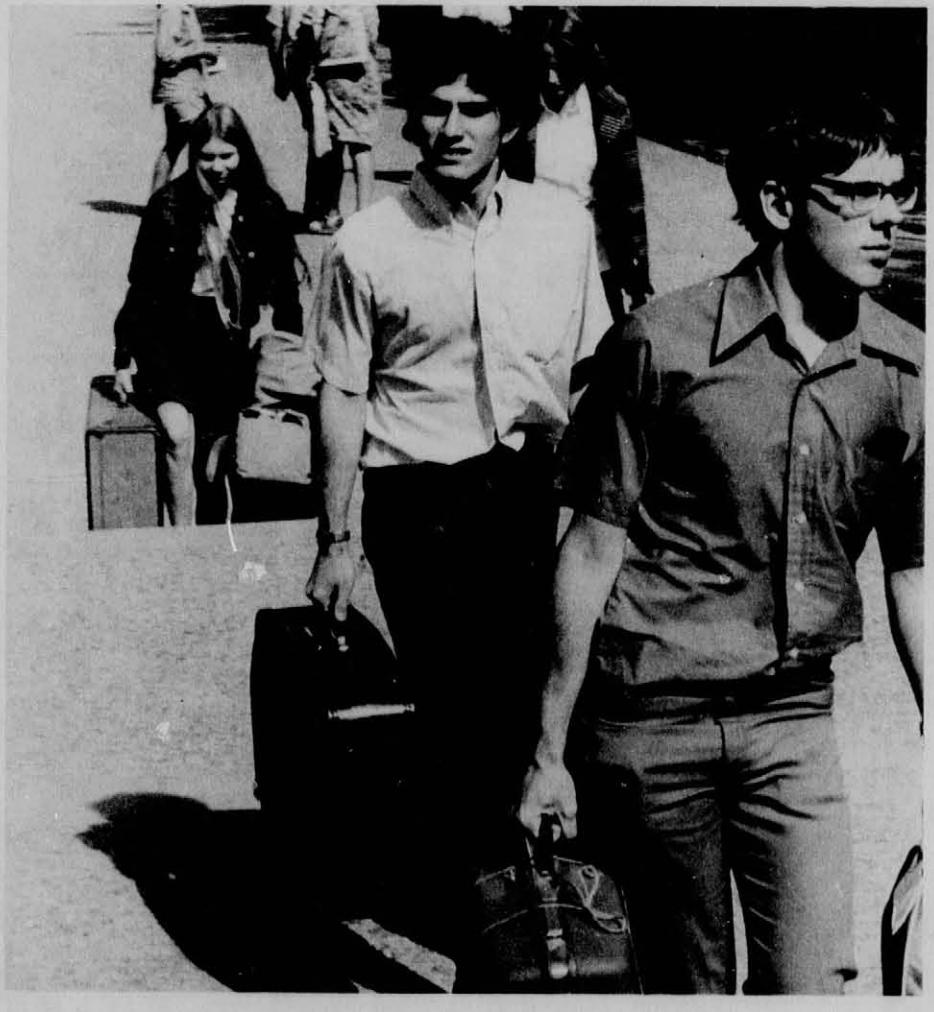






Deferred Admissions

Occasionally students wish to take off a year 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, test papers, and reports from the school 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.

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. before July 26 about their studies and should request information about the Advanced Standing Examinations at M.I.T.

Foreign Undergraduate Admission

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 High 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.

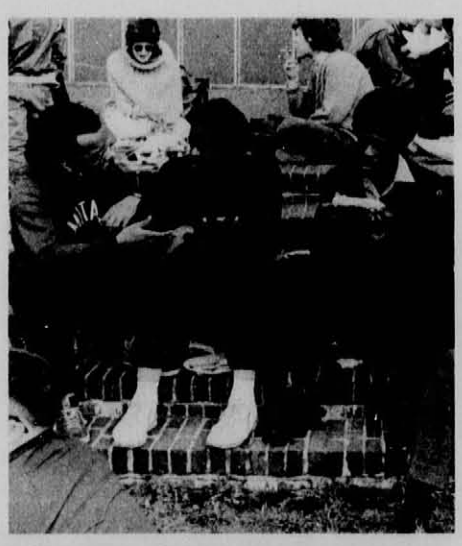
Application Procedures

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. A non-returnable $20 application fee is required with the Final Application.

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 or representative of the Institute for International Education.

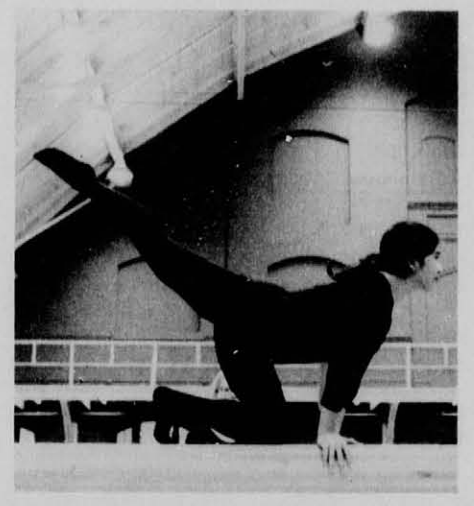


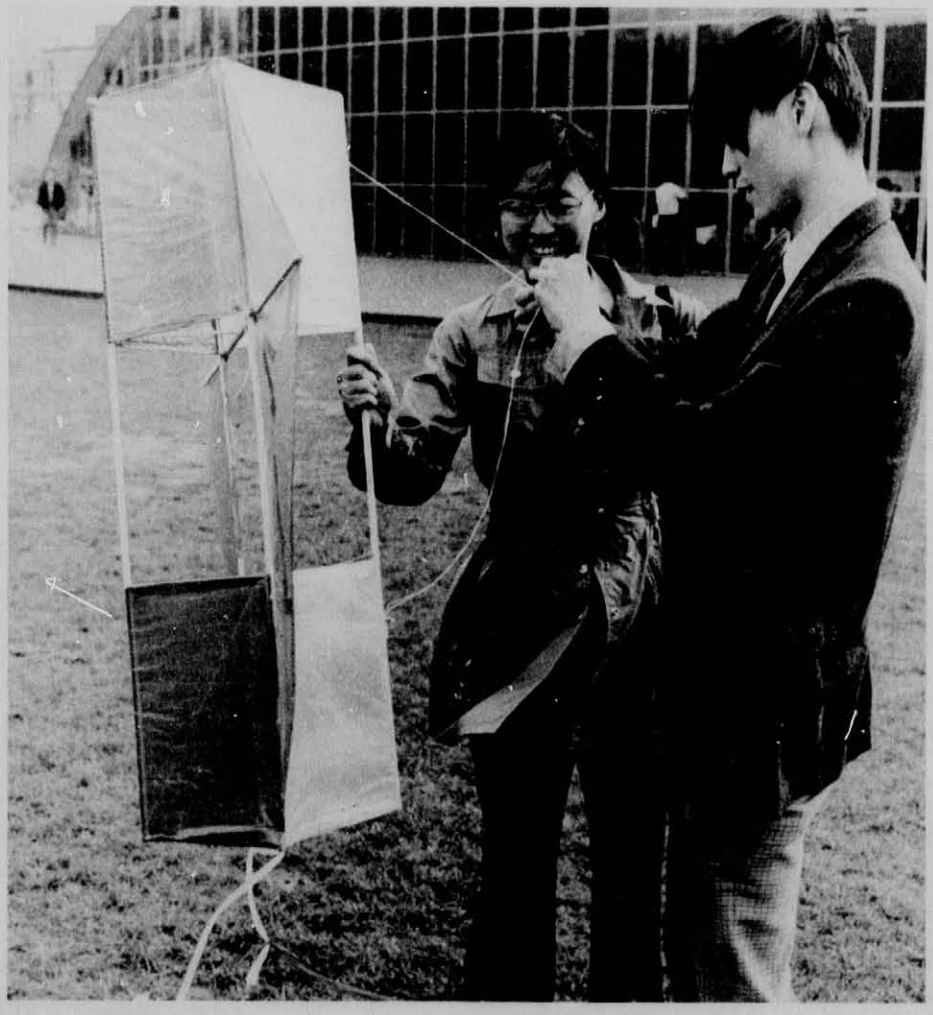




Facility in English

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.

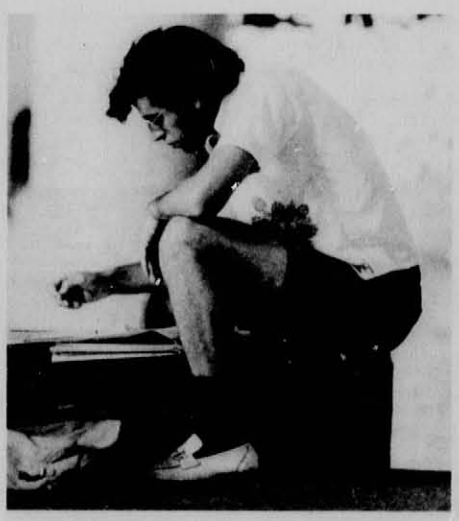




Entrance Examinations for Foreign Applicants

If an applicant's schooling has been in English for the past five years, the College Board tests listed above 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 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, U.S.A., for registration material and information about this test.



College Transfer Admission

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 from upperclassmen should be completed by May 1 if possible. 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 the academic preparation required of students entering the Institute from secondary schools.

Transfer applicants will be asked to take the College Board tests prescribed above for freshman applicants if they have not already done so. The tests may be waived by the Committee on Admissions for applicants who have completed a substantial amount of college-level work in mathematics and science.

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.



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, will arrange to have the final application materials sent, and will request a report directly from the applicant's secondary school.

The applicant should then submit the following:

1
A completed Application for Admission with Advanced Standing, indicating all subjects that will have been completed at the time of transfer, and a non-returnable fee of $20.

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. The applicant's name should be written on each page and each subject indicated by a check mark in the margin. Complete catalogues should not be sent.

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.

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

Transfer applicants who wish to be considered for aid should request a Financial Aid Application and submit it with a Parent's Confidential Statement to the Director of Student Financial Aid.

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. Students whose records appear not to warrant credit in a subject may be permitted to demonstrate, by passing an Advanced Standing Examination, that they are entitled to such credit.

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 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.

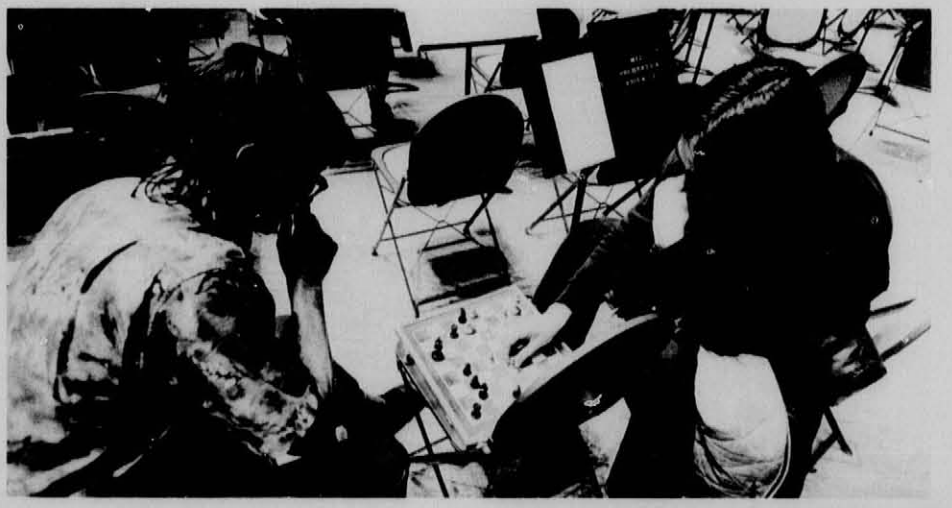


Special Student Admission

Foreign Transfers

Foreign students applying for admission with advanced standing should refer to the leaflet "Information for Prospective Foreign Students," which may be obtained from 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. Cross-registration privileges may be possible under special circumstances. Special Student status is granted for one term only but can be renewed for a successive term. 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 $20 for the first application; it is not required for renewal applications within a two year period. Completed applications should be submitted at least three weeks prior to the beginning of the term.



Costs

Tuition

M.I.T. is an independent, endowed institution; the tuition paid by each student covers less than half the cost of facilities and teaching. The balance is met by income from endowment and by gifts.

The following list gives an estimate of the average student's basic costs for the academic year 1974–75 at M.I.T.:

Tuition	$3,350	
Board and room	2,019	
Books and Materials	200	
Health Service Fee	130	($190 Foreign)
Total	$5,699	

In addition to these costs, there are variable personal expenses and costs for transportation. Typical costs for clothes, laundry, recreation, optional medical insurance, and personal necessities average about $800 per academic year; but there is a great range, depending on interests and tastes. Cost of travel obviously varies significantly and is not included in the above.

The tuition for all regular full-time students in the first and second terms is $1,675 per term. The two-term tuition fee for full-time students who are registered both terms covers the January Independent Activities Period. The regular term tuition for all full-time students who are registered only one term covers the January Independent Activities Period. Special tuition rates apply in the Summer session. These are published each year in the Summer Session Catalogue, available in March.

Special Students (including M.I.T. sponsored-research staff) and regular students other than fellows and academic and graduate student staff, who are permitted by their Registration Officers or Faculty Counselors to take only a few subjects in the first or second term, will be charged at the rate of $54 per unit taken either for credit or not for credit. This unit fee applies up to a maximum of $1,675 per term and is subject to the following minimum fees:

Members of the M.I.T. Community*	$325
Other Special Students	$485
S.B. thesis only	$140

The tuition fees for cooperative programs are as follows:

Electrical Engineering
Course VI-A
July 1 to June 30
$3,350

Chemical Engineering Practice
Course X-A
September–January **or**
February–June
$1,675

Aeronautics and Astronautics
Course XVI-B
June–August (15 months)
$3,350

Ocean Engineering
Course XIII-C
June–August (15 months)
$3,350

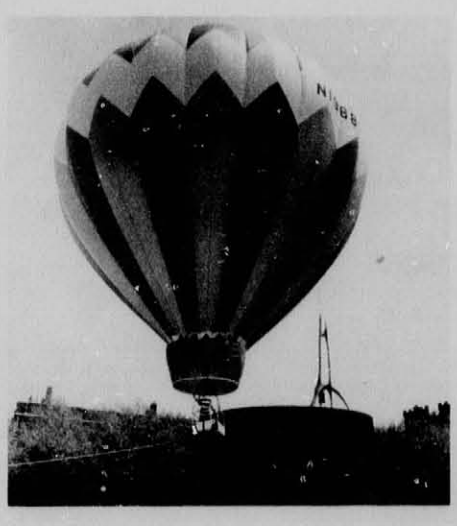
Mechanical Engineering
Course II-B
June–August (15 Months)
$3,350

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

In each case, the first $1,675 is due on the date when the first-term tuition is normally due, and the additional $1,675 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 for 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 fees appropriate to the program approved by his 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.

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.



Payments

Institute House Rentals and Meals

All term rentals for all undergraduate 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. Please see Undergraduate Residence in this Chapter for a listing of all Institute House rentals and meal charges.



Miscellaneous Fees

Anyone who files a final application for admission as a regular undergraduate student or as a beginning special student is required to pay a $20 application fee. This fee is not required of a student who applies for readmission as a candidate for the same degree, or, in the case of a graduate student, for a higher degree after a lapse of less than two years.

The fees for the Student Health Service Program are listed under Medical Services.

Fines are imposed: $20 for each scheduled payment missed or received late; $5 for late registration. Registration is *not complete* until all fees are paid in full or a suitable payment plan has been approved by the Student Accounts Office.

There is a $5 charge for each change in a student's program (addition, cancellation, or change of units) which is made in the last two weeks of a regular term.

All payments are to be made to the Massachusetts Institute of Technology, 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 will be 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.

Students or their parents may arrange with the Student Accounts Office by mail or in person to defer the payments over the term. For this service, an administrative fee of $10 will be charged to cover the cost of the additional handling. Information on this plan will be included in the Financial Registration mailing prior to the opening of each term.





Financial Aids

Scholarships, 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 the states sponsor scholarship programs for residents, and information concerning eligibility is usually obtainable from the state capitals. The Federal Insured Student Loan Program is a broadly based, Federally guaranteed loan program administered by the several states. Local banks and leading institutions are usually able to answer initial inquiries concerning the availability of loans under the Program.



The Institute Financial Aid Office provides scholarships, loans, and employment on the basis of the financial need of the individual student, as determined by analysis of the Parents' Confidential Statement of personal finances. This form is submitted through the College Scholarship Service of the C. E. E. B. as part of the application procedure. In addition, an official 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 scholarship resources; applicants need not request aid from a specific fund. That portion of an applicant's need which results from travel costs, as fixed by the Committee, will be covered by scholarship funds. Need in addition to travel costs, not met by scholarship, may be offset by long-term loans or term-time employment.

Loan funds allow the student to pay part of the cost of his education on long-term credit under favorable financial terms. However, loan fund capital is limited, and loans are granted only on the basis of financial need as established by the Parents' Confidential Statement. Undergraduate loans are provided from a number of sources, including the National Direct Student Loan Program and the Institute's own Technology Loan Fund, which is closely linked with the Federal Insured Student Loan Program.

Students may be offered a choice between a loan and a job of equal dollar value as an 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 are also maintained. Students can earn from $600 to $800 per year from part-time work, depending 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 Parents' Confidential Statement (P. C. S.) must be submitted to the College Scholarship Service, designating M.I.T. as a recipient. The P. C. S. form 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. Both the application form and the P. C. S. must be submitted prior to January 10. An application for admission is not prejudiced by an application for aid. There is no reason for a person with the ambition to attend M.I.T. to be deterred from applying concurrently for admission and aid.



Upperclassmen

Most M.I.T. awards are on an annual basis, and recipients are asked to reapply in December or January each year for continued assistance in the following year. Upperclassmen who have not received prior assistance may make application at this time. Upperclass financial aid application forms are available from the Student Financial Aid Office about December 15; the re-application process calls for a copy of the most recent parental federal tax return.

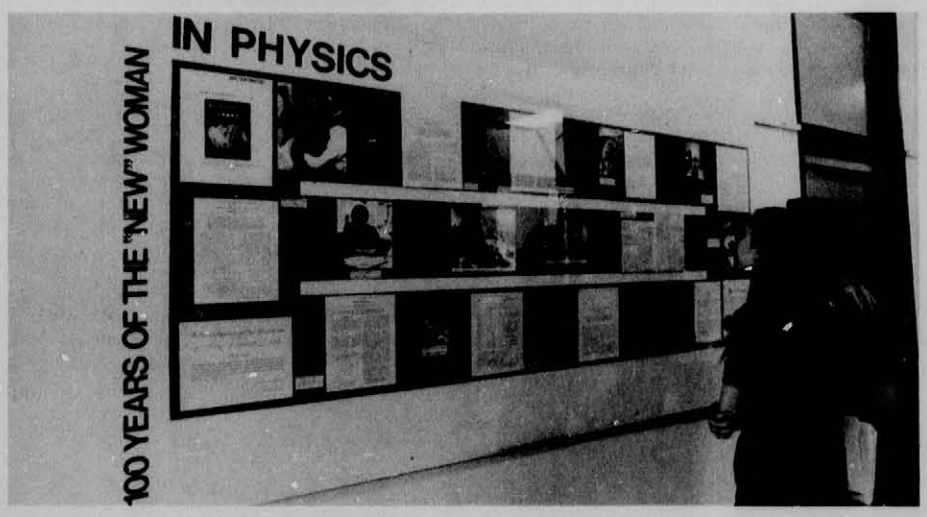
Foreign Students

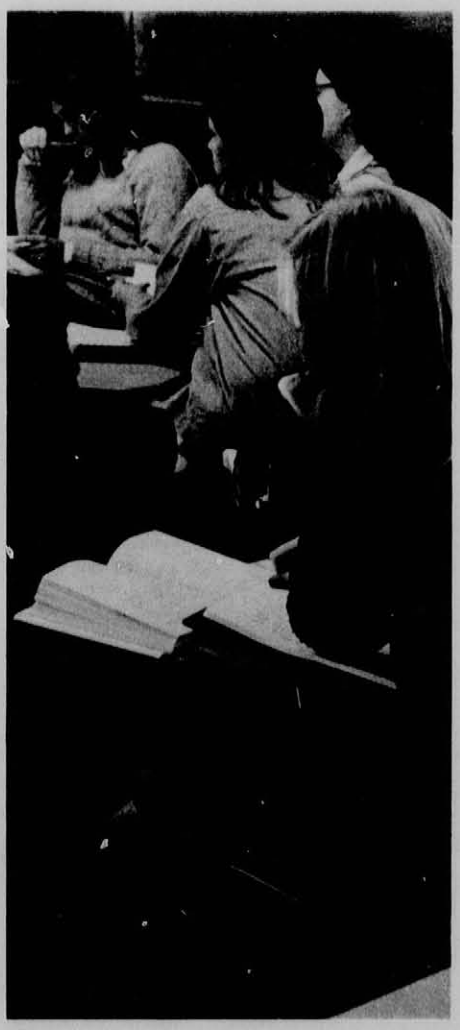
M.I.T. has small amounts of scholarship and loan funds which are made available to exceptionally well-qualified foreign students who can demonstrate financial need. Foreign students who wish to be considered for financial aid should complete and return the aid application included with their admissions material by February 10. Because our financial aid funds are quite 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. and for their entire stay in the United States before leaving their countries. Further information about the admission of foreign students is available from the Advisor to Foreign Students, M.I.T., Cambridge, Massachusetts 02139, U.S.A.

Transfer Students

Transfer applicants who wish to be considered for financial aid should request a Financial Aid Application and submit it, together with a Parent's Confidential Statement, to the Director of Student Financial Aid. Both forms must be submitted by April 15.







Scholarships for Undergraduates

The following is an alphabetical list of some of the funds from which scholarship awards are made. The figures in parentheses are the dates of establishment.

Frank W. and Carl S. Adams Memorial Fund (1955)
Established by Mr. and Mrs. Charles E. Adams, with The First National Bank of Boston as Trustee, and named in memory of their two sons as the Frank W. and Carl S. Adams Memorial Fund, this fund is used to assist needy and deserving students at M.I.T. A limited amount may also be available to assist an impecunious student who is unable to participate in recognized functions incident to graduation.

Alcoa Scholarships (1965 and 1968)
Two annual awards of $750, for needy and deserving undergraduate students in metallurgy and the information sciences.

Edwin E. Aldrin Jr. Scholarship Fund
A gift of the Class of 1917, this fund is restricted to undergraduates in the field of Aeronautics and Astronautics.

Max I. Alimansky ('28) Memorial Student Scholarship Fund (1973)
This scholarship fund was established by the friends of Max I. Alimansky ('28). The income from this memorial fund shall be used for qualified needy undergraduate students. Undergraduates from Pittsfield or from Berkshire County, Massachusetts, will be given first preference for scholarship aid.

Caroline Hadley Allen Fund
The income from this fund is to be used for purposes that the Institute may define, including financial aid.

Nils Anderson Scholarship (1961)
This scholarship, founded by a gift and added to by a bequest of Nils Anderson, Founder and Chairman of the Board of Debevoise-Anderson Company, Inc., is intended to assist promising students interested in entering the foundry industry.

William P. Anderson, Jr. Fund (1965)
The income only to be expended for such purposes as the Institute may from time to time, deem most appropriate, preference to be given to student financial aid.

Louie G. Applebee Fund (1942)
This bequest is "to be expended in assisting deserving students."

W. Cornell Appleton Scholarship Fund (1971)
This bequest of W. Cornell Appleton '01 established an endowment fund for scholarships with the income to be used to assist worthy students.

Association of Iron and Steel Engineers — Madsen Scholarship Fund (1966)
The income of this fund, established by the Association of Iron and Steel Engineers as a memorial to Ingvald Elias Madsen '33, is used to support one or more undergraduate students with preference given to those enrolled in the School of Engineering.

Athan Scholarship (1962)
This annual scholarship was established by D. J. Athan '54, for upperclassmen in the Department of Architecture. Demonstrated need and professional competence are the basic criteria for the grant. Selection and recommendations are based in part on nominations made by the Department of Architecture.

Elisha Atkins Fund (1894)
This fund, established by Mrs. Mary E. Atkins of Boston with a gift of $5,000, is used for undergraduate scholarships.

Hattie G. Atkins Fund (1962)
The income of this fund, established by the bequest of Mrs. Hattie G. Atkins in memory of her ancestor, Matthew Gannett, is used to provide not more than two annual grants "to worthy students."

Julian M. Avery Fund (1957)
Established by Julian M. Avery '18, this fund is designated for undergraduate scholarships in metallurgy.

Jason S. Bailey Fund (1952)
Established by the estate of Jason S. Bailey, this fund is used for undergraduate scholarships at the Institute.

Thomas Wendell Bailey Fund (1914)
The income from this bequest of Thomas Wendell Bailey is used to assist "needy students in the Department of Architecture."

Charles Tidd Baker Fund (1922)
One-half of the net income of this bequest from Charles Tidd Baker is "applied each year to the assistance of poor and worthy students."

Constance and Arthur H. Ballard Memorial Scholarship Fund (1969)
This fund, established by the bequest of Constance Ballard, is used for four-year undergraduate scholarships to students in electrical or mechanical engineering, physics, or chemistry. Recipients are selected on the basis of character, ability and demonstrated financial need.

Colonel Daniel Moore Bates Scholarship Fund (1973)
A fund established by John F. McCarty, in memory of Colonel Daniel Moore Bates, to provide scholarship assistance to students at the Institute.

Louis D. Beaumont Foundation Scholarships (1973)
This annual grant is to be used for needed scholarships to undergraduates in Aeronautics and Astronautics, with preference to students from St. Louis, Cleveland, Los Angeles and Denver.

John Rice Bell Memorial Scholarship (1961)
The income of this fund, established by Kenneth E. Bell '17, in memory of his brother, John Rice Bell, '11, is used to assist undergraduate students, preferably in chemical engineering.

Alf K. Berle Memorial Scholarship Fund (1960)
Income of this fund, established by his wife in memory of Alf K. Berle '27, is used to assist worthy and needy young men at M.I.T.

Billings Student Aid Fund (1900)
A bequest of $50,000 from Robert C. Billings founded the Billings Student Fund. "Any student receiving benefit from this fund is expected to abstain from the use of alcohol or tobacco in any of their varied forms."

Ernst Henri Birnbaum Memorial Fund (1964)
The income of this fund, established by bequest of Mr. David Bingham in memory of his son, is used for one or more scholarships for students in chemical engineering.

Huse Templeton Blanchard Fund (1946)
This bequest of Huse T. Blanchard '01 is for "the benefit of worthy boys of the State of New Hampshire."

Levi Boles Fund (1915)
The net income of this bequest from Frank W. Boles in memory of his father, Levi Boles, is "applied annually to the assistance of needy and deserving students."

Jonathan Bourne Fund (1915)
This bequest from Hannah B. Abbe constitutes a fund "known as the Jonathan Bourne Scholarship Fund, the income only to be used in aid of deserving students."

Albert G. Boyden Fund (1931)
This bequest from Elizabeth R. Stevens is a permanent fund, known as the Albert G. Boyden Fund, "income only to be awarded as scholarships to assist worthy and needy students, preference to be given to young men or women residents of the town of Swansea or the city of Fall River (Mass.)."

Bertram Brewer Scholarships (1952)
The income from this bequest under the will of Bertram Brewer is used "to provide annual scholarships for deserving undergraduates of good character and ability. . . ."

Hubert D. Broderic (1965)
The income of this fund, established by Stuart C. Broderic '47 and Mrs. Guyetta G. Custance in memory of Hubert D. Broderic, is used to provide scholarship assistance to worthy and needy students at M.I.T.; first preference is given to residents of Lexington, Massachusetts.

Harriet L. Brown Fund (1932)
This bequest of Harriet L. Brown is "to be held in trust as a scholarship . . . the income to be given to such needy and deserving young women desiring to become students at M.I.T., as would otherwise be unable to attend, and in case of two or more applicants of equal merit, preference shall be given to a native of either Massachusetts or New Hampshire."

Walter Stanley Brown Scholarship Fund (1968)
The income of this fund, established by the bequest of Maud M. Brown, is used for undergraduate scholarships, with preference for students from Vermont.

Willard B. Buck Scholarship Fund (1971)
The bequest of Willard B. Buck '07 for establishing a scholarship for student aid.

The John S. Buhler ('27) Memorial Scholarship Fund (1973)
The John S. Buhler Memorial Fund was established specifically to aid needy undergraduate students at M.I.T.

Denison K. Bullens Scholarship Fund (1958)
A gift of Denison K. Bullens '09, this fund is used to provide scholarships for needy and worthy undergraduates, with first preference to students in metallurgy.

Vannevar Bush Scholarship Fund (1960)
This fund, named in honor of Vannevar Bush '16, represents unrestricted gifts used for undergraduate scholarships.

Cabot Corporation Scholarships (1955)
The income of a fund established by the Cabot Foundation, Inc., provides scholarships for children (sons and daughters) of employees of the Cabot Corporation and its subsidiary and associated companies. Candidates are required to have certification of their eligibility for scholarship grants by first applying to the Personnel Office of the Cabot Corporation and are expected to comply with the usual policies governing the award of Institute Scholarships. In any year when there are no applicants admitted to the Institute included as children of employees of the Corporation, the income may be used for scholarships for other qualified applicants for admission to the Institute.

Godfrey L. Cabot Fund (1950)
Scholarships made possible by this gift are awarded with preference to students of chemistry or chemical engineering.

Thomas D. Cabot Scholarship Fund (1960)
Two-thirds of the income of this fund, established by Mr. and Mrs. Thomas D. Cabot, is used to assist worthy students with financial aid, and one-third is used for salaries for teachers.

Cambridge Scholarships (1916)
A limited number of scholarships are granted to students entering the first-year class at the Institute who are graduates of schools in Cambridge and children of legal residents of that city. These Cambridge Scholarships, which carry a stipend of full tuition, are confined to students who make application furnishing evidence of need. An award may be continued in the second, third, and fourth years upon annual reapplication, providing the holder maintains a satisfactory scholastic record and continues to furnish evidence of need.

William H. Carlisle, Jr. Scholarship Fund (1969)
The income from this bequest of William H. Carlisle, Jr. '28 to be used for undergraduate scholarships for students of good character and study habits and who exhibit promise and growth.

Mabel Blake Case Fund (1920)
This bequest from Caroline S. Freeman is "known as the Mabel Blake Case Fund, income to be used to aid deserving students (preferably women) who are in need of assistance."

Nino Tesher Catlin Fund (1926)
A gift from Maria T. Catlin established this fund in memory of her son, Nino T. Catlin '18, the income "to be awarded to needy and deserving students."

Francis Ward Chandler Memorial Fund (1969)
Established by H. Daland Chandler in memory of his father this fund is used to provide scholarship assistance to graduate or undergraduate students, with first preference being given to students in architecture.

Edward S. Chapin Scholarship Fund (1967)
Established by bequest of Marion Louise Chapin, with income to be used for scholarships for needy undergraduates.

Clapp and Poliak Scholarships (1966)
This annual gift of $20,000 from a fund established by Clapp and Poliak Inc., in honor of the Design Engineering Show Exhibitors, is for undergraduates in the field of design engineering, to provide awards up to full tuition and living expenses.

Lucius Clapp Fund (1905)
This gift from Lucius Clapp formed a fund "to aid worthy students who may not be able to complete their studies without help."

Clark Foundation Scholarships (1953)
This fund, established by the Edna McConnell Clark Foundation, provides scholarships for foreign students entering as freshmen, who would otherwise have insufficient means to allow them to matriculate.

J. Russell and Dorothy V. Clark Fund (1972)
Gift of J. Russell and Dorothy V. Clark '29, the income to assist graduate and undergraduate students in the Department of Aeronautics and Astronautics with a preference for scholarship assistance to undergraduate students.

Thomas L. Clark Memorial Scholarship (1956)
The income from this endowment, established in memory of Thomas Lynn Clark '59, by a number of his friends at M.I.T., is used to assist an entering freshman.

A. V. Clarke Fund (1950)
The proceeds of this gift by Mr. Clarke are "used for student aid at the discretion of the Financial Aid Office."

Class of 1887 Scholarship Fund (1967)
This fund was established by members of the M.I.T. Class of 1887. Its income is used for undergraduate scholarships.

Class of 1895 Scholarship Memorial Fund (1945)
This fund was given by the Class of 1895 on its fiftieth anniversary, "the income is annually to be used to provide scholarships for suitably qualified descendants of members of the Class of 1895. If in any year the total income is not required for this purpose, the balance shall be added to the Technology Loan Fund."

Class of 1906 Scholarship Fund (1967)
This fund was initiated by members of the M.I.T. Class of 1906. A portion of the interest is to be used for general purposes, with preference for scholarships.

Class of 1909 Memorial Fund (1957)
The income of this fund, initiated by gift from the widow of Carl W. Gram '09, and augmented by subsequent gifts in memory of Felix A. Burton, James H. Critchett, Benjamin W. Dow, Harold I. Eaton, Harry L. Havens, Reginald L. Jones, George A. Haynes, Helen Longworth Paul, William R. Reilly, and Clark S. Robinson, all members of this class, is used for scholarship aid, with first preference to descendants of members of the Class of 1909.

Class of 1910 Scholarship Fund (1967)
This fund was established by the members of the M.I.T. Class of 1910. The income is to be used for undergraduate scholarships.

Class of 1918 Memorial Scholarship Fund (1971)
This memorial from the Class of 1918 fiftieth year reunion fund establishes a class fund for an undergraduate scholarship.

Edwin E. Aldrin, Jr. Scholarship Fund
A gift of the Class of 1917, this fund is restricted to undergraduates in the field of aeronautics and astronautics.

Class of 1931 Compton Memorial Freshman Scholarship Fund (1956)
The income from this fund, established at the twenty-fifth reunion of the Class of 1931 as a memorial to Dr. Karl Taylor Compton, is used for freshman scholarships.

Class of 1932 Fund (1951)
The income from this fund, the twenty-five year gift of the Class, provides undergraduate scholarship grants.

Class of 1933 Fund (1958)
The income of this fund, a gift of the Class at its twenty-fifth reunion, is available for scholarship grants to undergraduates

Class of 1934 Fund (1959)
The income of this fund, an endowment by the Class as its twenty-five-year gift, provides awards known as the Karl T. Compton Scholarships.

Class of 1935 Memorial Scholarship Fund (1971)
The income from this fund, established by the Class of 1935, provides undergraduate scholarships.

Class of 1936 Scholarship Fund (1971)
The income from this fund established by the Class of 1936 is available for undergraduate scholarships without restriction.

Class of 1937 Scholarship Fund (1971)
The income from the Class of 1937 Scholarship fund is made available for deserving students.

Class of 1938 Scholarship Fund (1938)
The income of gifts from the Class of 1938 is used for scholarships, preference being given those applicants "who have shown their desire for an education by earning part of their expenses; and/or to those applicants who are descendants of the Class of 1938."

Fred L. and Florence L. Coburn Fund (1932)
The income of this bequest from Fred L. Coburn "shall be expended by the Trustees in giving aid and assistance to students of M.I.T. . . . preference being given by said Trustees to students residing in Somerville, Massachusetts."

Coffin Memorial Fund (1929)
This gift, from the executors of the estate of Charles A. Coffin — a bequest — carried out the wishes of Mr. Coffin. The fund is used for loans or other aid to students as determined by the Executive Committee of the Corporation.

W. A. Conant Scholarship Fund (1943)
This bequest was made "for the purpose of establishing a permanent fund to be known as the W. A. Conant Scholarship Fund, the income therefrom to be used for the education of native born American Protestant boys of New England of American Protestant parents, who are graduates of some high or preparatory school, public or private, in New England, preference to be given to the graduates of the public schools of Brookline, Massachusetts, but without limitation thereto, and whose parents are financially unable to send them to the Institute and whose own means are insufficient to allow them to attend the Institute."

Albert Conro Scholarship Fund (1943)
This bequest of Mary T. Conro, sister of Emma O. Conro '84, in memory of their uncle, is "for the purpose of establishing and maintaining a scholarship . . . to be known as the Albert Conro Scholarship." Awards are made to students in metallurgy.

The George R. Cooke Fund (1939)
Established by a gift in memory of George R. Cooke '08, the income of this fund is awarded preferably to a student in civil engineering or a related field. Consideration is given to those who have had experience through employment in a field before undertaking formal study; the recipient need not necessarily be a candidate for a degree. Grants will be based on character, achievement, need, and future promise.

Charles D. Coryell Memorial Scholarship Fund (1971)
Established by gifts in memory of Charles D. Croyell, Professor of Chemistry. This fund is for undergraduate scholarships in the Department of Chemistry.

John G. Crane Scholarships (1951)
This gift of J. G. Crane '90 is for undergraduate awards.

Allen S. Crocker Memorial Fund (1961)
The income of this fund, established as a memorial by the wife of Allen S. Crocker '97, is used to assist worthy and needy young men. Stipendiary awards will be according to demonstrated financial need up to a maximum of tuition in any one year. First preference in the selection is given to students domiciled in the Rochester, New York, area.

Lucretia Crocker Fund (1916)
By the will of Matilda H. Crocker, the Institute was made the residuary legatee of her estate "for the establishment of one or more scholarships for women in memory of my sister, Lucretia Crocker . . . the income to aid one or more young women in need of pecuniary assistance in obtaining instruction at said Institute."

Ernest J. Cronenbold Scholarship Fund (1974)
This fund, established as a memorial honoring Ernest J. Cronenbold ('03) by his sister, Evelyn M. Geidel, is used to provide scholarships for needy and worthy students at M.I.T.

Eunice McLellan Cruft Fund (1949)
This bequest of Eunice McLellan Cruft was made "to assist young men whose means are inadequate to pay their expenses at the Institute."

Ralph E. Curtis Scholarship (1960)
Income of this fund, established by gifts of the Curtis Universal Joint Company, Inc., is used to assist needy and worthy young men of Springfield, Massachusetts, to achieve their educational objectives at the Institute. Open to entering freshmen, initial preference is given to children and nephews and nieces of five-year employees of the Curtis Universal Joint Company, Inc. In the selection of awards for entering students, first preference is given to graduates of Springfield Technical High School; second preference to graduates of other Springfield high schools; and third preference to secondary school graduates resident in western Massachusetts.

Louis R. Damiano Memorial Scholarship Fund
This fund was established by Vincent Damiano in honor of his father. Scholarships are to be given to undergraduates chosen by the Institute.

Isaac W. Danforth Fund (1903)
This bequest from James H. Danforth for scholarship purposes was a memorial to his brother, Isaac Warren Danforth.

Tenney L. Davis Scholarship Fund (1967)
This fund, established in memory of Tenney L. Davis '13, is to be used in assisting students with need who show great ability in the study of chemistry.

Robert Taylor Dawes Scholarship Fund (1969)
The income of this fund, established by Mrs. Robert T. Dawes in honor of her husband, is used for scholarships for deserving and needy undergraduates.

The Delafield Memorial Fund (1960)
This fund was established by the parents of Benjamin T. Delafield '60 to be used to assist needy and deserving students at M.I.T. Preference is given to students from Pittsburgh or Sewickley, Pennsylvania.

Orville B. Denison Memorial Fund (1960)
The income of this fund, donated by the members of the Class of 1911 as a memorial to Orville B. Denison '11, is used to assist worthy and needy undergraduates at the Institute.

Carl Pullen Dennett Memorial Scholarship Funds (1956 and 1959)
Established by gifts in memory of Carl Pullen Dennett, these two funds provide awards for students in the School of Science, either graduate or undergraduate, who are deemed qualified by scholastic performance, intelligence, character, and promise. The annual selections are made by the Director of Financial Aid and the Dean for Student Affairs.

Marie G. Dennet Scholarship Fund (1963)
Established by gift of the Marie G. Dennett Foundation, this fund provides awards for students in the School of Science, either graduate or undergraduate, who are deemed qualified by scholastic performance, intelligence, character and promise. The annual selections are made by the Director of Student Aid and the Dean for Student Affairs.

Thomas C. Desmond Scholarship Fund (1960)
The income of this gift of Thomas C. Desmond '09 is awarded to deserving undergraduates at the Institute in accordance with the general policies of the Institute.

John H. Dessauer Scholarship Fund (1973)
The income from this fund will be used for scholarships for needy undergraduate students in Chemical Engineering upon recommendation by the Department.

Development Fund Scholarships (1950)
Scholarships provided by gifts to the M.I.T. Development Fund consist of grants to students who demonstrate need for financial assistance. They are open to all candidates from secondary schools.

Ann White Dickinson Fund (1968)
This bequest from Ann White Dickinson was made "to establish free scholarships in M.I.T. . . . such persons enjoying benefit . . . shall be worthy young men of American origin."

Frederick N. Dillon, Jr. Scholarship Fund (1968)
The net income of this fund, established by the will of Frederick N. Dillon, Jr. '22, is used for providing scholarships for undergraduate work to deserving students from Fitchburg, Massachusetts, and the immediate area.

Fred C. Dobbs Fund (1960)
The income of this fund, established in the name of Dr. F. C. Dobbs by his friends, is used to assist undergraduates to meet their expenses at the Institute. Selection is limited to citizens of the United States who have demonstrated a need for financial assistance and have given evidence of promise.

Dormitory Fund (1903)
This fund for scholarship purposes was raised by miscellaneous subscriptions; it was formerly known as Students' Aid Fund.

Philip B. Downing Trust
This bequest made in 1952 is available to a deserving student with financial need.

Charles Stark Draper Class of 1926 Scholarship Fund (1974)
This fund, established by the M.I.T. Class of 1926 as a tribute to their classmate, Charles Stark Draper, will provide assistance to needy students.

Henry C. Dresser Fund (1965)
Established from the bequest of Henry C. Dresser '92, the income is used for scholarships, preference being given to students residing in Southbridge, Massachusetts.

Thomas Messinger Drown Scholarships (1928)
A bequest from Mary Frances Drown was designated "to establish scholarships for deserving undergraduate students, to be known as the Thomas Messinger Drown Scholarships."

Charles Dyer Scholarship Fund (1968)
This fund was established by Ira Dyer '49, in memory of his father, Charles Dyer. The income is used for scholarships to undergraduates.

Daniel W. Edgerly Fund (1964)
The income of this fund, established by bequest of Daniel W. Edgerly '98, is used for the purpose of maintaining undergraduate scholarship aid for upperclassmen in the science departments, preferably in chemistry, physics, or biology.

Robert B. and Zsabel Ehrman Memorial Scholarship Fund (1970)
Income to be used for the "education of needy students majoring in science, who have demonstrated above average capabilities."

Calvin P. Eldred Memorial Scholarship Fund (1970)
This fund was established by bequest of Calvin P. Eldred for deserving and needy Protestant students.

Leola M. Farnham Scholarship Fund (1966)
Bequest for the purpose of supporting part tuition or full tuition for undergraduate students in the field of science.

Farnsworth Fund (1889)
This fund was founded by Mrs. Mary E. Atkins of Boston, the income to be used for scholarship purposes.

Alton J. Farrel, Jr. Scholarship Fund (1967)
Income from this fund is used to provide scholarships to students with need who are residents of Ansonia, Connecticut, or its vicinity or to other residents of the state of Connecticut.

Francis Edwin Faxon Scholarship Fund (1967)
The income from this fund, established by the Charlotte F. Faxon Trust, is used to provide scholarship aid to male undergraduates.

Charles Lewis Flint Fund (1889)
This bequest from Charles L. Flint is for the "support of some worthy student, preference to be given to some graduate of the English High School, Boston."

Sarah S. Forbes Fund (1913)
Originally given in trust in 1868 by Sarah S. Forbes to William Barton Rogers and Henry S. Russell, trustees, this fund was transferred in 1913 to the Institute "for the maintenance and education of a scholar in M.I.T."

Clara and F. Joseph Ford Scholarship (1951)
The income of a fund established by Mr. and Mrs. Joseph F. Ford is awarded "to worthy and well-qualified students who have demonstrated a democratic and tolerant spirit and who are well disposed toward people of all creeds and races."

Foundry Educational Foundation Scholarships (1947)
Established by the Foundry Educational Foundation, which represents the American Foundrymen's Association, the Gray Iron Founders' Society and the Malleable Founders' Society, and the Foundry Equipment Manufacturers Association, these awards are open to third- and fourth-year students in management, mechanical engineering, and metallurgy.

Arthur E. Fowle Fund (1956)
The income of this fund established under the will of Arthur E. Fowle '93 to be used for undergraduate scholarships.

Evert W. Freeman Scholarship Fund (1956)
The income of this fund, established by bequest of Evert W. Freeman '20, "shall be awarded annually to a student . . . who shows promise of substantial accomplishment but is in financial need."

Philip Jacob Friedlander Fund (1945)
This fund was the gift of Israel Friedlander "in appreciation of the opportunity my son, Philip Jacob Friedlander, had of spending little more than a year at M.I.T. before enlisting in the United States Naval Reserve . . . the income to be used with the income from other such funds for the purpose of helping qualified students at M.I.T. regardless of race, creed, or color, or geographical origin, who may be in need of financial assistance . . ."

Jurgis J. Geguzis Fund (1957)
Established under the will of the late Jurgis J. Geguzis, this fund is to be used for tuition and expenses for a student of Lithuanian parentage. The recipient is selected by the Institute upon the condition that he shall repay the amount of his award "when and if able so that other students may be granted the same benefits and privileges in the future."

General Motors Scholarships (1955)
These four-year grants, established under the General Motors College Scholarship Plan, are open to citizens of the United States and are intended for individuals who give evidence of potential leadership. Awards are made to entering first-year students. Stipends will be fixed on the basis of demonstrated need.

Norman H. George Fund (1919)
This bequest of Norman H. George is "to be used for the assistance of needy and worthy students in obtaining an education in M.I.T."

Arthur B. Gilmore Fund (1941)
This bequest from Arthur B. Gilmore is ". . . for the purpose of assisting needy students who shall be members of the Beta Theta Pi fraternity . . . said net income to be divided among not more than two students in any one year."

James R. Glazebrook Fund (1959)
The income of this fund is to be used to assist needy and worthy undergraduates at the Institute.

Ethel A. Gleason Memorial Scholarship (1963)
The income of this fund, established as a memorial to Ethel A. Gleason '01 by her nephew, Dr. Anthony H. Gleason, is used to assist worthy and needy undergraduates.

Goodyear Scholarship (1957)
A stipend of $1,500 made available by the Goodyear Tire & Rubber Company Fund is granted to a male U.S. citizen majoring in chemical engineering in his junior or senior year. Awards will be made on the basis of academic standing, character, and leadership qualities, and financial need.

Barnett D. Gordon Fund (1942)
The income from this fund, established by a gift from Barnett D. Gordon '16, is to be used "as scholarships for deserving students at M.I.T."

John H. Gregory Fund (1963)
The income of this fund, established by bequest of Sarah James Gregory in memory of her husband, John H. Gregory '95, is used to provide scholarships for juniors and seniors in civil engineering.

John A. Grimmons Fund (1952)
This fund was established by the estate of Katie M. A. Grimmons in memory of her son, John A. Grimmons '21. The income is to be used for scholarships for students . . . with preference to those in the Department of Electrical Engineering.

Robert G. Gross — Lockheed Aircraft Corporation Scholarships (1963)
The income of this fund, established by the Lockheed Aircraft Corporation to perpetuate the memory of Robert E. Gross, founder and principal officer of the Corporation for many years, is available to citizens of the United States who are studying in science, engineering or other fields applicable to the aerospace, electronics, marine, manufacturing, and construction industries.

Rita Welch Gruber Memorial Scholarship (1961)
The income of this Memorial Fund, established by the gift of Rudolf E. Gruber '16, is used to assist undergraduate foreign students to pursue a course of study at the Institute. Grants are available to foreign students in all departments of the Institute, and there are no limitations in fields of study. In its selection the Committee gives first preference to students who are nationals and residents of Germany, Italy, or France.

Gulf and South America Steamship Company Fund (1953)
Fund established by Gulf and South American Steamship Company from which scholarship grants may be made upon initiative of the Department of Naval Architecture and Marine Engineering. Preference is given to students in the Course in Shipping and Shipbuilding Management (Course XIII-B).

William T. Haebler Memorial Scholarship (1960)
This fund was established by his daughter in memory of her father, William T. Haebler '22. The income is used to assist worthy and needy students who are undergraduates and are citizens of the United States.

Humphrey M. Haley Scholarship Fund (1958)
This bequest of Humphrey M. Haley '04, is held in trust and the income used as scholarship aid to one or more deserving students, with first preference to students residing in the St. James Parish in Salem, Massachusetts.

Lucia G. Hall Scholarships (1945)
The income from this bequest of Louise K. Gunn, to "be known as 'the Lucia G. Hall Scholarships' . . . is to be used for the aid of worthy students."

Hall-Mercer Scholarship Fund (1940)
The income from this bequest of Alexander G. Mercer is to be used "for the benefit of such poor students as have passed through some of the public schools with the best reputation for character and ability."

Claire Morton Prince Hanks Fund (1966)
This fund, established by bequest of Claire Morton Prince Hanks, is to be used for "such purpose connected with financial aid as the Executive Committee may deem appropriate." Awards from this fund are made to undergraduate students who are citizens of the U.S.

Harrington Scholarship Fund (1961)
The income of this fund, established by Joseph Harrington, Jr. '30, in commemoration of his father, Joseph Harrington '96, is used for student aid purposes.

James H. Haste Fund (1930)
This bequest of James H. Haste '96 is "for the aid of deserving students . . . of insufficient means."

Charles Hayden Memorial Scholarships (1939)
Established through a grant from the Charles Hayden Foundation, these scholarship awards are in memory of the late Charles Hayden, graduate of the English High School Class of 1886 and of the M.I.T. Class of 1890.

Delos G. Haynes Scholarship Fund (1970)
Established by bequest of Emma P. Haynes, this fund provides scholarships for "outstanding students who deserve and need assistance, with a preference for men from the city and county of St. Louis."

Joseph Hewett '96 Fund (1965)
Established from the bequest of Joseph Hewett '96, the income from this fund is used in maintaining scholarships at M.I.T.; preference is given to students from the public schools of Brockton, Massachusetts.

Robert B. Hildebrand Scholarships (1974)
The Robert B. Hildebrand ('45) scholarships were established to assist deserving and needy students at M.I.T.

Bancroft Hill Memorial Fund (1957)
This fund was established by Frances G. Hill in memory of her husband, Bancroft Hill '11. The income is used for scholarship assistance to students in civil engineering who are in need of financial help.

Clifford E. Hoar Scholarship Fund (1972)
The Clifford E. Hoar Fund, established by his brother, Charles S. Hoar, provides financial assistance to needy M.I.T. students.

Eric Hodgins Memorial Scholarship Fund (1972)
This scholarship fund was endowed by Time, Inc. as a tribute to Eric Hodgins '22, the income to be used in supporting undergraduate students.

George Hollingsworth Scholarship (1916)
A bequest from Rose Hollingsworth founded the George Hollingsworth Scholarship.

Loren C. Holm Scholarship Fund (1950)
Established by Marie Holm in memory of her father, this fund is designated for worthy and needy students.

James T. and Esther Roen Holmes Scholarship Fund (1974)
The income from the James T. and Esther Roen Holmes trust is to be used to help needy M.I.T. students who are permanent residents of Southern California, who show high scholastic and leadership potential.

Theodore V. Houser Scholarship Fund (1956) Fund (1956)
The fund, established by gifts of Theodore V. Houser, is used for scholarship purposes.

Elias Howe, Jr., Scholarships (1949)
The income from a fund established under the will of Julia Howe Stockwell Smith "shall be available for aiding such students and in such amounts as shall be recommended by the Faculty."

Dr. and Mrs. Chiao-Yue (nee Yueh-Gin Gung) Hu Scholarship (1970)
Established by the gift of Dr. and Mrs. Chiao-Yue (nee Yueh-Gin Gung) Hu in honor of their beloved son, Robert Hsueh-Ko Hu '65, who graduated with high honors and was elected as an Associate Member of the Society of Sigma Xi at the time of his graduation. The stipend of this scholarship shall be awarded annually to needy undergraduate students of Chinese ancestry, restricted to students majoring in mathematics, physics, chemistry, or any branch of engineering in that order.

Huguenot Society of America Scholarship (1962)
This annual Grant of $1,000 for an M.I.T. undergraduate is provided by the Huguenot Society of America. Applicants must be certified by the Huguenot Society of America as descendants of a Huguenot who came into the territory (now United States) prior to November 28, 1787. The financial Aid Office will make a selection from certified and qualified applicants.

Hunt Scholarship Fund (1971)
An endowment for scholarships established under a grant by the trustees of the Roy A. Hunt Foundation in honor of Alcoa presidents who have been graduated from M.I.T. Preference is given to students in metallurgy.

Samuel Samuel P. Hunt Fund (1945)
This gift of Samuel P. Hunt '95 was designated for scholarship purposes.

T. Sterry Hunt Scholarship (1894)
A bequest from T. Sterry Hunt, for seven years Professor of Geology at M.I.T., was designated to found a scholarship in his name. The award is restricted to students in chemistry, and preference is given to those in the higher years.

William F. Huntington Fund (1892)
From Susan E. Covell the Institute received a gift to constitute a fund in memory of William F. Huntington '75, the "income to apply to payments of tuition of needy and deserving students . . . preference to be given to students in civil engineering."

Cuthbert Hurd Scholarship Fund (1968)
The income of this fund established by Cuthbert Hurd, is used for scholarships to students in the mathematical sciences.

Charles L. Ireson Scholarship Fund (1959)
Income of this fund, established by the will of Jennie E. Ireson, is devoted to the education of worthy students who may require financial assistance.

Jackson Charitable Foundation Scholarship (1971)
This contribution from the Jackson Charitable Foundation to be used in the support of undergraduate student aid at M.I.T.

Jakobson Scholarship (1951)
Established by Jakobson Shipyard, Inc., this annual freshman scholarship carries a grant of $1,000. First preference is given to a son of an employee of Jakobson Shipyard, Inc.; second preference is to graduates of the following New York high schools: Glen Cove, Huntington, Manhasset, Oyster Bay, Port Washington, Roslyn, Sea Cliff; and third preference is to secondary school graduates who reside on Long Island, excepting the counties of Kings or Queens.

David L. Jewell Fund (1928)
The income from this bequest from Colonel David L. Jewell is "to be used to pay part of the tuition charges for five young men who may be selected by the President or Board of Trustees of the Institute as worthy of assistance, and who, were it not for such assistance, might be unable to pursue their studies at such Institute."

Edward A. Jones Scholarship Fund (1947)
A bequest from Edward A. Jones was designated to be used for the establishment and maintenance of one or more scholarships."

Joy Scholarship (1886)
Established by the gift of Nabby Joy, this scholarship was created pursuant to a decree of the Supreme Judicial Court of Massachusetts for the benefit of "one or more women studying Natural Science at M.I.T."

Henri P. Junod ('21) Memorial Scholarship Fund (1974)
The income of this fund, given in memory of Henri P. Junod by his fellow trustees of the Elizabeth Ring Mather and William Givinn Mather Fund, is to be used to provide undergraduate scholarships with preference for students from Cleveland, Ohio.

Sarah Maude Kaemmerling Fund (1952)
This fund was established by a gift in 1952 and subsequently added to by a testamentary bequest in 1959. The income is used for scholarships or some alternate form of student aid.

William R. Kales Scholarship Fund (1953)
This fund, endowed by a gift of the Whitehead and Kales Company for scholarship purposes, provides income to assist worthy and needy undergraduates.

Kalker Scholarship Fund (1969)
In memory of Abraham and Ida Kalker "for the purpose of aiding and assisting needy and deserving students of high scholastic standing."

Walter R. and Nellie J. Kattelle Scholarship Fund (1972)
This bequest by Walter R. Katelle '00 provides for scholarship grants to undergraduates of M.I.T. with preference for needy students in the Architectural Group of Studies.

Henry Donald Kemp Fund (1964)
The income of this fund is to be used to provide scholarship aid to students in the Department of Electrical Engineering.

Bo Kwang Kim Scholarship Fund (1957)
Established under the will of Bo Kwang Kim, this scholarship is for students of complete Korean Ancestry. It is open to any deserving and needy Korean students. An award of $500 is made only when the income of the Fund permits.

Robert M. Kimball '33 Memorial Scholarship (1964)
This fund has beer established by the Class of 1933 as a memorial to Robert M. Kimball '33. Awards are made to students with established need, and preference, whenever possible, is given to descendents of the Class of 1933.

Amelia S. Kniesner Scholarship Fund (1944)
Gift of William T. Kniesner '16 and his sisters, the income is used "to provide scholarship aid to meritorious or needy students, either entering freshmen or undergraduate students of the Institute, preference to be given to graduates of the high school or high schools of Danbury, Connecticut."

Kurrelmeyer Fund (1947)
This fund was raised by contributions by alumni "for an undergraduate scholarship award to a needy student."

George J. Leness Scholarship Fund (1969)
The income from this fund is used to aid needy and worthy undergraduate students of the Institute in good standing who take an active part in intercollegiate athletics.

Teh Ching Li Memorial Scholarship Fund (1971)
The income of this fund, established by Y. T. Li scholarship fund for undergraduates in memory of Teh Ching Li '37.

Y. T. Li Fund (1959)
The income of this fund, established by Y. T. Li '38, is used to assist a worthy and needy student enrolled in the Department of Aeronautics and Astronautics; second preference is given to a student of Chinese origin.

Jacob and Jennie Lichter Fund (1949)
This scholarship fund is "for the aid of students who shall satisfy all entrance requirements of the Institute and be endorsed as to character and personality."

Gustaf Robert Lindberg Fund (1957)
This fund was established by Otto C. Lindberg, President of the General Drafting Company, to create the Gustaf Robert Lindberg Scholarships. The income is used for scholarships "that shall provide tuition, board and other necessary expenses preferably to one or more students who are citizens and residents of . . . Finland; second preference to citizens and residents of Sweden. If no worthy candidates from either Finland or Sweden, the scholarships may be awarded to the best qualified candidates who are citizens of the United States preferably of Finnish or Swedish extraction."

Paul Weeks Litchfield Scholarship (1954)
Established in honor of Paul W. Litchfield '96, this scholarship fund aids worthy and needy students at the Institute. Preference in selection is given to those students who have been members of the Boy Scouts of America.

William Litchfield Scholarship (1910)
A bequest from William Litchfield established "a single scholarship . . . known as William Litchfield Scholarship, income to be awarded and paid annually to such students in said Institute as may . . . be determined by the President of said Institute to be entitled thereto for excellence in scholarship and conduct.

Littman Foundation Scholarship (1960)
This four-year grant, supplied by the Littmann Foundation, is available to a male student desiring, preferably, to pursue a course of study either in engineering or management as related ultimately to manufacturing. First preference in the selection is given to a well-qualified secondary-school graduate, resident either in the general area of St. Louis, Missouri, or Charles City, Iowa. The amount of the award is based on demonstrated need.

Charles E. Locke Memorial Fund (1923)
Preference in making awards from this fund, which was established by the Class of 1896, is given to descendants of members of the Class of 1896, including freshman.

Richard W. Lodge Fund (1955)
The income of this fund, established by the will of Mary L. Lodge in memory of Richard W. Lodge '79, is used for worthy and needy students.

Sheridan A. Logan Fund (1964)
A gift of Sheridan A. Logan, the income and principal used as required to provide scholarships to outstanding young men coming from the St. Joseph, Missouri, area.

Elisha T. Loring Fund (1890)
This bequest from Elisha Thacker Loring is for "the assistance of needy and deserving pupils."

George J. Loveley Scholarship Fund (1960)
The income of this fund is used to assist needy students, with preference to sons of widows, whose fathers were native born citizens of Massachusetts, preferably of Boston and vicinity.

Percival Lowell Scholarships (1955)
The income of this gift is used for scholarships awarded from time to time at the discretion of the President of the Massachusetts Institute of Technology to students in astronomy, physics, and mathematics.

Loyal League Scholarships (1959)
Three $1,000 scholarships established by the Loyal League Philanthropies, Inc., are available to entering freshmen, graduates of public secondary schools in the Greater New York Metropolitan Area, who have demonstrated academic excellence and great financial need.

Samuel E. Lunden Leadership Grant (1968)
From a fund established at the Institute by Samuel E. Lunden '21, a grant is made annually to an entering freshman who evidences the potential of becoming a leader in the affairs of the nation. Recipients are selected primarily on the basis of high personal promise of leadership qualities. First preference goes to applicants from the territory of the M.I.T. Club of California, second to applicants from the western region of the U.S. Recipients must be U.S. citizens.

Eugene and Margaret McDermott Scholarship Fund (1960)
The income of this fund, established by Mr. and Mrs. McDermott, is used for four-year scholarship grants for superior students. First preference is given to students resident in Texas, Arizona, New Mexico, and Oklahoma, desiring to study in the earth sciences or related fields.

Frederick F. Mackentepe Scholarship Fund (1970)
A fund established by request of F. F. Mackentepe '14, the income of which is to be used for undergraduate scholarships.

Alice Maclaurin Scholarship (1951)
Gifts created a scholarship in memory of Mrs. Richard C. Maclaurin.

Georgia Lamar Malone Scholarship (1961)
Income from this fund, established as a memorial to his mother by Charles B. Malone, Jr. '15, is used for scholarships for undergraduates, with first preference to students from Georgia or the Deep South.

Theodore A. Mangelsdorf Fund (1961)
The income of this fund, established by gift of the Brookdale Foundation, is used to provide undergraduate scholarships.

Francisco Marcucella Fund (1953)
This gift of Francisco Marcucella '27 was designated for undergraduate scholarship purposes.

Rupert Anderson Marden Fund (1933)
This fund was established by an anonymous gift "toward a memorial to be known as the Rupert Anderson Marden Scholarship Fund, income available annually to aid a worthy student at M.I.T. — Protestant and of American Origin — preference to a student taking the Cooperative Course in Electrical Engineering."

Martin-Marietta Foundation Scholarship Fund (1954)
This fund of $25,000 functions as an endowment to provide scholarships for students majoring in fields identified with the operations of the Aerospace Group of the Martin-Marietta Corporation. Students from the Baltimore, Maryland, Washington, D.C., Denver, Colorado, Orlando-Canaveral, Florida, and Vandenberg, California, areas are eligible.

Waldo A. Martin Scholarship Fund (1950)
This fund was established by Eleanor P. Martin in memory of her brother, Waldo A. Martin '90. Until 1975 first preference in awards is to be given to male friends or relatives of Waldo A. Martin and the donor, and second preference to graduates of Milton High School, Milton Academy, or a resident of Milton. Awards are for the freshman year only, on the basis of character, integrity, and ability.

Margaret A. Matthews Fund (1947)
The income of this bequest from Margaret A. Matthews is "for the benefit of such of the women students at M.I.T. who intend to become teachers."

Thomas Mayor Fund (1963)
The income from this fund is for scholarships to aid worthy and needy young men who are citizens of the United States, with preference given to those of the Protestant Christian faith and of English or Scottish descent.

George J. Mead Prize Scholarships (1951)
This bequest of George J. Mead '16 established prize scholarships in aircraft propulsion open to juniors, seniors, and graduate students in this field. Consideration is also given to candidates from related engineering fields as applied to aircraft propulsion.

Charles E. Merrill Scholarship Fund (1955)
The gift of Charles E. Merrill, this fund is for "students having financial need . . . who have demonstrated through personality traits, initiative, or by scholastic achievement that they will become substantial democratic citizens." One-half the income is used to meet the overhead expense of the Institute.

Arthur Merkel Miller Fund (1960)
Income of this fund, established by the will of Arthur Merkel Miller '17, is to provide scholarship assistance to worthy students.

Robert W. Milne Fund (1943)
This bequest was made as "an endowment fund under the title of 'The Robert W. Milne Fund,' the income thereof to be used and applied for the assistance of worthy and needy students in obtaining an education in said Institute."

Joseph R. Minevitch Memorial Scholarship Fund (1957)
This bequest of Joseph R. Minevitch '16, in the name of his mother, Fannie Minevitch, and his brother, Borrah Minevitch, is to assist deserving young men or women with first preference to graduates of the Boston English High School, second preference to graduates of any Boston public high school, and third preference to graduates of any other public high school in the United States.

Li Ming Scholarship Fund (1969)
Income from this fund, established by bequest of Li Ming, is used for scholarships to undergraduates, preference being given to students of Chinese birth, descent, or nationality.

James H. Mirrlees Fund (1886)
This gift from James Buchanan Mirrlees of Glasgow, Scotland, constituted a scholarship in memory of his son, James Henry Mirrlees, who died in 1886 while attending the Institute. The income is awarded to the "student in the third or fourth year of the Mechanical Engineering Course most deserving pecuniary assistance."

M.I.T. Alumni Fund National Scholarships (1957)
These scholarships are funded by gifts specifically designated by Alumni for undergraduate scholarships. Grants are made to outstanding freshmen on the basis of demonstrated financial need, and continued awards depend upon achievement as well as need for assistance.

M.I.T. Boston Stein Club — New England and National Scholarship Funds (1955)
The income of these funds is granted to qualified applicants for the freshman year only. One or more awards are available to New England residents as well as to residents of other parts of the United States. There are no restrictions as to sex, religion, race, or color.

M.I.T. Club of Chicago Scholarship Fund (1944)
This fund was initiated by Harold B. Harvey '05 "to establish scholarships to be known as the Technology Club of Chicago Scholarship Fund," the awards to be made by a committee composed of the Honorary Secretaries of the Chicago area and the Director of Financial Aid, and restricted to students who reside in the area of the club membership.

M.I.T. Club of Rochester Scholarship Fund (1968)
This fund was established by the M.I.T. Club of Rochester — income is used for scholarships to undergraduates, with preference given to students from Rochester, New York.

Morningstar Scholarship (1953)
This undergraduate scholarship gives first preference to students in the Department of physics. Grants are equivalent to one term's tuition and are continued to a recipient for the entire undergraduate period.

Fred W. Morrill Scholarship Fund (1941)
The income from this bequest of Hattie B. Morrill is to be used "for the purpose of providing financial assistance to some student or students at the discretion of the Trustees of said Institute . . ."

Maude Phipps Morrissey Fund (1972)
The income from this bequest from Maude Phipps Morrissey to be used for scholarships for deserving students.

Frederick Taft Moses Scholarship Fund (1959)
This scholarship provides four-year awards ranging from $200 to $2,000 annually, and is offered to young people of superior talent and promise.

Floyd A. Naramore Memorial Scholarship Fund (1972)
This bequest of Floyd A. Naramore '07, is established to provide a scholarship or scholarships for undergraduate students in the field of Architecture.

Gertrude B. Newman Scholarship (1952)
This bequest from the estate of Mrs. Gertrude B. Newman is to aid worthy and deserving students.

Niarchos Scholarship (1956)
Established by Starvos S. Niarchos as a memorial for merchant mariners who gave their lives during World War II, these grants provide opportunities for higher education to the sons of merchant seamen. The awards are based upon demonstrated need and achievement in secondary school experience. In the selection of candidates, first preference is given to sons of merchant seamen and ships' officers who lost their lives in the line of duty during wartime. In other cases, candidates' fathers must be regularly employed in a seagoing capacity or, if deceased, so last employed. These awards are not limited to courses in marine engineering and naval architecture, but consideration may be given to the desire of qualified candidates to pursue careers in these fields.

Nichols Scholarship (1895)
This bequest from Mrs. Betsy F. W. Nichols constitutes the Nichols Scholarship in memory of her son, William Ripley Nichols '69, for sixteen years Professor of General Chemistry at the Institute. Preference is given to students in the Course in Chemistry.

Charles C. Nichols Scholarship (1904)
This bequest from Charles C. Nichols constitutes a scholarship fund.

Hart and Arthur Nichols Scholarship Fund (1966)
This fund, established by gifts from W. Hart Nichols '27 and Arthur A. Nichols '28, is used for undergraduate scholarships.

William E. Nickerson Scholarship Fund (1949)
The income from this fund, established by the Nickerson Trust, is used for a scholarship for a worthy student.

Howard A. Noble '97 Scholarships (1956)
The income of a fund established under the will of Catherine B. Noble and enriched by the bequest of Howard A. Noble, is used to maintain scholarships in engineering.

John Felt Osgood Scholarship (1909)
This bequest was made by Elizabeth P. Osgood "to establish and maintain a scholarship in electricity in memory of my hustand, John Felt Osgood."

Louise Parks Knight and Charles F. Parks Memorial Fund (1952)
Established as a memorial to Louise Parks Knight and her father, Charles F. Parks '75, this fund is "used for the aid of poor but worthy students who have already entered upon a course of study but are unable to finish owing to lack of funds."

George L. Parmelee Fund (1921)
This bequest from George L. Parmelee of "one third of my property and estate" specified that "interest thereof be used for tuition by worthy students, either special or regular, according to the direction of the Faculty."

Frank E. and Seba B. Payne Foundation Scholarship Fund (1962)
A gift of the Frank E. and Seba B. Payne Foundation is used for scholarships in the School of Engineering.

Langdon Pearse Memorial Scholarship (1958)
This fund was established by gift of Mrs. Langdon Pearse in memory of Langdon Pearse '01. Income from the fund is used toward the tuition of students in the field of sanitary engineering, with second preference to undergraduate students in the field of civil engineering.

Frank Stetson Pecker Fund (1947)
This fund was established by the wills of Frank Stetson Pecker and Annie J. Pecker for scholarships.

Richard Perkins Fund (1887)
The income from half of this bequest from Richard Perkins is available for the "support of free scholarships in said Institute."

Malcolm Oliver Petri Memorial Fund
The income from this fund is "to be used for the benefit of worthy students in need of financial assistance."

St. Elmo Tower Piza Memorial Fund (1962)
The income of this fund, a bequest of Margaret Piza Crane established in memory of her brother, St. Elmo Tower Piza '15, provides for "tuition or expenses of man or woman student in any of the five years of the Course in Architecture." The grants are awarded on the basis of scholarly achievement, demonstrated qualities of leadership, and financial need, but entirely without regard to race, color, or creed.

Charles H. and Helen Bartlett Pray Fund (1950)
Established under the wills of Charles H. and Helen Bartlett Pray, this fund provides "for scholarships for needy young men."

Florence E. Prince Fund (1943)
This bequest of Florence E. Prince is "for the aid of worthy students who may need assistance in the matter of maintenance and living expenses while pursuing their studies."

William W. Quarles Memorial Scholarship (1971)
This bequest of Catherine T. Madigan provides scholarships in memory of her late husband William W. Quarles '24.

Walter R. Ramsaur Scholarship Fund
This fund was established by the Garrett Corporation in honor of Walter R. Ramsaur '28, Executive Vice President of the Corporation. An annual gift of $4,000 provides four-year undergraduate scholarships to students intending to study mechanical or aerospace engineering. Walter R. Ramsaur Scholars will be selected on the basis of their personal and academic credentials, and their awards will be administered in accordance with the established policies governing student aid at M.I.T.

George H. Rand Scholarship (1958)
The income of this fund, established by a bequest of the estate of George H. Rand, provides scholarships for deserving undergraduate students.

Thomas Adelbert Read Scholarship (1934)
This bequest from Julia A. Read was designated "to establish the Thomas Adelbert Read Scholarship, in memory of my late brother of that name; the income of said fund to be awarded to some worthy and needy student of that institution, preferably to a resident of Fall River . . ."

Willis Ward Reeves, Jr. Fund (1945)
Established by Mr. and Mrs. Willis Ward Reeves of Hazard, Kentucky, "as a memorial to their son, Willis Ward Reeves, Jr. '46, late Lieutenant U.S. Army Air Forces, killed in action over France during World War II . . . the income to be used for scholarship aid to deserving undergraduate students, with preference to those from Kentucky."

Arthur Reid Memorial Scholarship (1966)
This fund is available to qualified needy students from the Avon, Massachusetts, community and was established by the Institute as a Memorial to Arthur Reid, who passed away while employed at M.I.T.'s Laboratory for Nuclear Science, assisting with frontier developments in High Energy Physics.

Charles A. Richards Fund (1939)
This bequest is "known as the Charles A. Richards Fund . . . The income only for assistance of poor Protestant students in the Institute."

Frederick L. Richards Memorial Fund (1960)
The income of this fund, established as a memorial to Frederick L. Richards '95 by his sister, is used to provide scholarship assistance to undergraduate students in chemistry, chemical engineering, or other curricula based on chemistry.

I. D. Richheimer Memorial Scholarship (1961)
The income of this fund, bequeathed as a memorial by Rose N. Rich is used for scholarships to worthy students.

John Roach Scholarship Fund (1937)
This bequest from Emeline Roach constitutes a fund "to be known as the John Roach Scholarship Fund, the income to be used to provide an annual scholarship to a needy and deserving student pursuing the course in Naval Architecture and Marine Engineering."

Karl Robbins Scholarship (1951)
First preference for this scholarship, a gift of the Robbins Foundation, is for either a graduate or undergraduate in textile technology; second preference is to a student in mechanical engineering.

Willard F. Rockwell Scholarship Fund (1961)
The income of this fund, established in honor of Willard F. Rockwell '08, is used to assist needy and worthy undergraduates.

Gilbert M. Roddy Scholarship Fund (1974)
Awards from this fund, established as a memorial tribute to Gilbert M. Roddy, life member of the M.I.T. Corporation, will be made annually to students in financial need.

William Barton Rogers Scholarships (1947)
A limited number of four-year grants established in honor of William Barton Rogers, founder of the Institute, enable young men of superior ability and future promise but of limited financial means to pursue an education in engineering, science, or architecture. Stipends are awarded according to demonstrated need. These scholarships are open to all freshmen with no restriction of geographical location.

William P. Ryan Memorial Fund (1935)
The income from this fund, established by friends of the late Professor William P. Ryan '18, is used for scholarship aid (graduate or undergraduate) in chemical engineering, the award to be made on recommendation of the Head of the Department of Chemical Engineering.

John P. Schenkl Fund (1922)
This bequest from Johanna Pauline Schenkl is "to be held in trust to establish one or more scholarships in the Department of Mechanical Engineering" in memory of her father, John P. Schenkl.

George Scher Fund (1949)
This gift of George Scher established a fund to be used for scholarship purposes.

Anna and David C. Schilling Scholarship Fund (1970)
This fund was established by bequest of David C. Schilling. Its income is used to provide first-year scholarships for needy students of high scholarship and character.

William E. Schrafft Charitable Fund
An annual gift of $3000 provides scholarships to needy students of good social and academic standing.

Science Scholarship (1956)
Donated by Friends of M.I.T., this scholarship is designed to assist a needy and promising student in the field of science after the completion of his freshman year. The award is made to citizens of the United States.

Science Teaching Scholarships (1955)
Established by the Institute to encourage young people who wish to follow a career in science teaching in secondary schools, these scholarships are open to students who have completed two years at the Institute and plan to follow a curriculum in science and mathematics teaching. Grants are based on demonstrated need, with a maximum of full tuition.

Paul D. Seghers, Jr. Scholarship (1948)
This award was established by the estate of May Towles Kirk Seghers in memory of Second Lieutenant Paul Dotrenge Seghers, Jr. '45, U.S. Army Corps of Engineers, who was killed in action in the Asiatic area on July 11, 1945, to aid worthy and needy Protestant students at the discretion of the Institute.

Robert J. Seid Award (1971)
Established by Mr. and Mrs. Irving L. Seid in memory of their son Robert J. Seid '61. This award is provided to "a worthy and promising student in Mathematics who is in need of financial aid."

Louis E. and Theresa Seley Student Aid Fund (1961)
The income of this fund, the gift of Louis A. Seley, provides scholarships for undergraduate students who are needy and worthy.

Irving Shaknov Scholarship (1954)
The income from this fund, established as a memorial for Irving Shaknov '43, is available for an undergraduate scholarship for a student in the Department of Physics.

Frederick J. Shepard, Jr. Fund (1959)
Income from the gift of the Lewis-Shepard Fund in honor of Frederick J. Shepard, Jr. '12, is used to assist needy and worthy young men from New Hampshire with first preference to graduates of Pinkerton Academy in Derry Village.

James and Donald H. Sheridan Scholarships Fund (1961)
The income of this fund, established by the bequest of James Sheridan, is used to aid needy and worthy students.

Frank Arnold Sherman Scholarship Fund (1947)
The income from this bequest of Frank Arnold Sherman '03 is used "first and preferentially for a scholarship to some boy graduate of Westerly High School, Rhode Island, or if no suitable candidate, preferentially a boy graduate of some other Rhode Island high school."

Thomas Sherwin Scholarship (1871)
Founded with a gift from the English High School Association in memory of Thomas Sherwin, this scholarship is limited to graduates of the English High School of Boston who are pursuing a regular course at the Institute.

Frank Langdon Smith Scholarship Fund (1968)
Established by bequest of Alice Wilder Smith, in honor of F. L. Smith '79, the income from this fund provides scholarships for needy and deserving students.

G. H. Miller Smith Fund (1945)
Established by Mr. and Mrs. George Blackwell Smith of Lookout Mountain, Tennessee, "as a memorial to their son, G. H. Miller Smith '43, late Lieutenant, U.S. Army, killed in action in France during World War II . . . the income to be used for scholarship aid to deserving undergraduate students, with preference to those from Tennessee."

H. Hilliard Smith Fund (1950)
This bequest of Grace J. F. Smith in memory of her husband, H. Hilliard Smith '96, is for the purpose of assisting young men in architecture.

Horace T. Smith Fund (1931)
This bequest from Horace T. Smith '98 provides scholarships to worthy students, with preference given to graduates of the East Bridgewater (Massachusetts) and Bridgeport (Connecticut) High Schools.

Society of Naval Architecture and Marine Engineering Scholarships (1957)
These grants were established by the Society of Naval Architects and Marine Engineers. Four Scholarships, each in the amount of $1,000, for students in, or planning to be in the Department of Naval Architecture and Marine Engineering. Preference will be given to secondary school graduates of outstanding promise. These awards may be renewed annually upon application.

Sons and Daughters of New England Puritan Colony Scholarship (1931)
Holders of this scholarship, made possible by a gift from the Sons and Daughters of New England Puritan Colony, must be of New England ancestry.

Walter W. and Edna J. Soroka Memorial Student Aid Fund (1971)
The purpose of these gifts by Walter W. and Edna J. Soroka '30 is to establish a fund to be used for either scholarships or loans to M.I.T. students.

Anna Spooner Fund (1939)
The income from this bequest is used "in assisting meritorious students."

Standard Oil Company of California Scholarships (1955)
This annual grant, sponsored by the Standard Oil Company of California, is made to a senior in chemical engineering.

Philip B. Stanley Memorial Scholarship Fund (1971)
This fund, established by the trustees of the Alix W. Stanley Charitable Foundation as a memorial to Philip B. Stanley '06 is used to support the undergraduate scholarship program.

Wentworth Stevens Fund (1957)
One-half of the income from this fund, established by William Wentworth Stevens '98 in honor of his mother and father, is made available for scholarship aid.

William L. Stewart, Jr. Memorial Fund (1972)
The income from this fund, established by Mrs. Julia Stewart in memory of her husband, will be used to provide needed scholarships for undergraduate students enrolled in the Sloan School of Management.

Philip Stockton Fund (1961)
The income from this fund, given in memory of Philip Stockton by Mrs. Philip Stockton, is used for undergraduate scholarships.

Albert F. Sulzer Scholarship (1955)
Established under the will of Albert F. Sulzer, this fund is "to be used by the trustees of the Massachusetts Institute of Technology for the establishment and maintenance of scholarships for meritorious first-year students who are non-residents of the State of Massachusetts."

Tau Beta Pi Memorial Scholarship Fund (1947)
This gift from members of Tau Beta Pi, Massachusetts Beta Chapter, on their twenty-fifth anniversary, provides an annual award of $500 for freshmen to be selected by the M.I.T. Financial Aid Office. There is no restriction of geographical area, and candidates are selected on high scholastic standing, character, and future promise.

Howard F. Taylor Memorial Scholarship Fund (1962)
The income from this fund, donated by students, friends, and associates of Professor Taylor, is used for assistance to undergraduate and graduate students interested in foundry and allied fields.

Lawrence E. Teich '40 Memorial Scholarship Fund (1966)
This fund, established by the Curt Teich Foundation as a Memorial to Lawrence E. Teich, Class of 1940, who gave his life while on active duty during World War II, is used to support the undergraduate scholarship program.

Mary Thacher Scholarship (1956)
This bequest established a scholarship fund, the income of which is applied against the tuition of needy students, with first preference to students from Yarmouth, Massachusetts; second to students from the Cape Cod region; and third to students from the Commonwealth of Massachusetts.

Richard H. Tingey Memorial Fund (1962)
This fund, a gift from the Herman W. Falk Foundation, was established in memory of Richard H. Tingey '27, a noted ship propulsion engineer. Its income provides scholarship grants to undergraduate students.

Samuel E. Tinkham Fund (1924)
Established by the Boston Society of Civil Engineers, this fund is to aid a worthy student in civil engineering.

Arthur L. Townsend Fund (1960)
Income of this fund, established by the bequest of Professor A. L. Townsend '13 of the Department of Mechanical Engineering and Director of Lowell Institute, is used exclusively for M.I.T. scholarships. Preference is given to worthy and well-qualified graduates of Lowell Institute who are in good standing and taking a regular full-time day program, preferably in mechanical or electrical engineering.

W. H. Triplett ('12) Scholarship Fund (1961)
This fund was established by Mr. W. H. Triplett, Class of 1912, to provide scholarship assistance for undergraduate students.

Y. T. Tsai Memorial Scholarship (1955)
This fund for worthy and needy students was established by gift.

John L. Turner Fund (1960)
Income of this fund, established by John L. Turner '31, is used to assist needy and worthy young men. First preference is given to students who are direct relatives of the donor or residents of the State of Mississippi; second preference to students domiciled in the Southeast.

Uniroyal Foundation Scholarships (1957)
These grants, established by a gift from the Uniroyal Foundation, are awarded to students in the junior or senior year who demonstrate need for financial assistance, who show capacity for higher education, and who are interested in a career in industry. The Foundation expects that beneficiaries will assume a moral obligation to repay a part of their grants after graduation and over a reasonable period of time; such repayments will be made to the Institute's scholarship fund and will then be used to help other needy students.

Susan Upham Fund (1892)
This gift from Susan Upham is "to assist students deserving financial aid."

Samson R. Urbino Fund (1927)
This bequest from Samson R. Urbino is "to be used to aid students who need assistance, Germans preferred."

Vermont Scholarship (1924)
This scholarship "in memory of Vermonters who, having received their education at the Institute, served as engineers in the Armies of the Allies in the World War" was founded by a gift from Redfield Proctor '02. The income is awarded annually "to worthy students . . . preference to any bona fide residents of Vermont doing undergraduate work at the Institute, and also Vermont students doing graduate work, or students who are graduates of or transfer [illegible] Middlebury College or Norwich University . . . who shall meet regular scholastic and other requirements."

F. P. von Olker Fund (1962)
The income of this fund, established by the bequest of F. P. von Olker, is to be used "yearly in giving scholarships for the benefit of deserving students."

Ann White Vose Fund (1896)
This bequest from Ann White Vose was designated "to establish free Scholarships in M.I.T. . . . such person enjoying benefit . . . shall be worthy young men of American origin."

Arthur M. Waitt Fund (1925)
This bequest from Arthur M. Waitt was designated for "assisting needy and deserving students in the second-, third-, and fourth-year classes of the Mechanical Engineering Course."

Grant Walker Fund (1943)
The income from this bequest is used "for scholarships for deserving students."

Muriel Alvord Ward Fund (1960)
The income of this fund, established by the gift of Mrs. Ferrari P. Ward, is used to assist needy and worthy undergraduates.

Henry E. Warren Fund (1961)
As a memorial to Henry E. Warren, '94, the Trustees of the Warren Benevolent Fund, Inc., contribute to the support of a limited number of entering freshmen. Grants are made by the Financial Aid Office to students who demonstrate financial need. The Office gives first preference to well-qualified students domiciled in New England and second preference to women students from any part of the United States or its possessions. It is hoped that beneficiaries of this fund will make contributions to the Warren Fund after graduating, so that other students may benefit from it.

Henry Arthur Waterman Scholarship Fund (1969)
The income of this fund, established by the will of Henry A. Waterman, is used for scholarships to benefit worthy and needy undergraduate students.

John J. Watson Memorial Fund (1963)
The income of this fund, given by the Watson Foundation as a memorial to John J. Watson, one of its founders, is for scholarships for needy and deserving undergraduates.

James Watt Scholarship (1942)
This bequest of Jennie A. Douglas established "a scholarship in mechanical engineering to be known as the James Watt Scholarship."

Louis Weissbein Fund (1915)
This bequest from Louis Wiessbein was designated "to found a scholarship to be awarded each year to a promising student, preference to be given a Jewish boy in making the award."

Western Electric Scholarships (1956)
These two scholarships in engineering, established by the Western Electric Company, are awarded on the basis of need and ability, with a maximum grant of $1,200.

Frances Ervin[illegible] Fund (1912)
This bequest of Frances Erving Weston is "to aid a native-born American Protestant girl of Massachusetts."

Samuel Martin Weston Fund (1912)
This bequest of Frances Erving Weston was made to found a scholarship in memory of her husband, Samuel Martin Weston, "to aid a native-born American Protestant boy, preference to be given one from Roxbury."

Archer E. Wheeler Scholarship Fund (1957)
This fund is a bequest of Archer E. Wheeler '95, its income is used for scholarship towards fees for undergraduates at the Institute.

Ray Hill White Memorial Fund (1956)
Income from this fund, established by Frances French White in memory of Ray Hill White '05, is used for scholarship assistance for poor and needy students.

Amasa J. Whiting Fund (1927)
This bequest from Mary W. C. Whiting was designated "to constitute a fund to be known as Amasa J. Whiting Fund . . . the income . . . to pay or help to pay tuition of deserving students whose means are limited . . . Preference shall be given to students coming from the town of Hingham, Massachusetts."

Granger Whitney Fund (1957)
Income of this bequest, made by the will of Julia Whitney in the name of Granger Whitney '87, is used to assist worthy students of the Institute, with first preference being given to students residing in the area of the M.I.T. Club of Detroit.

Harold O. Whitney Scholarship Fund (1968)
This fund was established by members of the M.I.T. Class of 1916 in honor of Harold O. Whitney '16. The income of the fund is used for scholarships for male native-born citizens of the United States.

Special Loan Funds

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

Thomas H. Wiggin '95 Fund (1965)
Established by the bequest of Thomas H. Wiggin '95, the income is used to provide scholarship assistance to needy and worthy students.

Elizabeth Babcock Wilmann Fund (1935)
This bequest from Elizabeth Babcock Willmann is "to help in paying the tuition of girl students taking the Chemistry Course."

Wilson Scholarship (1953)
Gift of John J. Wilson '29 in memory of his parents, the income for scholarships to worthy undergraduates.

Gilbert Williams Winslow Memorial Fund (1967)
A gift from Mrs. Edward Williams Winslow established this fund in memory of her son, Gilbert Williams Winslow '37. The income of this fund is available to assist undergraduates, with a preference for students in Civil Engineering.

Walter Phelps Bliss Memorial Fund
This fund is governed by the same conditions as the Technology Loan Fund and is available to students in financial need.

Boston Stein Club Freshman Loan Fund (1953)
Established by the M.I.T. Boston Stein Club, this fund is designed to assist needy students resident in the Greater Boston Area. It is open only to first-year students who show good promise, and, in general, grants are for less than full tuition. Recipients are required to sign notes to repay amounts granted, without interest, after graduation.

Anna J. and Francesco Casaretta Loan Fund (1966)
Established in memory of Anna J. and Francesco Casaretto, to be operated as a loan fund for the benefit of needy and worthy students regardless of race, creed or color.

Francis W. Chandler Loan Fund (1927)
This fund was established as a loan fund to assist worthy and needy students in the Department of Architecture.

Ruth Hornblower Churchill Memorial Loan Fund (1958)
Established by a gift in the name of Ruth Hornblower Churchill, this loan fund is used to help needy students at M.I.T.

Class of 1917 Loan Fund (1937)
The income and principal of this fund is used to assist deserving students, preference given to direct descendents of members of the Class of 1917. Beneficiaries are expected to issue notes agreeing to repay the face value, without interest, of amounts received.

Class of 1963 Loan Fund (1963)
This fund, established by the members of the M.I.T. Class of 1963, is used as a source of short-term emergency and special-use funds, without some of the restrictions associated with the Institute's educational loan funds. Repayment is expected before graduation in most cases; where appropriate the repayment period may be extended to one year beyond graduation. Preference is given to undergraduates.

Thomas F. and Lida Niles Connors Loan Fund (1962)
Established by the bequest of Lida Niles Connors, the principal and income of this fund is available to "qualified and deserving students who are undergraduates in Civil Engineering." Procedures of the Technology Loan Fund are followed in granting loans.

Daunis Family Fund (1971)
This fund established by Mr. Alexander Daunis '32 as a loan fund administered under terms of the Technology Loan Fund.

George Freydberg Fund (1972)
This fund established by Irwin G. Freydberg '38 in memory of his father, George Freydberg, is for the purpose of student loans and administered similarly to the Technology Loan Fund; with emphasis on student need and not grades.

Ethel I. Fryer Scholarship Loan Fund (1951)
This fund was a gift of Herbert Fryer '11 to establish a loan fund for deserving students from the states of Washington, Oregon, and California. Grants are limited to $600 per student and are repayable within five years of graduation.

Nathan R. George Loan Fund (1943)
This bequest from Professor Nathan R. George of the Department of Mathematics is "to be loaned to undergraduates of M.I.T. who are either citizens or who intend to become citizens" and who are members of the third- or fourth-year classes.

Gerald L. Hartstein Memorial Loan Fund (1963)
The principal and income of this memorial fund, established at the request of Mr. Hartstein's mother, are available for loans to undergraduates.

John A. Herlihy Loan Fund (1962)
This commemorative fund was established by gift of the United Air Lines Foundation in honor of John A. Herlihy '27, Senior Vice President of United Air Lines. Grants from this fund, limited to undergraduates in the field of aeronautics and astronautics, are administered in the same manner as those from the Technology Loan Fund.

Jerome Hunsaker Loan Fund (1970)
This fund was established by Professor Jerome C. Hunsaker '12 for the purpose of making loans to students in the Department of Aeronautics and Astronautics, under the same terms as the Technology Loan Fund.

Rebecca R. Joslin Loan Fund (1924–36)
This fund is open to undergraduate and graduate students in chemical engineering and is restricted to students who are residents of Massachusetts and who abstain from using tobacco in any form.

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)
Two prizes of $250 each are awarded annually to seniors in recognition of distinguished scholastic achievement, originality, and breadth of interest in chemistry and closely related fields.

American Institute of Chemists Award (1957)
The American Institute of Chemists offers annually two medals, one to a student in chemistry and one to a student in chemical engineering. The medals are given to students who show outstanding professional promise.

Association of M.I.T. Alumnae Award (1958)
This cash award is given to one or more outstanding women students in the junior class.

Avery Allen Ashdown Award
Awarded to a resident of the Ashdown House who carries on the tradition and spirit of service through participation in the affairs of the House.

Baton Society Awards (1960)
These awards are given to seniors for outstanding contributions to music at M.I.T.

Robert A. Boit Prizes (1921)
These annual prizes are made "to stimulate the interest in the best use of the English language." They are awarded to undergraduates on the basis of essays and imaginative works submitted by them. The prizes are made possible by a bequest of $5,000 from Robert A. Boit.

Karl Taylor Compton Prizes (1951)
These prizes are awarded in recognition and encouragement of outstanding contributions in promoting high standards of performance and good citizenship within the Institute community. They are awarded from the income of a fund composed of gifts by members and friends of the Boston Stein Club.

The Frederick Gardner Fassett, Jr. Award
Awarded to a member of the Interfraternity Conference, for qualities of spirit, dedication, and service in furthering the ideals of the M.I.T. fraternity brotherhood.

Klock-Overton-Mills-Roberts-Longyear Loan Fund (1961)
This loan Fund, established by Felix S. Klock '36, on the 25th anniversary of his graduation from M.I.T. in recognition of the people who significantly influenced and guided him in his education, functions on the same basis as the Technology Loan Fund. In granting awards, the Committee gives preference to needy and worthy students who are children of the employees of the Klock Corporation.

Lamson-Virgin Loan Fund (1946)
This bequest from Elizabeth H. Lamson is used in aiding a worthy student of excellent character who "must have shown not only respect for his parents but also proper consideration for the rights of others." Students thus aided shall repay if and when they find themselves able to do so.

Harry J. and Iolia R. Lohbiller Loan Fund (1962)
This fund was established by trusts created by Harry J. '01 and Iolia R. Lohbiller. Loans are restricted to juniors and seniors and in certain instances to sophomores.

M.I.T. Incentive Loan Fund (1971)
A loan fund established by a gift of the Kerr Foundation, Inc. of Oklahoma. Loans from this Fund are available at the discretion of the Student Financial Aid Office to incoming undergraduate students who do not qualify for other forms of student aid and who feel that their attendance at M.I.T. will be facilitated by a loan. The loans will be administered in accordance with the financial provisions of the Technology Loan Fund. First preference is given to students from Oklahoma and the Southwest.

Anthony P. Mathesius Loan Fund (1970)
This fund was established as a memorial to Anthony P. Mathesius '08 by members of his family. The principal and interest are used for loans in the same manner as are those of the Technology Loan Fund. First preference among recipients is given to students who are members of Phi Beta Epsilon.

George H. May Loan Fund (1914)
A gift from George H. May '92 provides a fund "to assist graduates of the Newton High Schools who are students at M.I.T. and who have been recommended as eligible by the Superintendent and Headmaster of the Newton High Schools." Beneficiaries under this fund are expected to issue notes agreeing to repay, without interest, the amounts received.

Helen and Leo Mayer Loan Fund (1967)
Established by a gift of the Helen and Leo Mayer Charitable Trust, the principal and interest of this fund are administered in the same manner as those from the Technology Loan Fund.

George J. Mead Loan Fund (1951)
This bequest of George J. Mead '16 is for loans to upperclassmen in aeronautics and astronautics and mechanical engineering.

Arthur T. Nelson, Jr. Memorial Loan Fund (1962)
Established by a gift of Mrs. Arthur T. Nelson and the Trustees of Arthur T. Nelson, Jr., this fund is used for loans administered under the regular procedures adopted by the Institute to students residing in certain states.

Michael Joseph Pollock Loan Fund (1962)
The income of this memorial fund, established by the parents, relatives, and friends of Michael Joseph Pollock '59, is available for loans to deserving students.

Ellen H. Richards Loan Fund (1964)
This fund, established by a gift from the Eastern Massachusetts Home Economics Association as a memorial to Ellen H. Richards, is used to provide loans, preference being given to women students in chemistry relating to food processing and food technology.

M. H. Rogers Loan Fund (1945)
This bequest of Minnie Hempel Rogers '90 is for loans to worthy students.

Lillie C. Smith Fund (1965)
Income from this fund in memorial of an early alumna is administered by the Association of M.I.T. Alumnae for aid to women students.

Gertrude W. Swartz Memorial Student Loan Fund (1971)
This bequest of Gertrude W. Swartz to be used as a loan fund for needy students. 5/11/72.

Technology Matrons Loan Fund (1960)
This gift of the Technology Matrons is used to assist needy and worthy students with loans.

Robert Kelley Thulman Loan Fund (1963)
The gift of the wife of Robert Kelley Thulman '22, this fund is designated for loans to students.

Timbie Memorial Fund (1954)
This fund was established by graduates of the Cooperative Course in Electrical Engineering (VI-A) in the name of William H. Timbie. It is used to provide loans for students in the Cooperative Course.

F. B. Tough Fund (1924)
Established by a gift of Mr. F. B. Tough, this fund is used to provide loans "for the purpose of extending financial assistance to worthy students while pursuing their courses."

Frank P. Wakefield Loan Fund (1955)
One-fourth of the income of this fund is available for loans to needy and worthy students majoring in chemistry, chemical engineering, and biology.

The Goodwin Medal
The Goodwin Medal together with a cash prize may be awarded in any year (but not necessarily in every year) to a graduate student who is also a member of the academic staff of the Massachusetts Institute of Technology, in recognition of conspicuously effective teaching. Candidates for this award are nominated through departmental channels or by the Student-Faculty Committee to the Dean of the Graduate School. The award is in memory of Dr. Harry Manley Goodwin, the first Dean of the Graduate School, through a fund given by Mary E. and Richard H. Goodwin.

Ellen King Prize (1950)
This prize is a collection of books valued at approximately $50, awarded for the best essay written by a freshman upon any topic suitable for treatment in literary form. Papers submitted in a regular subject, as well as extracurricular compositions, will be eligible for the prize. Specific topics must be registered and approved at the Headquarters of the Department of Humanities.

Military Prizes
A number of individual prizes are awarded to selected outstanding cadets in the Department of Air, Military, and Naval Science on the Basis of technical and professional proficiency.

Outstanding Freshman Award
This award is made to recognize distinguished scholarship, integrity, breadth of interests, adaptability, and high degree of unselfish activity toward the community at large. It is presented by the M.I.T. chapter of the Tau Beta Pi association, National Engineering honorary.

Phi Lambda Upsilon Award in Freshman Chemistry
This award is given yearly to the outstanding student in freshman chemistry. Taken into consideration are academic achievement for the two terms of freshman chemistry, over-all ability, interest, and promise.

Phi Lambda Upsilon Sophomore Award
This award is given annually to an outstanding sophomore who has demonstrated academic achievement and professional promise in pure and applied chemistry.

Scott Paper Foundation Leadership Award
This award of $1,500 is made annually to a student in the spring of his junior year for senior and first-year graduate study. It is presented in recognition of demonstrated high character, actions on behalf of the welfare of colleagues, and potential for making outstanding contributions to the professional aspects of engineering in business or industry.

William L. Stewart, Jr. Awards (1964)
These awards are given to individual students and student groups for outstanding contributions to extracurricular life. They are made from an annual gift by the W. L. Stewart, Jr. Foundation in memory of Mr. Stewart, member of the Class of 1923, member of the M.I.T. Corporation from 1952 to 1963, and long-time friend and benefactor of the Institute.

Stratton Prizes (1930)
Awards presented yearly for outstanding skill in organized debating. They are made possible by the income of a fund established by the late President Samuel W. Stratton.

Aeronautics and Astronautics

Luis de Florez Awards (1960)
The late Admiral Luis de Florez, distinguished engineer and alumnus of the Department of Mechanical Engineering, Class of 1911, endowed awards totaling $1,000 or more to recognize "original thinking or ingenuity" demonstrated by students in Aeronautics and Astronautics.

James Means Memorial Prize (1925)
A medal and monetary prize of $100 or more is offered annually to a senior for excellence in systems engineering.

Henry Webb Salisbury Memorial Award (1941)
Established by the family and friends of Henry Webb Salisbury '33, this award, consisting of books chosen by the recipient, is given for outstanding work in the Department of Aeronautics and Astronautics.

Architecture and Planning

Alpha Rho Chi Medal (1932)
This medal is given each year to a graduating senior in the Department of Architecture who has shown an ability for leadership, performed willing service for his School and Department, and given promise of real professional merit through his attitude and personality.

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
Established by the Class of 1948, this award is given annually to the member of the graduating class who has best combined the traits of leadership and character with excellence in athletic performance.

Admiral Edward L. Cochrane Award
This award, made possible by Mrs. Cochrane in memory of her husband, is given to a member of the graduating class, participant in the intercollegiate athletic program, who has shown qualities of humility, leadership, and scholarship.

Eastern College Athletic Conference Merit Medal
This medal, established by the Conference to be awarded by its member institutions, gives recognition to an athlete for scholarship and athletic achievement.

Chemical Engineering

Robert T. Halsam Cup (1959)
Established by Mr. and Mrs. Louis E. Seley in honor of Robert T. Haslam '11, this cup is awarded annually by the Department of Chemical Engineering to a student who shows outstanding professional promise in chemical engineering.

Hunneman Prize (1927)
Established by William Cooper Hunneman in memory of his son Roger DeFriez Hunneman '23, this award of $100 is made to the most meritorious senior who has shown outstanding originality in his work in the regular Course in Chemical Engineering.

Civil Engineering

A.S.C.E. Student Chapter Scholarship
Funds under this award are provided through the gift of Samuel Tapman as a scholarship given annually to an outstanding undergraduate who is a member of a Student Chapter of the American Society of Civil Engineers in A.S.C.E. Zone 1.

Tucker-Voss Award (1953)
Gift of the alumni and friends of the late Professors Ross F. Tucker and Walter C. Voss, former heads of the Course in Building Engineering and Construction, this prize is awarded annually to an undergraduate or a graduate student with high scholastic standing, leadership, and professional promise in the building field.

Richard Lee Russel Prize (1967)
This scholarship award of $500 for graduate study in civil engineering at M.I.T. is for an outstanding senior selected by the faculty of the Department. The award is supported by the Richard Lee Russel '89 Fund established in 1904 by Mr. Theodore E. Russel.

Electrical Engineering

Morris J. Levin Award
Award to juniors in electrical engineering who have demonstrated excellent performance through independent work in an undergraduate laboratory project.

Supervised Investors' Services, Inc., Awards (1957)
Four prizes $500 each are awarded to graduate students who are members of the teaching staff of the Department of Electrical Engineering. They are given to honor those who have demonstrated an interest and proficiency in the field of teaching and to help defray the expenses of graduate study for advanced degrees.

Carlton E. Tucker Awards for Excellence in Teaching (1962)
Two prizes of $500 each, awarded to graduate students who are members of the teaching staff of the Department of Electrical Engineering, are given to honor those who have demonstrated an interest and proficiency in the field of teaching and to help defray the expenses of graduate study for advanced degrees. The Awards honor Professor Carlton E. Tucker, the Department's Executive Officer for 24 years, for his dedication to and interest in high teaching standards; they are supported in part from funds given in memory of Professor Tucker and Professor William H. Radford.

David T. Schultz Award (1969)
An award made annually to an assistant professor in the Department of Electrical Engineering for outstanding accomplishment in teaching undergraduate students. The David T. Schultz Award for Excellence in Teaching in Electrical Engineering was established in 1969 by a gift for Baird-Atomic, Inc. of Cambridge of 1,000 shares of its common stock. The award honors Mr. David T. Schultz who is Chairman of the Executive Committee of the Company.

Management

The Brooks Prize in Management
The E. P. Brooks Master's Thesis Prize of $100 is awarded each year for the thesis judged to be the best submitted for the Master of Science in Management. Nominations may be made by the Chairman of any Master's Thesis Committee to the Sloan School of Management's Prize Committee.

Editorship of the Sloan Management Review
The editorship of the journal of the Sloan School of Management is awarded annually to selected graduate students in management who have achieved distinguished records of scholarship and leadership in the School.

Sloan School of Management Senior Prize
This annual award of $100, established through the generosity of Samuel Berke, '15, is made to an outstanding senior student in the field of management with high scholastic standing, leadership, and professional promise.

Mechanical Engineering

American Society of Mechanical Engineers Student Paper Awards
This contest for outstanding professional papers by student members of A.S.M.E. is sponsored by the local chapter. Prizes totaling about $60 are awarded, and local winners are eligible for regional and national contests.

Luis de Florez Awards (1957)
The Late Admiral Luis de Florez, distinguished engineer and alumnus of the Department of Mechanical Engineering, Class of 1911, endowed these awards to recognize "outstanding ingenuity" demonstrated by students in mechanical engineering. Prizes totaling $1,000 or more are awarded each year.

Silent Hoist and Crane Company Materials Handling Award (1950)
These annual prizes, totaling more than $500, are awarded for the best papers or theses submitted on subjects in the field of production, materials handling, or machine design related to materials handling equipment, on the basis of a competition held each year. The award is a gift of the Wunsch Foundation, Inc.

El Wellech — Corning Glass Works Award
This award is to be given to students in the Mechanical Engineering sophomore subject Engineering Design and Manufacturing. An aggregate of $250 is awarded for the best design project (or projects) and an equal aggregate for the best manufacturing project report (or reports) submitted during each year.

Engineering Projects Laboratory — Showcase Awards
Undergraduate and graduate students are encouraged to offer exhibits of their work at any time throughout the year. Prizes of about $25 to $50 are offered at the end of the year for exhibits judged most effective by a panel.

Meteorology

The Carl-Gustav Rossby Award in Meteorology
This award was established in part, by the gift of Julius Honig '53 in memory of Professor Carl G. Rossby who established the course in meteorology at M.I.T. The award of $100 is made in any year for the most outstanding graduate thesis submitted to the Department of Meteorology.

Metallurgy and Materials Science

Metallurgy and Materials Prize (1963)
The sum of $150 is awarded to an outstanding junior in the Department. The award was established by graduate students and associates of Professor Morris Cohen in recognition of his significant contributions to undergraduate education in materials. It is presently supported by the Boston Section, A.I.M.E.

American Metal Climax Foundation Prize (1969)
The sum of $300 is available for awards to students who perform outstanding laboratory projects.

Ocean Engineering

American Bureau of Shipping Prize, Naval Architecture and Marine Engineering (1924)
This award of $100 is provided by the Bureau to the American citizen who attains the highest average in scholarship for the third and fourth years in either the Course in Naval Architecture and Marine Engineering or the Course in Shipping and Shipbuilding Management.

American Bureau of Shipping Prize, Ocean Engineering (1973)
This award of $100 is provided by the Bureau to the American citizen who attains the highest average in scholarship for the third and fourth years in Ocean Engineering.

Brand Award (1957)
This award, in memory of Rear Admiral Charles L. Brand, U.S. Navy Class of 1915, is made annually by the American Society of Naval Engineers to the student officer in the graduating class who attains the highest scholastic average in the Course in Naval Construction and Engineering (XIII-A).

Naval Ship Systems Command Award (1970)
This award, established by the Naval Ships Systems Command, is awarded annually for professionalism and scholarship to an Engineering Duty (Ship Engineering) officer in the graduating Class of the Course in Naval Construction and Engineering (XIII-A).

Other Information

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. Therefore, it is M.I.T.'s policy to have as few rules and regulations as are consistent with efficient administration and general welfare.

Fundamental to the principle of independent learning and professional growth is the requirement of honesty and integrity in the performance of academic assignments, both in the classroom and outside, and in the conduct of personal life. Accordingly, M.I.T. holds its students to the highest standards of intellectual integrity and thus the attempt of any student to present as his or her own any work which he or she has not performed or to pass any examinations by improper means is regarded by the faculty as a most serious offense and renders the offender liable to immediate expulsion. The aiding and abetting of a student in any dishonesty is also held as a grave breach of conduct.

M.I.T. has traditionally placed considerable responsibility on undergraduate governing groups to deal with problems in the student community. Each residential unit has its own judicial system which is responsible to an overall undergraduate judicial system, which in turn is responsible to the Dean for Student Affairs and the Faculty Committee on Discipline, a standing committee of the faculty. Minor infractions are usually handled by that student judicial group which is closest to the problem. Serious infractions which occur on campus and some off-campus infractions are considered by the Faculty Committee on Discipline. The Faculty Committee on Discipline is composed of eight faculty members, five students, and the Dean for Student Affairs (ex officio).

It should be noted that the Institute reserves the right to dismiss at any time a student whom it deems undesirable for any reason. Unethical conduct, wherever it may occur, is held to be sufficient grounds for dismissal.

If a student's infraction involves him or her both in Institute judicial proceedings and in court proceedings, and if an Institute decision might prejudice his or her court case, the Institute will usually hold its decision in abeyance until after the court proceedings have been concluded.

The Office of the Dean for Student Affairs is responsible for all matters pertaining to general student welfare.

Motor Vehicles

All motor vehicles operated by students must be registered each term with the Campus Patrol within 30 days after Registration Day. Students should also note the requirement that out-of-state automobiles operated by M.I.T. students must be registered with the M.I.T. Campus Patrol.

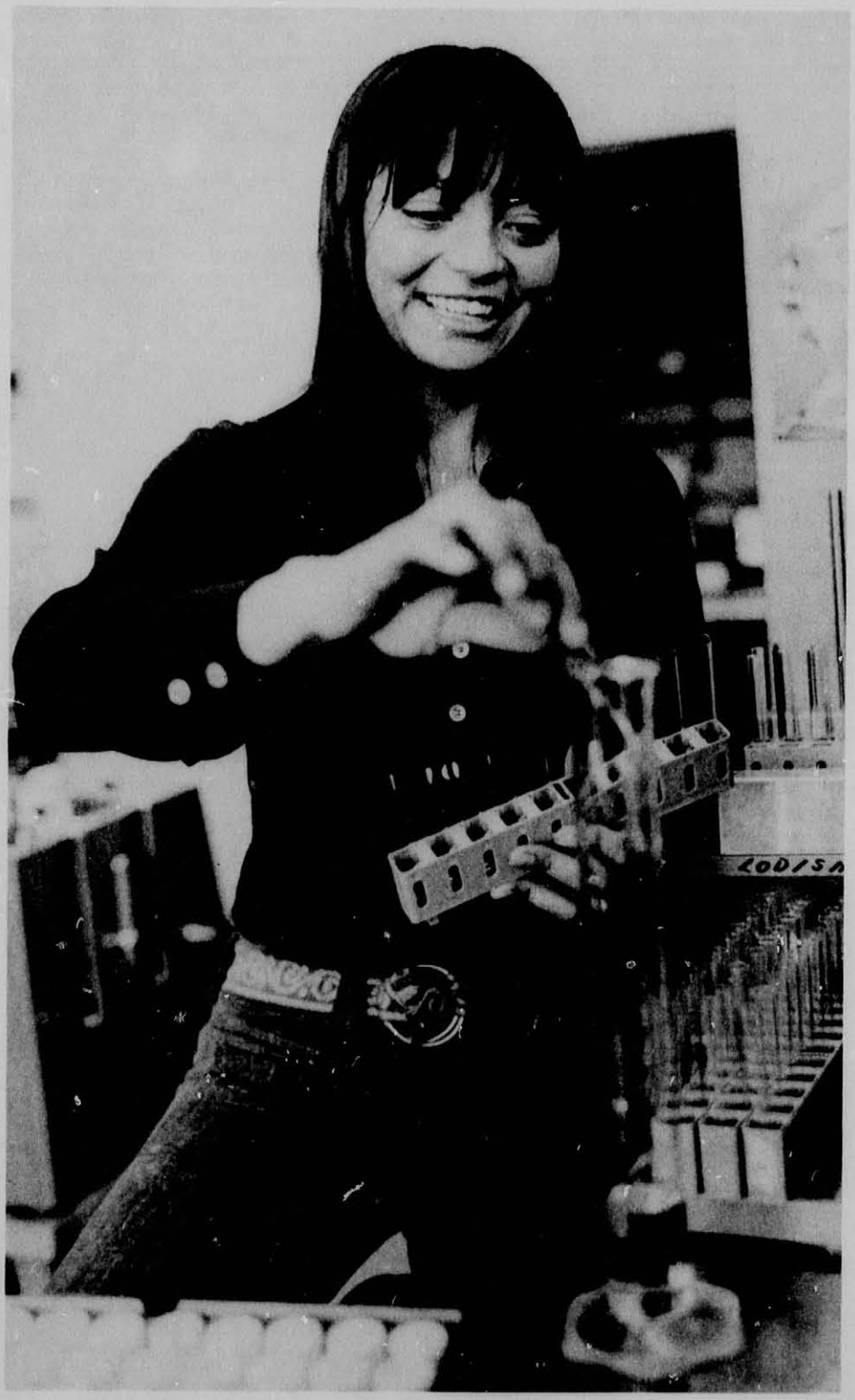
Parking facilities at M.I.T. are limited. In general, the Institute cannot provide parking for the use of resident students. A limited number of spaces are available for assignment with the approval of the Dean for Student Affairs to students with physical handicaps demanding use of an automobile and to a few other undergraduates. Recent regulations issued by the U.S. Environmental Protection Agency require a systematic reduction in the total number of available parking places, to begin in 1975.

Students who plan to bring motor vehicles to Cambridge should take careful note of the information regarding pertinent Massachusetts laws which is mailed with their registration material.









III Graduate Education at M.I.T.

For more than 80 years, the Graduate School has sought to promote the best environment for advanced study among creative workers, both faculty and students, as a community of scholars working to extend the boundaries of knowledge. With this goal in mind, the Institute, for almost 50 years, has consistently awarded the largest number of master's and doctor's degrees in engineering in the nation, and in recent years has ranked near the top in doctoral output in mathematics and the physical and life sciences. In addition, graduate programs in economics, social sciences and humanities, architecture and urban studies, and management have assumed an integral role in the broad spectrum of graduate education at M.I.T.

Of first importance to the Graduate School at M.I.T. is the quality and productivity of its faculty. Faculty strength is needed over a wide range of fields to serve varied student interests, and M.I.T. is proud of its internationally recognized faculty of scholars and academic leaders who in their close association with students are also effective teachers and collaborators in research.

Of equal importance in the Graduate School is a characteristic 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 his intellectual growth and subsequent success are directly related to the depth of his 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, while valuable, is secondary to extending intellectual and humanistic horizons, producing new orientations, and developing growth in intellectual courage and 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 and similar positions as research assistants offer the student professional assignments with an approach to financial self-sufficiency. 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 upon a consideration of 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, oceanography, operations research, biomedical engineering, economics and urban studies, and environmental engineering. Students in such programs are supervised by special faculty committees appointed by the Dean of the Graduate School.

The broad scope and high quality of its graduate education has made M.I.T. a leader in the international field. Some 28 percent of its graduate students come from foreign nations. In recent years it has also 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 many 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 in fields of the Institute's interest. M.I.T.'s high productivity of advanced degrees is the result of these pioneering interests of its faculty that have generated both demand and support for research. The wealth and diversity of teaching and research resources, described in this Catalogue, particularly by the individual departments in their respective sections and in the section on interdisciplinary study and research, are a direct result. Graduate students participate in all of the Institute's wide-ranging research activities; collaboration in research is vital to the educational experience of both 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 own particular interests, subject to the general requirement that the field thus defined has 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 limit to the bounds of scholarly interests. The scope of many interdisciplinary programs and facilities is described in this Chapter under Interdisciplinary Study and Research.

The M.I.T. Libraries provide a major resource for graduate study. They serve New England as a depository for unclassified reports of the Department of Defense, the Atomic Energy Commission, the National Aeronautics and Space Administration, and the Rand Corporation. The collections are notably strong in science and technology of the U.S.S.R. The M.I.T. Library system is supplemented by exchange arrangements with other Boston universities.

Another significant resource for graduate study is the cooperative cross-registration program with Harvard University (including the Medical School), Wellesley College, Brandeis University, Tufts University, Boston University, and the Woods Hole Oceanographic Institution. These programs 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 frequent, 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 graduate students may take advantage of the exceptional opportunities available.

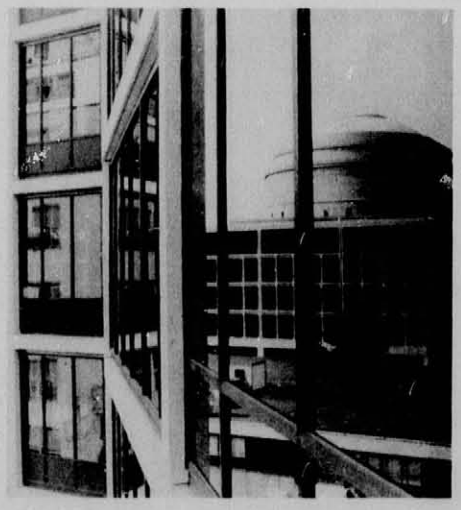
Graduate students are encouraged to use M.I.T.'s extensive athletic facilities. A number of teams composed of both undergraduate and graduate students participate in intercollegiate competitions, as well as the intramural athletic program. The Nautical Association welcomes graduate students as participants.

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 Dean, Assistant Deans, and Executive Officer 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 automony for its graduate program under a policy 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, which administers departmental graduate activities. The Graduate Registration Officer advises and assists 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 at the back 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.; Master in City Planning, M.C.P.; and Master of Architecture in Advanced Studies, M.Arch.A.S.

The major fields for graduate study are listed. Each graduate program is described in individual department statements on graduate education 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. However, students in interdisciplinary programs continue to register in their parent departments.

In addition to specialized professional competence, graduate students are expected to have a background in the humanities and social sciences. The faculty believes that those who receive advanced degrees should have the breadth of interests and understanding which tends to promote qualities of leadership and an awareness of professional, social, and moral responsibility, along with specialized competence.

School of Architecture and Planning

Architecture, Course IV

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
Aeronautical and astronautical engineering
Biomedical engineering*
Computer systems
Dynamic energy conversion
Estimation and control
Flight transportation
Fluid mechanics
Gas dynamics
Gas turbines
Guidance and control systems
Instrumentation
Materials engineering
Physics of fluids
Plasma physics
Propulsion
Space mechanics
Structures
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

Chemical Engineering Practice, Course X-A

*Approved Interdepartmental Program

Civil Engineering, Course I
Applied earth science
Building systems
Civil engineering
Civil engineering systems
Construction and operation
Earthquake engineering
Environmental engineering*
Geotechnical engineering
Geotechnology
Hydrodynamics
Materials
Materials engineering
Ocean engineering*
Operations research*
Project management
Soil mechanics
Structural engineering
Structural mechanics
Structures
Transportation
Transportation systems
Urban engineering
Urban systems
Water resources

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

Mechanical Engineering, Course II
Acoustics
Applied mechanics
Automatic controls
Biomedical engineering*
Combustion
Computer-aided engineering
Cryogenics
Desalination
Design engineering
Dynamics
Energy and power
Environmental engineering*
Fibers and polymers
Fluid mechanics
Gas turbines
Heat transfer
Internal combustion engines
Lubrication, wear, and friction
Man-machine systems
Materials
Materials engineering
Mechanical engineering
Metals processing
Propulsion
Refrigeration and air conditioning
Statistical mechanics
Stress analysis
Thermodynamics

Metallurgy and Materials Science, Course III
Ceramics
Materials engineering
Materials science
Metallurgy
Polymerics

Naval Architecture and Marine Engineering, Course XIII

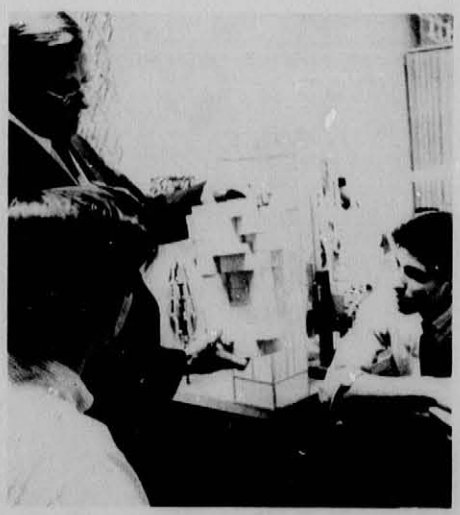
Naval Construction and Engineering (USN and USCG), Course XIII-A

Ocean Engineering, Course XIII
Acoustics
Coastal zone utilization
Environmental engineering*
Hydrodynamics
Marine data systems engineering
Marine engineering
Marine resource development
Naval engineering
Ocean engineering*
Ocean engineering and law
Operations research*
Sea floor engineering
Ship propulsion
Ship systems
Shipping and shipbuilding management
Structural mechanics

Ocean Engineering (Joint Program with the Woods Hole Oceanographic Institution), Course XIII-W

Shipping and Shipbuilding Management, Course XIII-B

Nuclear Engineering, Course XXII
Applied plasma physics
Applied radiation physics
Nuclear fuel management
Nuclear materials engineering
Nuclear reactor engineering
Nuclear reactor physics



*Approved Interdepartmental Program

School of Humanities and Social Science

Economics, Course XIV

Foreign Literatures and Linguistics, Course XXIII
Linguistics

Philosophy, Course XXIV

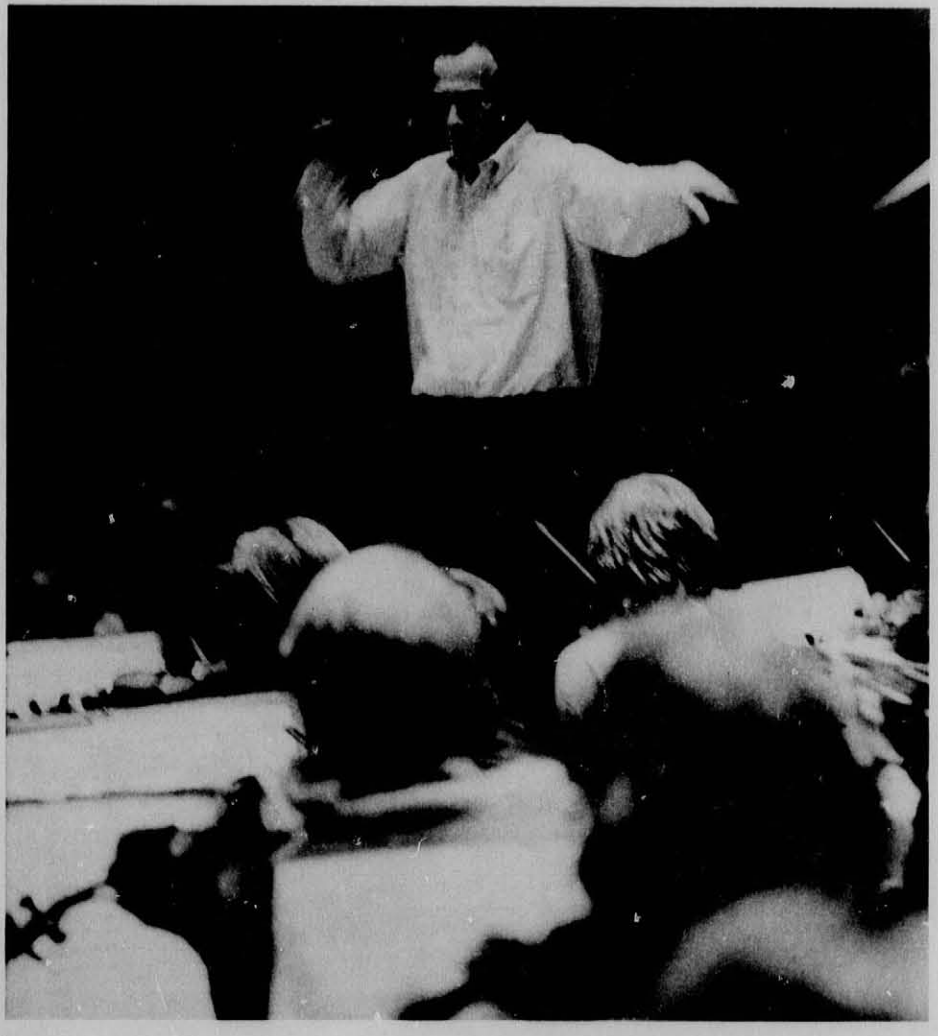
Political Science, Course XVII

Psychology, Course IX
General experimental psychology
Physiological psychology
Developmental psychology
Psycholinguistics
Neuromorphology
Neurophysiology
Cognitive psychology

Alfred P. Sloan School of Management

Management, Course XV





School of Science

Biology, Course VII
Biochemistry
Biophysics
Cell biology
Microbiology
Physiology
Biological Oceanography
(Joint Program with Woods Hole Oceanographic Institution) Course VII-W

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

Earth and Planetary Sciences, Course XII
Geochemistry
Geology (classical geology, theoretical geology)
Geophysics
Oceanography
Oceanography
(Joint Program with Woods Hole Oceanographic Institution)
Course XII-W
Planetary Sciences

Mathematics, Course XVIII

Meteorology, Course XIX
Oceanography
Oceanography
(Joint Program with Woods Hole Oceanographic Institution) Course XIX-W

Nutrition and Food Science, Course XX
Biochemical engineering
Clinical nutrition
Food engineering
Food science and technology
International nutrition planning
Neuroendocrine regulation
Nutritional animal pathology
Nutritional biochemistry and metabolism
Oral biology
Toxicology

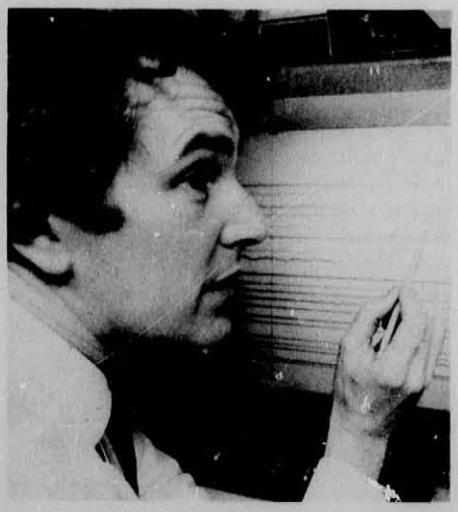
Physics, Course VIII

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; these requirements are 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 in full-time association with the faculty, other graduate students, and the Institute community. In a stimulating and scholarly atmosphere, the student enjoys free and unhampered discussion with colleagues, both faculty and students, within his or her professional field and over a broad range of subjects. This environment includes access to libraries and reference sources, to the educational opportunities offered by other disciplines, and also to recreational, cultural, religious and athletic opportunities.

The minimum residence requirement for all Master's candidates is one academic term, not counting the summer term. For the Engineer's degrees, two academic terms of graduate work must be completed with residence credit. The course of advanced study for the doctoral degrees must be pursued under the direction of the Committee on Graduate School Policy 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 Committee that they have successfully accomplished advanced work of a grade similar 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 the equivalent of three full-time academic 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.)

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. With departmental acceptance to graduate status, a student may work for the simultaneous award of the S.B. in Art and Design and the graduate M. Arch. degree.

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

The degrees Master of Science, Master of Architecture in Advanced Studies, and Master in City Planning are awarded upon the satisfactory completion of an approved program of study of at least 66 subject units, of which 42 units must be in "A" subjects, and the completion of an acceptable thesis.

A student who has a Bachelor's degree from the Institute in the same department in which he or she enrolls for the Master's degree, or who has had equivalent preparation elsewhere, may attain the Master's in one year. Others with less direct or extensive preparation will require a longer time.

A student who completes the requirements for the Bachelor's degree at the Institute with substantial extra advanced credits in graduate subjects may, upon application, be granted a relaxation of the normal residence requirement (apart from the one term requirement for thesis registration) and may be recommended for the simultaneous award of the Master's degree.

The choice of field of specialization must be approved by the Committee on Graduate Students of the department in which the student is enrolled. Approval of the entire program must be obtained from this Committee and from the student's faculty advisor. A special interdepartmental committee may be appointed by the Dean of the Graduate School 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 is expected to register for thesis in all periods during which his or her thesis research is actually in progress and during the term his or her name appears on the Degree List.

To be recommended for a Master's degree, a student must have earned a satisfactory record in a program of graduate study and research.



Degrees With and Without Specification

In an approved program for a Master of Science degree, if 34 units of "A" subjects and the thesis are in a single field of science or engineering (as determined by a departmental Committee on Graduate Students), 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 is required in either case.

Simultaneous Award of Two Master's Degrees

Occasionally, a graduate student seeks two Master's degrees simultaneously or in sequence in different departments. Such a procedure is permissible provided a program of study acceptable to both departments is completed. Such a program must include at least 66 subject units (exclusive of thesis) and the submission of an acceptable thesis. A common thesis may be submitted for both degrees if not less than 60 subject units are unique to each program. If separate theses are submitted, not less than 30 subject units must be unique to each program. Registration shall be in one department at a time. For simultaneous degrees, a petition must be filed with the Registrar at least two terms before graduation, stating the expected program in both departments.

Interdepartmental Master's Degrees

Any approved interdepartmental graduate program leading to the doctoral degree is approved as a Master's program as well. These are described in Chapter III. Because degree requirements differ, those interested should seek specific advice from the program headquarters.

Engineer's Degrees

The objective of a program leading to an Engineer's degree is 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 that characterizing a doctoral program. In general, the Master's degree requires a minimum of one academic year and the Engineer's degree 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.); Marine Mechanical Engineer (Mar.Mech.E.); Materials Engineer (Mat.E.); Mechanical Engineer (Mech.E.); Metallurgical Engineer (Met.E.); Naval Architect (Nav.Arch.); Naval Engineer (Nav.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 Interdisciplinary 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 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.

Doctoral Degrees

M.I.T. offers the degrees of Doctor of Science and Doctor of Philosophy interchangeably in branches 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, 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. Full-time effort in formal study or by a combination of formal study and relevant work as a teaching or research assistant is recommended in most cases.

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 may be appointed by the Dean of the Graduate School 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

The Institute believes that candidates for the doctor's degree should be aware of the context of their special field in the spectrum of human knowledge. 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 require the equivalent of at least one full-time academic year of research, while many doctoral research efforts require a substantially longer time. Each doctoral candidate is expected 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 partial fulfillment of the thesis requirement, nor can credit be granted for thesis research done **in absentia**, except under very special conditions and with specific **prior** approval by the Committee on Graduate School Policy. A full statement of policy on thesis research in absentia is given in the Graduate School Manual.

A final 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 Department of Foreign Literatures and Linguistics; or 3) by taking a two-term subject in a language or languages offered by the Department of Foreign Literatures and Linguistics. Depending on student demand, the Department of Foreign Literatures and Linguistics 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 listed above, the Department of Foreign Literatures and Linguistics 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.

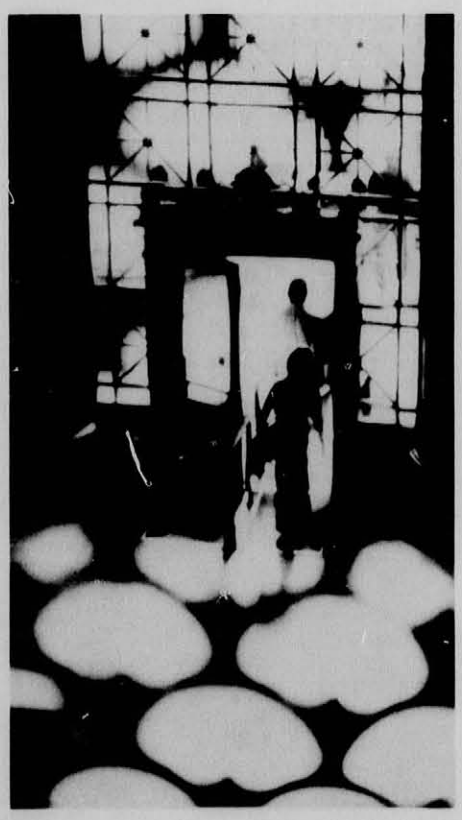
Any student who fails to appear for a predoctoral language examination is subject to a fine of $10.

Interdepartmental Programs

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

Independent Activities Period

The January Independent Activities Period, established at M.I.T. three years ago, continues to provide a new dimension to educational activities through the freedom it offers students between the first and the second term of each year. 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 over 600 special activities, individual projects, intensive subjects, and exploratory programs, which do not fit into the normal academic calendar, are offered both at M.I.T. and at numerous off-campus locations. Among the range of options available this past January were: glassblowing workshop; a field trip to study volcanoes in Central America; numerous film series; a residential German House; biomedical engineering projects; seminar on Madness in Literature and Medicine; projects in geotechnical engineering; problems in applied meteorology; seminar on urban organization in China; and a seminar on Jazz in the 1920's and 1940's.



Cooperative Programs

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 for advanced study (exclusive of thesis) at the other institution, without paying additional tuition, provided that this exchange enrollment does not exceed one-half of his 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 applicable only to the regular academic terms and not 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 which are so crowded that additional registration puts 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.*

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 Studies in Social Welfare at Brandeis University. Cross-registration is restricted to one or two subjects per term in the area of social welfare at Brandeis and urban studies at M.I.T.

Tufts University

A cooperative arrangement 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.

Wellesley College

Graduate students are eligible to participate in the Wellesley-M.I.T. Exchange Program. Information concerning the details of this program may be found in a publication entitled *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 Department of Ocean Engineering at M.I.T. can provide information about the program in Ocean Engineering and the Departments of Biology and Nutrition and Food Science can provide information regarding the program in Biological Oceanography. The Woods Hole Oceanographic Institution may be consulted also for information concerning all these programs.

Preprofessional Advising and Education

The Office of Preprofessional Advising and Education serves students in the fields of medicine, law, public administration, education and/or related fields. The Office supports three faculty/student entities, the Committee on Preprofessional Advising and Education, the Premedical Advisory Council, and the Prelaw Advisory Council. The Executive Officer to the Committee on Preprofessional Advising and Education acts as liaison between students and members of 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 of mechanical 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. By proper selection of electives, medical school entrance requirements can be met. Each student is encouraged to take advantage of the flexibility and diversity of subjects offered within the Institute. 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. *A Premedical Handbook for M.I.T. Students* has been prepared by the Committee on Preprofessional Advising and Education to provide general information to students interested in medical education and a medical career. Copies of the Handbook are available through the Office of Preprofessional Advising and Education.

Education Studies

The profession of education, including teaching at high school levels, has interested an increasing number of students. M.I.T. students may receive certification in teaching in the Commonwealth of Massachusetts by taking a prescribed series of subjects. A teaching program in one of the Cambridge high schools, available as a credit seminar, provides the practical teaching experience necessary for certification. 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.

Copies of catalogues of graduate programs in education are available in the Office of Preprofessional Advising and Education.

Some of the course work offered at the Institute gives academic support to several voluntary activities conducted by students. These activities include the M.I.T. Educational Studies Program, Tutoring Programs, and other student-initiated programs. *A Handbook for M.I.T. Students Interested in a Career in Education* tells of these as well as other opportunities at M.I.T. Copies of the handbook are available through the Preprofessional Advising and Education Office.



Professional and Honorary Societies

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, but prefer applicants who have completed a degree program. Students from every Institute School — Engineering, Science, Humanities and Social Science, Architecture and Urban Planning, and Management — have been admitted to law school. Prelaw students may wish to 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 — it 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 under Interdisciplinary Study and Research for a further discussion of opportunities and programs.







Phi Beta Kappa

While the M.I.T. chapter, Xi of Massachusetts, elects only seniors, it welcomes the affiliation, during their stay at the Institute, of graduate students and their spouses who are members of other chapters.

American Institute of Aeronautics and Astronautics

Members of all classes who are interested in aeronautics and astronautics will find it well worth their while to join the A.I.A.A. The society offers an excellent way of meeting others of similar interests; the Student Branch at M.I.T. presents films on aircraft topics, speakers, and field trips in the Boston area.

American Society of Mechanical Engineers

Membership in the A.S.M.E. is open to all students in good standing in any engineering curriculum. Joining the A.S.M.E. provides the student with a broader perspective of the engineering profession than he or she would receive in class; at the various seminar meetings, the student will have the opportunity to meet professors and members of the profession on an informal basis.

Institute of Electrical and Electronics Engineers

The I.E.E.E. is the world's largest professional engineering society, and M.I.T. has one of the largest student branches, with over 300 members. Any graduate or undergraduate student in engineering or science is eligible for student membership and may join any of the 32 professional technical groups, including the groups on Information Theory, Biomedical Electronics, Nuclear Science, and Electronic Computers.

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 is mailed early in August to regular students whose home address is in the U.S. or Canada and should be returned by the last week in August. Second-term registration material is available at the Registrar's Office late in the first term. An individual who has not completed the registration procedures by the start of the sixth week of the 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.

In the last two weeks of a regular term, registration in any subject may not be cancelled by a student without the additional approval of the departmental Committee on Graduate Students. The final date for cancelling subjects without this approval will be posted outside Room 7-111 (Information Center).

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.

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.



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 7-111), 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.

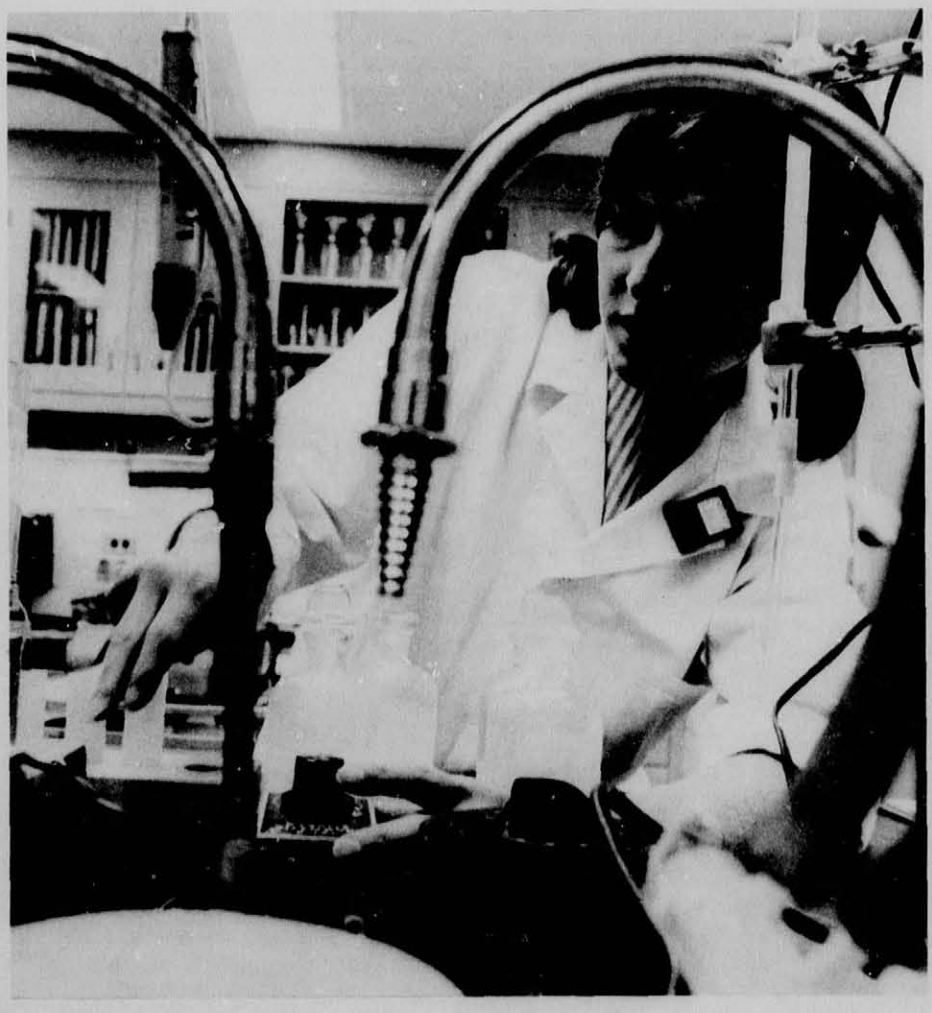


Grade Reports and Transcripts

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 $1 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 performance of all graduate students whose grades during that term average less than midway between C and B. In addition, departmental graduate committees may at any time 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.





Interdisciplinary Graduate Study

Programs

Acoustics

Acoustical study and research activities are carried out at M.I.T. within the Departments of Mechanical, Ocean, and Electrical Engineering, the Department of Aeronautics and Astronautics, and the Department of 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 deaprtment. It is possible to set up more specialized interdepartment programs of study and research in acoustics. One mechanism is the Engineer's degree program within the School of Engineering which may have a specialization in acoustics. Another possibility is the establishment of a special faculty committee under the Office of the Dean of the Graduate School for doctoral students.

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 and Mechanical Engineering and within the Department of 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, and aerodynamic noise and medical ultrasonics. A third set of subjects are in the "professional practice" category, and include noise control, architectural acoustics, and sonar applications. A complete listing of these subjects is contained in the brochure *Acoustics at MIT*.

Research work in acoustics is carried out in the Acoustics and Vibration Laboratory, jointly administered by the Departments of Mechanical and Ocean Engineering; the acoustical wind tunnel and gas turbine laboratory administered by the Department of Aeronautics and Astronautics; the Eaton Peabody Laboratory administered by the Department of Electrical Engineering in cooperation with the Massachusetts Eye and Ear Infirmary; and the Laboratory of Experimental Medicine administered by the Department of Mechanical Engineering.

The research activities encompass the major categories of acoustical study, the sources of sound, sound propagation, and its reception. Research on sound sources includes studies of speech and noise produced by fluid machinery and mechanical devices. Propagation studies include the transmission of ultrasound in tissue, the propagation of urban noise in city streets and in communities, the propagation of subway and seismic noise through soil, and the propagation of sound within auditoria and through the walls of buildings. Research on the reception and effects of sound include the physiology and neurology of the ear and perception of speech, the vibration of structures in response to ground motions, and the effect of ultrasound on tissue.

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

Biomedical Engineering

Students and faculty in many departments at M.I.T. are conducting research in biomedical engineering. These research interests, spanning biology, engineering, and the physical and social sciences, have led to new programs of graduate study for students wishing to pursue careers in these rapidly evolving fields. The spectrum of academic and research programs is extremely broad — ranging from basic physiological studies to the development of new medical and biological techniques with related engineering analysis and design to problems in the design of new systems for the delivery of health services. Each of these programs, although strongly interdisciplinary in nature, has evolved out of the interests and professional specialities of the participating faculty. Many are based primarily in the School of Engineering departments and, therefore, are available to students as regular departmental activities. In addition, graduate students from any department may apply for admission to the interdepartmental program in biomedical engineering described below.

There are active programs of research in the biological and medical sciences within the School of Engineering departments listed in the accompanying table. In addition, there is a broad range of activities closely related to biomedical engineering in the Schools of Architecture, Management, and Science. Virtually all of the engineering studies are collaborative with life scientists, many of whom are faculty of the medical schools and affiliated teaching hospitals in the Boston area. A background in mathematics and the physical sciences is a necessary prerequisite for graduate study in biomedical engineering; preparation in the biological sciences, though desirable, is not required.

With the establishment in 1970 of the joint Harvard-M.I.T. Program in Health Sciences and Technology, new programs of study and research and many new subjects have become available to students in biomedical engineering and the related life and health sciences. A description of the Program is included in this section. An interdepartmental doc-

toral program in biomedical engineering is offered under the administration of the Committee on Biomedical Engineering. This program is designed for the graduate student enrolled in a department who desires training in depth in both the biomedical and the engineering sciences.

Major areas of interest in biomedical engineering are given for each department.

Aeronautics and Astronautics
Visual and vestibular control systems
Postural control
The human operator
Vehicle and display systems

Chemical Engineering
Biomaterials
Artificial organs
Mass transfer in artificial lungs and kidneys
Aerosol technology

Electrical Engineering
Sensory- and neuro-physiology
Visual, tactile and auditory psycho-physics
Biomedical instrumentation
Speech analysis
Sensory aids
High energy radiation
Artificial intelligence
Image processing, pattern recognition

Mechanical Engineering
Biomaterials
Fluid mechanics: Cardiovascular system, pulmonary system, Peristaltic blood pumps
Blood oxygenators
Cryogenics
Human control characteristics
Reproduction
Medical telediagnosis
Musculoskeletal mechanics and joint function
Rehabilitation technology
Sensory and limb prostheses
Ultrasonics
Physiology of pain

Metallurgy and Materials Science
Metallic and polymeric surgical implants
Articular joint prostheses
Bone properties
Metal ions in biomolecules and biomaterials

Nuclear Engineering
Activation analysis, including *in vivo* studies
Neutron capture therapy
Radiation instrumentation

Students desiring to enter the program in biomedical engineering should normally apply for admission to the department most closely related to the field of their undergraduate major. A *Guide to Graduate Study in Biomedical Engineering at the Massachusetts Institute of Technology* can be obtained from the Committee office, M.I.T., Room 16–512, Cambridge, Massachusetts 02139.



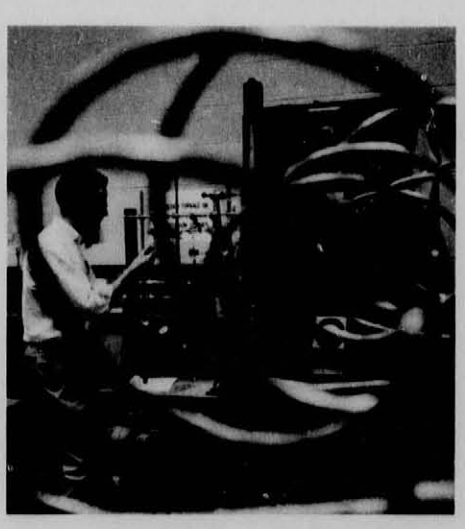
Environmental Studies

Environmental studies for graduate students at M.I.T. are available through a variety of departmental and interdepartmental subjects and laboratories which are growing in number. The M.I.T. Environmental Laboratory and the Energy Laboratory are interdisciplinary mission-oriented laboratories designed to encourage research on environmental issues which cross academic departments and schools.

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.

Information concerning environmental education and research activities at M.I.T. is centered in the office of the Provost, which works closely with faculty and appropriate centers and laboratories. Further information, lists of departmental advisors, and sample programs of study on environmental issues are available through the office of the Provost, Room 3-234.

As of 1973, a graduate degree in Environmental Engineering is offered by the School of Engineering. The specific description of this degree program follows.



Environmental Engineer

The School of Engineering offers an interdisciplinary graduate program in environmental engineering leading to the degree of Environmental Engineer. The program is directed by a standing interdepartmental committee composed of faculty 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 the new degree is to provide appropriate recognition and certification for a coordinated program of graduate study which is characterized by its breadth of scope and by its overriding concern with the interactions between technology and the environment.

Requirements 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. The subjects are to be distributed as follows:

Basic Engineering Subjects
A set of approved subjects in an environmentally related engineering area, the set of subjects to be approved by the standing interdepartmental committee. Units to total at least 66, at least 44 of which must be in graduate "A" subjects.

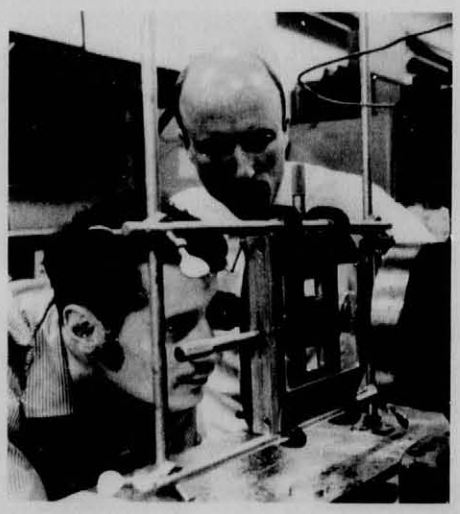
Environmental Engineering Subjects
At least three, selected from an approved list in one of the following areas: 1) air quality; 2) water quality; 3) natural resource utilization, either Option A: materials or Option B: energy. Units to total at least 25.

Environmental Policy Subjects
At least five, selected from an approved list. Units to total at least 42.

Free Electives
To raise total units to at least 162.

Thesis
Dealing with both the technical and the policy aspects of an environmental engineering problem. Thesis proposals must be approved by the standing interdepartmental committee. In some instances a Master's thesis written at M.I.T. may be accepted as fulfilling this requirement. All theses must be defended before the Committee. Units to total at least 24.

Additional information about the Environmental Engineer degree may be obtained from Professor Peter S. Eagleson, Chairman of the standing interdepartmental committee.



Health Sciences and Technology

Harvard University and M.I.T. are engaged in a major collaborative effort, the Harvard-M.I.T. Program in Health Sciences and Technology, designed to focus science and technology on human health needs. In this Program, 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 Program 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 Program'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 Program 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. These subjects in human biology are available to qualified graduate and undergraduate students who may be interested in particular aspects of the biomedical sciences curriculum.

At this time, students may select a program of study in biomedical sciences

leading to the M.D. degree, or in biomedical engineering leading to the Ph.D. degree.

Biomedical Sciences Curriculum
This curriculum has these characteristics and objectives: it attempts to develop the interface of medicine with the natural sciences and engineering and to foster an informed understanding of the social and human implications of health activities; it seeks to afford curricular flexibility and richly diversified educational opportunities that are appropriate to the interests, talents, and aspirations of each student; and it is designed to promote continuity and coherence in the educational experience of the student, beginning in college and extending through predoctoral education into the postdoctoral period.

The educational program 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 his interest that may complement the courses offered in the Program. 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. degree program. Students in the Program join the students of the regular Harvard Medical School curriculum in the clinical clerkships. Program 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, Program 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. While students are selected principally from applicants who are enrolled at Harvard, Radcliffe, or M.I.T., students from other colleges and universities are eligible to apply for admission to the Program.

In addition, qualified undergraduates at Harvard, Radcliffe, and M.I.T. are eligible to apply to the Program 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 the Harvard Medical School be completed prior to enrollment in the Program; 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.

Since the Program seeks to design individualized educational programs, there is no single curriculum. Many variations are possible. The following scheme is presented for illustrative purposes and as an indication of subjects developed for the Program. In many of the subjects offered during the first and second years, the significance of the medical sciences for the understanding of health and illness is emphasized by affording the student the opportunity to study normal individuals and patients with various clinical disorders.

Year 1

	Fall term
HST-010	Functional Anatomy of Man
HST-030	Human Pathology
HST-141	Molecular Basis of Some Clinical Disorders

	Spring term
HST-090	Cardiovascular Pathophysiology
HST-060J	Endocrinology
HST-080	Hematology (half term)
HST-120	Gastroenterology (half term)
HST-020	Bone and Connective Tissue (half term)
HST-021	Biology of the Skin (half term)
HST-070	Human Reproductive Biology (half term)

Additional subjects may be selected from among human physiology, general biochemistry, microbiology, immunology, immunopathology, and other fields. The number of subjects taken by each student will vary depending on the student's prior preparation and the pace at which he or she prefers to work. During the summer between Year 1 and Year 2, opportunities for research or for work in health care programs is provided insofar as possible for interested students.

Year 2

	Fall term
HST-130J	The Human Nervous System
HST-110	Renal Pathophysiology
HST-100	Respiratory Pathophysiology
HST-040	Mechanisms of Microbial Pathogenesis

Spring term
Students will be encouraged to study or to do research in areas of their special interest. They may choose, however, to begin the study of clinical medicine. If the spring term is spent in additional preclinical study, the opportunity to begin clinical work will be available at the beginning of Year 3.

Years 3 and 4
The students in the Harvard-M.I.T. Program join the students in the regular Harvard Medical School clinical clerkships. Every effort will be made to provide students from the Program with special educational opportunities which take advantage of their backgrounds in science and engineering.

Biomedical Engineering Curricula
The curricula in biomedical engineering focus on engineering, the physical sciences, and mathematics as they relate to human biology and medicine; they lead 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. (See the description of Biomedical Engineering earlier in this Chapter).

A spectrum of academic offerings is available or under development. These range from basic subjects in systems physiology, biomechanics, biomedical materials, and fluid flow, to subjects in the development of new medical and biological techniques. Also under development is a program, analogous to the clinical clerkships of medical students, which combines lectures with tutorial sessions in several of the local teaching hospitals. This program will provide educational opportunities for bioengineering students in such areas as cardiology, surgery, anaesthesiology, radiology, neurology, orthopedics, pulmonary and renal disorders, and physical rehabilitation. These educational opportunities will be developed in conjunction with the organization of departments or units of medical engineering in the Harvard teaching hospitals. Bio-engineering subjects developed or supported by the Program include:

2.277	Biomedical Fluid Mechanics
2.75	Biomechanics
2.76J and HST-530J	Biological Effects and Medical Applications of Ultrasound and Non-ionizing Radiations
2.900J 3.101J	Biomedical Materials
2.907J 8.531J	Science and Engineering of Biological Membranes and Structural Tissue
5.64J 7.07J	Biophysical Chemistry
8.013	Physics I
8.023	Physics II
8.033	Physics III
8.043	Physics IV
22.83S	Physical Aspects of Nuclear Medicine
HST-510	Medical Engineering Practice
10.58J HST-520J	Artificial Internal Organs
2.793J 6.023J 16.351J	Quantitative Physiology; sensory and motor systems
16.352J	Sensory Neural Systems
9.341J 16.353J 6.532J	Seminar in Sensorimotor Processes
Harvard Engineering Science 145	Introduction to Systems Analysis with Physiological Applications
Harvard Engineering Science 146	Fluid Flow in the Human Body
Harvard Engineering Science 148	Bioelectric Signals and Their Processing in Neural Networks

See also many of the regular subjects presented by the departments in the School of Engineering and School of Science.

Many of the regular subjects offered by the Department of Biology, the Department of Nutrition and Food Science, and the Department of Psychology are relevant to this Program. See also subjects offered by Harvard College and Harvard Medical School.

An educational program in health services planning and management is being developed at M.I.T. This program will seek to provide educational opportunities for individuals currently involved in the operation of health care programs and for students interested in careers in the planning, operation, and management of health services. See the Department of Urban Studies and Planning and the Sloan School of Management.

Further information about the Program may be obtained from the office of the Director of the Program, Room 16-512 at M.I.T.

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.

For those interested in formal law school training after graduate work at M.I.T., the Office of Preprofessional Advising and Education and the Prelaw Advisory Council provide guidance and information concerning admission to, and programs in, various law schools. They and the Coordinator of Law-Related Studies also have additional information regarding the Law-Related Studies Program at M.I.T.

Neurosciences Research Program

The Neurosciences Research Program (N.R.P.) is an international, interdisciplinary, and interuniversity organization of scientists operating under the sponsorship 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 man.

The N.R.P. consists of a center staff located in Brookline, 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 are four main elements in the program of the N.R.P.: the operation of information-exchange activities within the world-wide neuroscience community; the organization of scientific meetings; a program of publications, and programs in graduate and post-doctoral education. There is opportunity for a few M.I.T. graduate students and postdoctoral fellows to participate in a seminar, 7.97 Seminar in Neuroscience Research Topics.

For more information, contact F. G. Worden, Director, 165 Allandale Street, Jamaica Plain Station, Boston 02130; telephone 522-6700.

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, Metallurgy and Materials Science, or Chemical Engineering, and have his or her program of classwork and research specially arranged in consultation with an interdepartmental committee chosen for the purpose. This procedure allows for a high degree of flexibility, depending on the candidate's central interests.

It is expected that the student will select at least four subjects from the following list:

1.471J 3.91J	Mechanical Behavior of Plastics
2.905	Polymer Viscoelasticity
2.921	Polymer Deformation and Fracture
3.21	Kinetic Processes in Materials
3.66	Materials Science of Polymers
3.68	Electrical and Optical Properties of Polymers
10.641	Structure and Properties of Polymers
10.681	Physical Chemistry of Polymers
10.691	Principles of Polymer Synthesis

In addition, the candidate 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. The supporting subjects listed below indicate the scope of offerings available for the formulation of individual programs:

	Polymer Chemistry, Polymerization, Synthesis
2.906	Physical Chemistry of Macromolecular Systems
5.42	Organic Chemistry
10.67	Polymer Science Laboratory
10.682	Statistical Mechanics of Chain Molecules
10.692	Advanced Topics in Polymer Synthesis
10.695	Network Formation in Polymers
10.698	Seminar in Polymer Chemistry

	Continuum Deformation and Mechanical Behavior
1.41J 3.90J 13.16J	Fracture of Structural Materials
2.072	Mechanics of Continuous Media
2.073	Solid Mechanics-Plasticity and Anelastic Deformation
2.301	Advanced Mechanical Behavior of Materials
2.333J 3.26J	Physics of Deformation and Fracture of Solids II
2.923	Mechanical Behavior of Fibers
3.39	Fracture Mechanisms in Materials
10.311	Continuum Mechanics
10.51	Macromolecular Hydrodynamics
10.642	Viscoelasticity of Polymers

	Polymer Processing and Applications
1.472J 3.92J	Composite Materials
2.867	Thermomechanical Processing of Polymers
2.914	Fibers and Polymers Seminar
2.922	Mechanics of Fiber Processing
3.37	Deformation Processing
3.67	Polymer Processing
10.696	Compounding and Processing of Polymers

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

Power Engineering

Academic programs and research in power engineering are active on an interdepartmental basis in the Departments of Aeronautics and Astronautics, Electrical Engineering, Mechanical Engineering, Ocean Engineering, and Nuclear Engineering. These programs cover a wide range of activities in various aspects of power systems.

Research in power systems is carried on by individual professors in various departments as well as at the Gas Turbine Laboratory, Electric Power Systems 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 the following subject offerings and research activities an academic program and thesis research which he or she wishes to pursue. Research assistantships are available for graduate students, and some part-time employment is available for undergraduates. For information on financial support the Graduate Registration Officer of one of the participating Departments should be contacted.

2.23	Environmental Pollution Seminar
2.275	Turbomachinery Design
2.615	Advanced Internal Combustion Engines
2.618	Automotive Vehicles
2.621	Gas Turbine Design
6.681	Power System Engineering I
6.682	Power System Engineering II
6.684	Special Topics in Power System Engineering
6.685	Dynamics of Electric Machines
13.21	Ship Power and Propulsion
13.22	Naval Ship Propulsion
13.25J 2.41J	Thermodynamics of Power Systems
13.26J 2.601J	Thermal Power Systems
13.27	Ocean Engineering Power Systems
14.23	Economics of Fuel and Power
16.52	Introduction to Energy Conversion
16.53	Rocket Propulsion
16.54	Aircraft Engines
16.541	Aircraft Turbine Engines
16.55	Ionized Gases
16.551	Plasma Propulsion and Power Generation
22.312	Engineering of Nuclear Reactors
22.313	Advanced Engineering of Nuclear Reactors
22.32	Nuclear Power Reactors
22.33	Nuclear Reactor Design
22.34	Economics of Nuclear Power
22.35	Nuclear Fuel Management
22.39	Nuclear Reactor Operations and Safety
22.62	Thermonuclear Reactor Design

In addition to these subjects treating specific topics in power engineering, many other related subjects are available on thermodynamics, fluid mechanics, heat transfer, control theory, materials, stress analysis, vibrations, cryogenics, and combustion.



Centers and Divisions

Center for Advanced Engineering Study

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 programs of the Center include the Advanced Study Program, the Advanced Study Program in Air Transportation, the Advanced Study Program in International Nutrition Planning, the Education for Public Management Program, short programs in specialized areas of science and engineering, and interdisciplinary projects concerned with the potential contributions of new and advanced technological developments to important and complex problems. Full descriptions of all the Center's programs are given at the end of the School of Engineering in Chapter IV.

Center for Transportation Studies

The Center for Transportation Studies has been established to promote cooperation on interdisciplinary and intermodal matters in transportation, to facilitate innovative research in transportation, and to provide a focal point for educational programs within the Institute. The Center's research emphasis is on problem-oriented, interdisciplinary, 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. Interdisciplinary 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 interdisciplinary 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 and community values, railroad reliability and network planning, innovative urban transportation, transportation in developing countries, transportation demand models, urban freight movements, airport planning and development, commodity movement, industry location, freight terminal simulation, energy transport, superport location, air traffic control, dual mode transportation, 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.

Graduate programs leading to the master's and doctor's degrees and professional training are available through the departments in cooperation with the Center. The master's level program is designed to prepare an individual for a professional career in transportation planning, analysis or management. The doctoral program is for students interested in teaching, consulting and other research-oriented transportation careers. The professional training program is offered primarily to meet the needs of the practicing professional in industry and government.

The academic program includes subjects in the areas of transportation system analysis, economics, social and environmental effects, management, public policy and technology. The core subjects are:

1.201	Transportation Systems Analysis
1.281	Transportation Economics
1.290J	Introduction to Transportation
2.120J	Technology

These subjects emphasize the fundamental disciplines underlying analysis, planning and problem-solving in transportation. Although most students will take the core subjects, programs are flexible to allow an individual the latitude to pursue a particular area of specialization. For each graduate student a selection of subjects will be made from those available at the Institute to tailor his or her education to the particular requirements of his or her subsequent career. The subjects available include:

	Transportation Systems
1.202	Analysis of Transportation Demand
1.203	Transportation Supply Models
13.61	Network Scheduling, Routing and Planning
13.63	Reliability, Availability and Maintainability of Systems

	Theory and Methods
1.00	Information Systems
1.07	Analysis of Uncertainty
1.183	Applications of Multivariate Statistical Analysis
1.143	Mathematical Optimization Techniques
1.146J 2.192J 13.62J	Engineering Systems Analysis
1.148	Decision Theories and Social Realities in Engineering and Planning
1.154	Simulation Methods

	Modally Oriented
1.231J 16.781J	Planning and Design of Airport Systems
1.232J 16.782J	Airport Operation and Management
1.24	Transportation Investment Planning and Programming
1.25	Innovative Urban Transportation Systems
1.45	Highway Technology
13.65	Ship Production Analysis
13.66	Marine Transportation Economics
13.67	Marine Decision Making Under Uncertainty
13.68	Management of Marine Systems
16.72	Air Traffic Control
16.73	Airline Management and Marketing
16.74	Air Transportation Economics
16.751	Flight Transportation
16.77	Flight Transportation Operations Analysis II
16.752	Flight Transportation Seminar

	Problem Oriented
1.22	Topics in Commodity Distribution
1.262J 11.66J	Transportation Policy Analysis
1.271	Research Seminar in Transportation
1.282	Structure and Economic Characteristics of Transportation Services
2.066	Noise and Vibration in Transportation Systems
11.08	Urban Transportation Planning
16.79	Legal and Regulatory Aspects of Transportation

	Transportation Related
1.162	Analytic Formulation of Engineering Systems Problems
2.190J 20.05J	Modelling and Analysis of Systems Pertaining to National Development
1.74	Public Expenditure Theory
11.01	The Planning Process
11.06J 17.32J	Politics, Planning, and Public Policy
11.07	Economic Theory and Urban Planning
11.232	Urban Land Development
11.271J 14.573J	Urban Economic Analysis I
11.272J 14.574J	Urban Economic Analysis II
11.403	Urban and Regional Growth Issues in Developing Countries
11.41	Metropolitan Planning in Developing Countries
11.44	Regional Economic Analysis
11.48	Applications of Regional Economic Theory
11.64J 6.281J 16.76J	Analysis of Urban Service Systems
17.980	Seminar in Urban Politics

Each program will be decided upon by the student and his/her faculty advisor and approved by the associated faculty.

The master's program will be conducted in cooperation with the students' department of registration and requires the equivalent of at least one year of full-time study. It can ordinarily be completed in about two years with a student assistantship, the exact duration depending on the individual's background and area of specialization. For a master's degree, a thesis topic will generally be selected by the student in an area of research and study which is under investigation in the Center or by associated faculty.

For a Ph.D. in transportation the candidate, working from his department of registration, will form an interdepartmental doctoral committee spanning the area of interest. The Center for Transportation Studies will assist in forming this committee. A program of study particularly designed to meet his or her needs will be worked out with the committee and approved by the department of registration. Ordinarily, the candidate will require a complete year of course work during the first year to prepare for the general examination. The second year of study is devoted to further preparation in the candidate's major and minor fields. The final portion of the Ph.D. program centers on the doctoral dissertation, which consists of an original contribution in some area of transportation.

The professional training program is designed to provide "managers" in the transportation industry and "policy makers" in the government an opportunity to extend their knowledge of the fundamentals of transportation analysis and planning. The program will furnish an opportunity to review material studied previously or learn new material and recently developed tools and techniques. Professionals will be able to broaden their specialty areas and should benefit from the ability to approach transportation problems from different perspectives as well as to interact with other professionals in the field. Programs can be varied depending on the individual's background, interests and career objectives. The professional certificate will be awarded following satisfactory completion of the program. Participants may also want to apply for admission to the M.I.T. Graduate School as regular degree candidates. Those who are accepted and who fulfill all the requirements are eligible for advanced degrees as described above. Grades will be recorded for all M.I.T. subjects taken for credit.

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.

Entering students should apply to: Center for Transportation Studies, Graduate Registration Officer, Room 5-206, M.I.T., Cambridge, Massachusetts 02139. A formal department of registration will be assigned depending on the individual's background and area of specialization. Alternatively, students with interests in transportation studies may apply directly to the department of their choice.

Division for Study and Research in Education

The Division for Study and Research in Education administers a program which coordinates established interdepartmental procedures to provide a small number of Ph.D. candidates with experience in educational research. Insightful research in education requires a combination of skills from many disciplines; professionals need competence in the subject matter (mathematics, physics, chemistry, architecture, history, 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 specialty.

Admission to the program requires admission to a graduate department through the normal M.I.T. procedure. 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 in the normal manner. Applicants are urged to contact the Education Division Graduate Coordinator, named below, to discuss their interests and how they relate to the interests of the Division. Following concurrent department and program acceptance, applicants will be notified before April 1 of admission to the program for the subsequent academic year.

Because of the small size of the program and its innovative nature, degree requirements are based on the individual's interests and career objectives and the requirements of his or her department of registration. Students may find a wide range of Institute subjects appropriate for their programs of study, including subjects offered by the Division for Study and Research in Education.

In accordance with 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 faculty committee will include representatives from both the student's department of registration and the Division for Study and Research in Education. A thesis will be presented in educational or interdisciplinary research. The Ph.D. degree will be awarded through the student's department on recommendation of his or her faculty committee.

Further information may be obtained by contacting the Dean of the Graduate School, Room 3-134, or the Education Division Graduate Coordinator, Dr. Edwin F. Taylor, Room 20-B-138.



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 traffic control systems rather than the design of cars; with the management, organization, and scheduling of production rather than the technology of machines; and with 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.

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. 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, equipment replacement and marketing. Public systems applications encompass health services, police operations, housing, energy, and transportation. In most applications emphasis is laid on the successful integration of field data and measurements with mathematical models and computers to assist managerial decision making.

The Center interacts with faculty members from all the Schools at M.I.T.; its staff members and students are affiliated with numerous Departments, in-

cluding Urban Studies, Management, Mathematics, Physics, Aeronautics and Astronautics, and Civil, Electrical, Mechanical, and Ocean Engineering.

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 operations research. Or, during the first or second year of their graduate program, these students may decide to apply for admission to the interdepartmental doctoral program in operations research. Subsequent steps to the attainment of an interdepartmental operations research degree are the same for these students as for those entering directly.

Students seeking either a departmental master's degree with emphasis on operations research or a specified master's degree in operations research should normally apply for admission to the department of their choice, rather than to the Center directly.

The following basic subjects, or equivalents thereof, are recommended to master's degree candidates who wish to concentrate in operations research. This program is designed to prepare graduates to do professional work in the field. Also, these subjects will provide a solid background for students who desire to continue their work toward a doctorate in operations research:

6.041	Probabilistic Systems Analysis
6.262J	Advanced Markor Models and Their Applications (A)
15.065	Decision Ana' sis (A)
15.081	Mathematical Programming (A)
15.075	Statistical Theory and Application (A)

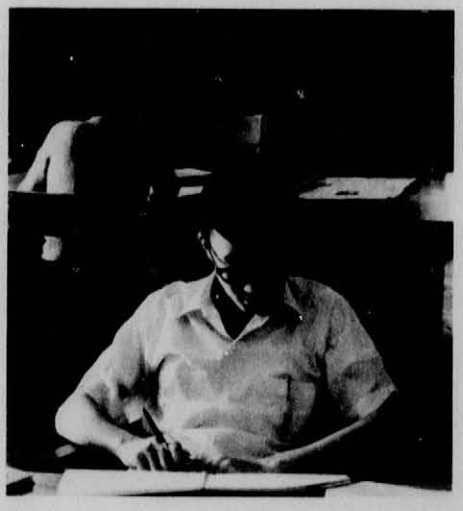
A master's candidate elects further subjects to develop a cohesive educational program. Details are worked out in consultation with his or her advisor. In addition, each S.M. candidate writes a master's thesis.

The goal of the doctoral program in operations research is to enable the doctoral candidate 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.

Candidates for the doctorate in operations research normally complete the following subjects: 1) the subjects listed above for the Master of Science; 2) 18.100 Analysis I; 15.083 Combinatorial Optimization, or 6.251J/15.084J Nonlinear Programming and Discrete Optimal Control; 15.073 Stochastic Systems; 3) one additional graduate subject in mathematics; 4) a research seminar in operations research; and 5) a minor consisting of an approved program of three subjects. An individual student in consultation with his or her advisor may make adjustments in this program to reflect special interests. Additional subjects in operations research or closely related to the field are listed in a brochure available from the Center; the subjects represent some of the electives which the student may select in constructing his program.

The doctoral candidate must pass a qualifying examination, normally taken during the second term at M.I.T. Following that, the requirements for the doctor's degree include a general examination consisting of both oral and written parts, normally taken in the fourth term of graduate study, and the completion of a dissertation which represents an original contribution to knowledge expressed in a satisfactory form. A doctoral candidate also selects a suitable minor program consisting of at least three subjects in a field not directly related to operations research.

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 Center. Inquiries may be addressed to: Professor John D. C. Little, Director, Operations Research Center, Room 24-215, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139.



Interdisciplinary Research Facilities

Arteriosclerosis Center

The Arteriosclerosis Center is an interdisciplinary, 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 V. 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, Electrical, and Mechanical Engineering at M.I.T. and the Department of Nutrition and Food Science.

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. Major projects include: a large clinic for the diagnosis and treatment of arteriosclerosis and its precursor risk factors; a Noninvasive Diagnostic Laboratory for the assessment of cardiovascular disease by methods which do not penetrate the human body with catheters or significant doses of radiant energy; a laboratory for animal research in atherogenesis; a laboratory for research into the structure and function of human plasma lipoproteins; and basic investigations of blood flow and intravascular turbulence.

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 persons should contact the Center's headquarters at M.I.T. 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" suggests a primary interest in understanding the class of phenomena associated with the layman's use of words like "mind," "mental," "intelligence," "purpose," and "perception." "Cognitive engineering" suggests a fundamental respect in which the Laboratory's approach to such problems differs from that of philosophers and psychologists: the cognitive engineer tries to produce intelligence. In the Artificial Intelligence Laboratory this leads to these branches of activity:

Heuristic Progamming and Robotics The Laboratory is well known for its work in Artificial Intelligence in constructing machines capable of such cognitive functions as seeing, understanding English, and learning.

Mathematical Studies The Laboratory is equally distinguished for its tradition of mathematical investigation into the computational complexity and forms of cognitive functions.

Education The computational analysis of intelligence has led to new insights into how intelligence develops in people and to some radically new concepts of how it can be made better. Increasingly, the fundamental problems of robotics and of education are seen as convergent. For both areas the key problems turn around questions such as, what is knowledge? how can it be represented? what mechanisms can govern the interaction of diverse goals and purposes? In the Laboratory, work on education takes several forms: experimental and theoretical studies of children in the style of Piaget; curriculum development and experimental teaching aimed at finding a substitute for the elementary school as an educational environment for young children; studies of riding bicycles, juggling, eye-movements, musical perception, philosophical puzzlement, mathematical thinking, and other human abilities.

Work on these problems requires knowledge of mathematics, of subjects related to machine intelligence, such as programming techniques, and subjects related to "natural intelligence," such as epistemology, linguistics, the history of ideas, dynamic psychology, and so on. Perhaps the unique feature of the Laboratory's methodology is the goal of uniting sophistication in these areas so as to create a coherent new discipline rather than an "interdisciplinary" interaction. In following this goal the Laboratory is developing a new program of graduate studies which will include seminar subjects in appropriate mathematics, philosophy, and psychology; laboratory work in heuristic programming and robotics; and work with children towards the goal of creating new educational forms. The Laboratory has faculty and material resources to support doctoral theses in any of these areas. For additional information, students should contact Professors Marvin Minsky, Seymour Papert, or Patrick Winston at the Artificial Intelligence Laboratory, M.I.T.

Bates Linear Accelerator

In 1951, a small linear accelerator was completed at M.I.T. by a team of research groups working in both the Research Laboratory for Electronics and the then Laboratory for Nuclear Science and Engineering. This machine, developed under the leadership of the Department of Physics faculty and staff, found itself among the prototype linear accelerators that emerged following the stimulus of the advances in microwave radar power sources and techniques during World War II.

Operated by the Laboratory for Nuclear Science and Engineering as a research tool, the "17 Mev Linac," as it was known, served over the next decade to generate a number of studies using the accelerator as a source of electrons and gamma rays with which to examine the properties of the atomic nucleus. The machine also provided the focus for the growth of a small but competent group of researchers who, with their students and others in the field, recognized the increasing importance of electrons as

probes with which to look at the nucleus of the atom. By the early 1960's, and after a steady progression of pioneering machines developed at M.I.T. and elsewhere, it was clear that further experimental progress required the advantage of electron beams of higher energy and of better precision and yield. At this point, the M.I.T. group undertook the task of developing a facility of advanced design suitable for the next generation's effort, leading to the development of the plan for the present 400 million electron volt William H. Bates Linear Accelerator.

The Accelerator's operation as a facility and the research projects to be undertaken with it are planned through Laboratory for Nuclear Science-Atomic Commission support and, where appropriate, by scientists-users from other universities and institutions through their own research contracts with the A.E.C., the National Research Foundation, and other sponsors with relevant interest in this field.

During the past few decades, the study of the nucleus and its components has necessitated equipments of such size that require them to be available essentially as national facilities and to a wide community of investigators. The William H. Bates Accelerator, though funded by the U.S. Atomic Energy Commission through M.I.T. for use within its Laboratory for Nuclear Science, will be accessible also, through a formal user's organization, to eligible researchers in the New England area and the nation as a whole. Toward these ends a Policy Board and a Program Advisory Committee for the Accelerator have been established comprising representative non-M.I.T. membership from among recognized leaders in the field.

As currently being completed, and in the form that will, at first, be usable, the machine will have its major application to research involving the scattering of electrons from a variety of nuclei. Taken together with a large novel magnetic analyzer being built to detect the scattered electrons, the high quality of the Bates Linear Accelerator beam will make possible a large number of precisely controlled experiments.

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 225 kilogauss and pulsed fields to 750 kilogauss are available in a variety of configurations. A magnetically shielded room of walk-in size is available for ultra low magnetic field experiments. The special facilities of the Laboratory are made available to research groups from other 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 the magnetic, electrical, optical and acoustic properties of solids with the aim of increasing understanding of the electronic band structure, the lattice vibration spectrum, phonon-electron interactions and magnetic interactions. The research effort in plasma physics includes work on laser-induced breakdown and heating of magnetically confined plasmas, and the Alcator thermonuclear fusion experiment.

The Laboratory also conducts research and development programs aimed at the practical application of magnetic fields to technology and medicine. These include magnetically guided catheters, studies of the weak magnetic fields of the human body, magnetic separation, and magnetic levitation and propulsion of high speed ground vehicles.

Faculty and students from the following departments are conducting research at the Laboratory: Physics, Electrical Engineering, Metallurgy and Materials Science, Chemical Engineering, Nuclear Engineering, Aeronautical and Astronautical Engineering, Mechanical Engineering, Biology and Chemistry.

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

Center for Advanced Visual Studies

The Center for Advanced Visual Studies provides artists of achievement with the opportunity to explore new artistic forms of civic dimensions warranted by the scientific technology and complex scale of our urban world. Collaboration through a working dialogue between artists and scientists and engineers is of primary importance in the exploration of new creative objectives. This mutually beneficial contact between artist and scientist allows the artist to develop the technical competence to utilize advanced technology and test its applications to new creative challenges.

A limited amount of work space is available for a small number of research affiliates and special students, though there is no formal program of study offered and no degrees are granted.

Center for Cancer Research

The Center for Cancer Research provides facilities for interdisciplinary 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. Seminars in cancer research both for credit and as public colloquia of the Center are available.

Center for International Studies

The Center for International Studies is a research center on the social, political, and economic problems of the contemporary international scene, particularly those related to scientific and technoiogical 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, with some illustrations of current and planned projects:

Science and public policy Part of the Center's program is concerned with the

broad question of the ways in which scientific and technological changes affect public policy decisions. Within this program area, research is underway on long-term resource availability, the international management of pollution, problems related to the international control of the resources in and under the oceans, and the general problem of how technical advice is utilized in the policy-making process. In addition the Center has been seeking to identify priority research needs in this area.

Problems of advanced industrial societies It is increasingly recognized that the advanced industrial societies face a number of public policy choices in the same or similar problem areas. Each has much to learn from the experiences, successes, and failures of the others. For example, the Center together with several other American and European universities is studying the approaches taken in Europe, North America, and Japan to environmental protection and improvement. Another study is planned on the national and international implications of likely growth of the nuclear energy industry. The question of economic dualism — the persistence of non-modern economic sectors in advanced industrial societies — is being studied in the U.S. and in Western Europe.

Project in international business The role of international businesses in the international sphere and the international problems encountered by international corporations constitute major new areas of Center research in collaboration with the Sloan School of Management. A program of studies has been initiated to do research on the economic and political environment within which international business operates and the interrelated effects between their operation and that environment. Specific subjects selected for analysis include the following: monetary system reform; adjustment assistance; costs and benefits to the host country of direct foreign investment; "reverse investment" in the U.S.; effects of disequilibrium exchange rates on foreign investment decisions; workers' participation in management; comparative studies of changes in economic returns to corporations; evolution of an industrial complex in non-industrial countries and the role of foreign investment; early indicators of trade impacted industries; national efforts to establish guidelines for the behavior of multi-national enterprises. In addition, research is being done on the effectiveness of public sector enterprises and economic development and on the role of business leadership in economic development in Africa.

International nutrition planning program Jointly with the Department of Nutrition and Food Science, the Center has initiated a program of research and training on questions relating to the critical problem of malnutrition in low income countries. The program brings to bear the contributions of many disciplines at the Institute. The program has three long-range objectives: to serve as a source of policy advice on matters relating to nutrition planning and alternative strategies; to provide a training program; to mount a research program related to the delivery of nutrition services. Several training programs on nutrition planning have been held for members of aid-giving agencies, people engaged in technical assistance in the field of nutrition, and officials from governments seeking to set up nutrition improvement programs. In addition, efforts are being made to develop a model capturing the variables — food supplies, health, sanitation, etc. — that affect nutrition in order that alternative approaches to nutrition planning can be tested.

Communications policy One consequence of the rapid growth of new electronic communications systems (such as radio, TV, CATV, telephone, satellites, etc.) is that one cannot take the historically evolved communication system for granted. The design of the system itself becomes a policy issue on the agenda of the day. Among the topics being addressed are: the comparative structure of communication regulation in advanced industrialized countries; the development of a world-wide data communication system of particular use to developing countries; the international controversy about direct satellite broadcasting; and the allocation of spectrum for landmobile communication. Research in this area is being carried on in collaboration with the Center for Policy Alternatives.

Migration studies A number of Center research projects deal with the political effects of the movement of people, within states and among them. A migration and development study group has been created to provide a forum for discussion among those working on migration questions and a framework for designing further research. The focus of the study group will initially be on three interrelated problem areas: the place of origin of migrants, the factors that influence outmigration, and the impact of return migration and outmigration; migration of skilled populations; the relationship between employment, wages, and migration and their impact on the distribution of income. Research is underway or planned on internal migration in India, Mexico, Nigeria, and Indonesia as well as on migration among countries in Europe, the Middle East, and North America.

Arms control problems The Center has developed in collaboration with the Program for Science and International Affairs of the Center for International Affairs at Harvard, a major program of research, teaching, publication, and seminars on arms control and disarmament issues. A joint seminar has been instituted, with participants drawn from the Cambridge community; new courses are under consideration; and research has begun on such issues as safeguards against diversions from nuclear power plants, the considerations that lay behind the successful negotiation of the strategic limitations of SALT I agreements, trade in arms, and non-superpower interests in arms control. Funds are available under this program to support a limited number of doctoral dissertations.

International political problems and conflict studies A number of Center research projects fall under this general area. Included among these are: studies of communism, revisionism, and revolution; patterns of international interdepen-

dence; comparative studies of internal social conflict; relations among classes and nationalities in the Soviet Union.

Political and economic development For many years a major focus of research at the Center has been on development. At present research is under way on: voting behavior in India, constitutional change in Yugoslavia, communication in Indonesia, group identity and ethnicity, changes in Asian political cultures, and the impact of modernization on Asian institutions.

Social science methodology In addition to research on substantive international issues, the Center has a long-term concern for developing and improving social science methodology. A large part of the current work in this area concerns methodologies of forecasting and the development of software and languages for social science research, particularly on high-capacity high-speed minicomputers.

Further information about the Center and its research program can be obtained from the Director, Professor Eugene B. Skolnikoff.



Center for Materials Science and Engineering

The Center for Materials Science and Engineering (C.M.S.E.) is located in the Vannevar Bush Building. Funding of research at C.M.S.E. comes largely from the National Science Foundation as part of its Materials Research Laboratory core-funded program. Additional projects and programs are funded through other sources and agencies.

Graduate and post-doctoral research assignments are arranged through individual faculty members who receive support through C.M.S.E. Located within C.M.S.E. are solid state oriented faculty groups from the Departments of Physics, Metallurgy and Materials Science, Electrical Engineering, and Chemistry. Other faculty from these same departments, as well as some from Mechanical Engineering and Civil Engineering, also receive research support, however they are located within their respective departments.

Undergraduate research programs may also be arranged through participating faculty.

C.M.S.E. maintains excellent, modern central service facilities such as an analytical laboratory, machine shop, four crystal growing and characterization laboratories and facilities for NMR, scanning electron microscopy, Leed and Auger, electron microscopy, electron microprobe, ion microprobe, and others. These central facilities are available to everyone in the M.I.T. materials community, as well as to others who may require the expert services and consulting advice.

Major research programs currently supported by the Center are concerned with surfaces and surface phenomena; materials processing; mechanical behavior of materials with emphasis on temperature and strain rate effects; optical sciences, materials and applications; electronic materials and microelectronics; interdisciplinary science with emphasis on phase transitions and critical phenomena.

The Director of the Center is Professor Nicholas J. Grant. There are two Assistant Directors, Professor Peter Wolff and Professor Merton Flemings.

An annual report *Research in Materials* is published by C.M.S.E. covering all research in materials at M.I.T., including that portion performed through support by C.M.S.E. This report is available through the Center by contacting David Mauriello, Room 13-2149.

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 beneficially connect technology and social and economic welfare, and to stimulate faculty and students to participate in activities which have the greatest potential to social or economic utility.

The Center studies and investigates substantive issues for a wide spectrum of pressing socio-technical 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.

The Center encourages studies related to these issues in all parts of the Institute and provides a mechanism whereby students and faculty can become involved in the analyses of real problems that lead to alternative policies and programs and

evaluation of their consequences. The Center has close ties and cooperates with other departments throughout M.I.T. in order to interlock with such disciplines as political science, economics, management, systems studies, and architecture and urban planning.

Research activities are carried out by the Center's interdisciplinary professional staff, by associated faculty and students (graduate and undergraduate) from M.I.T. and other educational institutions, and by part-time participants from government and industry. In addition, research groups in several foreign countries work with the Center in the study and analysis of issues of international scope.

The Center's Technology Policy Program is illustrative of the kind of research activity that the Center fosters. The program seeks to examine and evaluate the mechanisms of government policy which influence technological change in various nations, and then to develop alternative policies to encourage technological change for economic and social welfare in individual countries. Research focuses not only on policies and mechanisms influencing invention, innovation and diffusion of technology, but also on government instruments for ameliorating or moderating the adverse consequences of technical change within the society. As an international cooperative effort supported in part by foreign nations, the exchange of Center participants with representatives of the studied countries plays a central role in the overall research effort. Although the program currently focuses on France, Japan, West Germany, the Netherlands, the United Kingdom, São Paulo (Brazil) and the U.S., other nations will be included as new cooperative arrangements are established.

Some of the other initial program areas being studied in the Center include: the supply and demand of professional manpower; selected problems in the industrial system such as improving the serviceability of consumer durables and developing strategies for integrated computer/machine processing; the international transfer of technology; alternatives for engineering education in the U.S.; occupational health and safety; coastal zone policy; and defining strategies for the development of the drought-affected Sahel-Sudano zone of Africa.

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 and in developing individual research projects. During 1974–75, some of the program areas being developed and expanded include: science, technology and public policy; manufacturing technology, the nature of work and job satisfaction; natural resources, recycling and substitution; energy policy; communications policy; and the delivery of public services, particularly education, health and municipal services.

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 39-551, M.I.T.

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, and protostars.

Space science studies include measurement 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, and orbiting satellites. Coupled with the foregoing flight measurements are ground-based optical and radio frequency observations of related astrophysical phenomena. 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.

In other fields the Center has active projects for the measurement of multiple loop control characteristics of the human operator and biophysical evaluation of the human vestibular system, life support in unusual environments, properties of planetary surfaces and atmospheres and, finally, exploratory studies on future Space Shuttle engineering and scientific payloads.

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.



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 clinicians.

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. degrees.

Commodity Transportation and Economic Development Laboratory

This interdepartmental laboratory is designed to meet the growing need for transportation analysts and engineers in the field of commodity transportation and reflects the fact that transportation of raw materials and processed goods is crucial in the economic development of society, whether on a national or an international scale.

The projects carried on in this laboratory are of a multidisciplinary nature and are strongly oriented to specific problem solving. The main emphasis is on the analysis of effective commodity transportation systems in the context of regional, national, and international economic development and the education of modern commodity transportation engineers.

This Laboratory supplements transportation efforts presently underway at M.I.T. in the Departments of Aeronautics (air transportation), Ocean Engineering (ocean transportation), and Civil Engineering. It also interlocks strongly with many of the dispersed activities related to social, political, economic and legal aspects of commodity transportation in an effort to develop integrated approaches to the solution of transportation problems. Though the Laboratory is in the School of Engineering, close cooperation will be sought with other activities at M.I.T., as well as other universities, institutions, and organizations vitally concerned with the development and impact of commodity transportation.

Continuum Electromechanics Group

The Continuum Electromechanics Group is concerned with areas such as electrohydrodynamics and magnetohydrodynamics which involve electromagnetic forces interacting with classic as well as multiphase continua. Specific objectives range from environmental control to the development of electromechanical transducers based on biological materials.

Division for Study and Research in Education

The new Division for Study and Research in Education offers a number of opportunities for interdisciplinary work in various phases of fundamental education research. Current research foci involve relating the following areas to developing new theoretical perspectives of learning: problem solving, modeling representations and transformations of information and knowledge; group process theory, organizational learning and reliable processes for change; information processing theories of perception and new technologies.

The effort to develop new paradigms upon which to restructure early mathematics learning has been a major substantive area for the integration of much of these activities.

Several approaches to achieve new perspective on learning phenomena include:

1
Pilot programs in elementary schools involving children in new learning environments designed to augment the learning process. Practical projects include the development of hardware, software, and conceptual frameworks that will enable children of elementary school age to use a computer system to compose music, make animated cartoons, simulate space voyages and the like, thereby learning mathematics, science, music, and visual and dramatic arts in an integrated and active fashion.

2
Cognitive research underlying design of a mathematics and problem solving project for video broadcast and classroom use, geared to 8-11 year old children

3
At the higher education level, a multidisciplinary examination of student learning experience starting from difficulties in learning a subject-matter and branching out to students' experience in modeling their own learning processes

4
Research on individuals' theories-in-use and on their own efforts to develop more effective theories-in-use

5
Participant/observer case studies of organizational learning

The Division for Study and Research in Education provides opportunities for faculty and students from departments of the Institute to join in its research of educational problems. Further information about research activities in the Division for Study and Research in Education may be obtained from Professor William T. Martin, 20-C-125; Professor Seymour A. Papert, NE43-328; or Professor Benson R. Snyder, 20-C-120A.



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. Prior to its separation, the Laboratory had been for nearly 40 years an integral part of the Institute's corporate structure, with a close coupling to the academic program of the Department of Aeronautics and Astronautics. 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, 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 mutual interrelationships that lead to a complete operational system. Probably the most outstanding achievement of the Laboratory has been the technical development and supervision of the 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 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.

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 may also be employed by the Laboratory and work directly in the project itself. This provides an excellent technical internship which greatly broadens the student's educational experience.

The research work at the Laboratory is generally done under sponsored contracts. Such sponsorship has been primarily by the Department of Defense, the National Aeronautics and Space Administration, and the Department of Transportation. However, no restrictions exist that limit the nature of the sponsoring agency. The sponsored research provides challenging work in the most advanced and new aspects of science and engineering. The Laboratory is large enough to have all the facilities needed to study, design, develop, and test the engineering model of a complete aerospace system. The Laboratory is the home of inertial guidance and is world-famous and academically unique in its work in this field.

The interdepartmental doctorate in instrumentation which is described in Chapter IV in the Department of Aeronautics and Astronautics, receives much of its vitality from close association with the Draper Laboratory. Doctoral students with backgrounds in aeronautics and astronautics, electrical engineering, mechanical engineering, physics, or mathematics will find this doctoral program of interest.

Specific areas of interest for research in the Draper Laboratory are: inertial navigation systems — air, marine, space; air-traffic-control systems; components — gyroscopes, accelerometers, vehicle-borne computers; modern control theory, including industrial process control; and biomedical and oceanographic instrumentation.

Electric Power Systems Engineering Laboratory

The Electric Power Systems Engineering Laboratory (E.P.S.E.L.) is an interdepartmental laboratory within the School of Engineering. It is principally concerned with problems related to the generation, transmission, distribution and utilization of electric power but some work in the field of high power semiconductor devices is also underway 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 audible noise from UHV transmission lines, contamination flashover of insulation, design, construction and testing of an alternator with a superconducting field winding, an electromagnetically scaled model of a power system, and statistical approaches to insulation coordination. Since most of the research is experimentally oriented, design and instrumentation is a major concern almost comprising an additional research area.

The E.P.S.E.L. has all facilities necessary to perform its research tasks. A well-equipped machine shop is available for student use. A darkroom and printed circuit board fabrication facility is also available. A high voltage AC/DC power supply capable of providing 160 kV at 60 mA is available for studies of such phenomena as audible noise and corona. The laboratory also maintains an instrument room, an inventory of rotating machines and has high power 400 HZ capabilities.

For further information, contact Professors G. L. Wilson, J. L. Kirtley, Jr., or J. G. Kassakian.

Electronics Systems Laboratory

In the Electronic Systems Laboratory fundamental and applied research is carried out in broad interdisciplinary areas, closely coupled with graduate study. Faculty, students, and fulltime staff are engaged in research in the following areas: system science, control theory and applications, industrial systems control, environmental systems, biological systems, socioeconomic systems, transportation systems, aircraft dynamics and control, air traffic control, data communication networks, cable TV, information retrieval and transfer systems, man-machine systems, digital computer technology, displays, radar systems, "goods-and-services" distribution systems, and analog-digital devices. Taken together, these research efforts provide excellent educational opportunities for both undergraduate and graduate students in the analysis and design of complex systems and devices.

Energy Laboratory

In November, 1972, M.I.T. announced the establishment of the Energy Laboratory. The Laboratory is organized as a special laboratory of the Institute, as is Lincoln Laboratory, reporting directly to the Vice President for Research. The Energy Laboratory enables M.I.T. to concentrate its diverse intellectual resources on the complex societal issues and technological problems involved in supply, demand, and consumption of energy. At the same time, the Laboratory serves as a focal point for energy related research at the Institute.

The impetus for creating this Laboratory grew out of M.I.T.'s history of public service and its many contributions in the energy field coupled with the desire of various academic departments to strengthen and expand energy research and education at the Institute. Fundamental to establishment of the Laboratory was the recognition that nothing less than a comprehensive and coordinated interdisciplinary effort, such as M.I.T. was capable of launching and sustaining, would be required to resolve the projected energy crisis and develop long-range perspectives and solutions.

The Energy Laboratory was founded to serve both a public service and an educational function. In fulfilling this dual role, the Laboratory has three broad objectives:

1
To identify and work towards short-term and long-range solutions to energy related problems requiring broad, interdisciplinary capabilities drawn from humanities and social sciences, physical and biological sciences, and engineering, architecture, and technology.

This involves research, modeling, testing, and evaluating total systems, including hardware prototype development where appropriate, that takes into account such contributing factors as consumption, demand, economic feasibility, ecological impact, sociological acceptability, and the availability of energy resources. Towards this end, a highly competent staff with diverse capabilities is being recruited particularly from M.I.T. and graduates of other institutions and in addition, temporary appointments offered to key people from government, industry, other academic institutions, foundations, and concerned citizens' organizations.

2
To inform public policymakers on energy related matters and provide comprehensive and objective assessments of current and future resources, equipment, and systems involved in the supply and consumption of energy in all forms.

Identifying options for society, policymakers, and energy system managers that balance engineering, economic, environmental and societal goals provides the conceptual thrust of the program. Both long-term research efforts and specific studies of interest to industry and government are undertaken.

3
To strengthen research and educational opportunities in energy related areas at M.I.T.

In addition to involving faculty, students, and graduates of the Institute in comprehensive, large-scale energy projects, the Laboratory serves as an invaluable educational resource for training the energy engineers and scientists (physical, biological, and social), technologists, managers and policy makers of the future. In achieving this goal, members of the Laboratory staff work with and through the various academic departments at M.I.T. in developing relevant energy related subject material, curricula, and thesis-oriented research. Furthermore, the Laboratory provides a comprehensive source of reference material and a data base for energy studies.

The Laboratory is an Institute-wide special laboratory because the energy area spans engineering and sciences (physical and biological); management, and economics; plus legal, social and political factors on both national and international fronts. The size and complexity of the energy system in terms of energy sources and consumption patterns coupled with the broad interdisciplinary interactions keeps any small disorganized effort from being effective. This integrated approach by M.I.T. is in the Institute's best tradition and will yield total results exceeding the sum of the individual efforts.

As a special laboratory with a selected high quality professional staff supplementing the academic research by faculty and students, it adds a broad capability, allowing a new dimension for technological assessments, advisory functions, new prototype development, environmental evaluations, resource analysis, and utilization assessments. It can, thereby, perform studies which integrate engineering, environmental, resource, and economic aspects with societal and policy issues both nationally and internationally involved in maintaining the nation's energy system. It also offers a unique opportunity for new modes of continuing education not possible within the present academic research environment.

In the initial phase of establishing the Laboratory's programs, the approach has been to draw upon the expertise and facilities of ongoing academic programs of education and research. This has led to formulating programs that span traditional department and School lines. The six major program areas are: 1) headquarters; 2) energy economics, management, and policy; 3) fossil fuel utilization; 4) electric power; 5) energy productivity; and 6) advanced energy systems. These programs have specific projects that are funded and active, as well as projects under intensive development. Currently involved are some 25 students and over 75 faculty and staff from numerous M.I.T. departments, laboratories, and centers.

For additional information, please contact Nancy Stauffer, Room 26–143, 253-3405.

High Voltage Research Laboratory

The High Voltage Research Laboratory is concerned with the techniques for producing high-energy particles and radiation, and with their application to the needs of science, medicine, and industry. In addition, dielectrics are studied for high-voltage insulation purposes.

Information Processing Services

At M.I.T., the computer and techniques for the processing of information each serve as subjects of study and as specific tools in programs of teaching, research, and administration. Many programs are in progress that seek to contribute to our understanding of the structure of computer systems and languages and to the application of new techniques to computer design and organization, to the development of operating systems and programming languages, and to applications.

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

Students, both undergraduate and graduate, are intimately involved in much of this activity. A large majority of students begin to use the computer early in their programs of study and many continue to do so on into graduate work. Opportunities to pursue programs of study oriented toward computer sciences are available and are described elsewhere in this Catalogue. Within each department, 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 to meet the teaching and research needs of the Institute community; and those provided through the local departmental and laboratory computer facilities, which provide somewhat specialized information processing requirements to meet specific needs.

The Information Processing Center offers its users a broad spectrum of services, including high-performance job-stream processing, remote-job-entry, systems for experimentation, research and development, general purpose, interactive time-sharing, programming assistance, and documentation.

The Center provides its users with two major computer environments:

Operating System/360 A large, complex job-stream and time-sharing facility is available operating currently on an IBM System/370, Model 168, and providing a full spectrum of local and remotely-accessible services. A wide variety of programming languages and applications software is available to each user, together with consulting services and other user-oriented facilities and services. Although the principal use of this service is on a local basis, a considerable and growing fraction of the total work load of this system is generated through telecommunication connections to many locations on the M.I.T. campus and to several other universities in the greater Boston area. This system currently processes approximately 2,000 jobs per day.

Multiplexed Information and Computing Service (MULTICS) This system, currently implemented on the Honeywell 6180, was developed by a cooperative effort among the Institute's Project MAC, the General Electric Company, and the Bell Telephone Laboratories. The system, which has been generally available to the campus since the fall of 1969, provides the most advanced and sophisticated remote access service currently available. It offers a system environment and a developing set of tools not only to the novice programmer with limited applications but also for faculty and students performing the most advanced research in computer science and subsystem development. The maximum number of simultaneous users is now 70.

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.

Sequentially there are three stages of participation which the student may choose to go through. These consist of a preparatory stage where innovative ideas are formulated followed by stage one and stage two of product development. According to an individual's need he or she may go in or out at any stage or proceed with a mixed program.

In the preparatory stage the student learns the role of the innovator and the entrepreneur, studies the process for generating innovative ideas, and generates ideas of his or her own which might be established as innovation projects. A student entering the preparatory stage is encouraged to take one of the seminars offered by the Innovation Education Program.

Stage one is the first step in the development of an idea into a specific product. The goal is to develop a working model of the idea, perform an in-depth marketing survey, and prepare a business plan. The student may pursue this activity as a laboratory subject, a thesis, or a special project. In doing so he or she receives faculty supervision and retains rights relating to any accomplishments.

Stage two begins when the business plan for a product is accepted by the Innovation Co-op. Adequate financial support and professional capability are provided by the Innovation Co-op to develop the product for marketing as a new venture or to enter it into a license arrangement with existing firms. The student is involved in the operation of the Co-op as project coordinator and participates in the decision-making process. Through this association the Co-op plays an educational role in developing a potential entrepreneur that is similar to the educational role of a teaching hospital. The result is a simulation of the conditions, experiences, work pace, and market exposure that students might experience in starting their own companies. More information may be obtained from the Special Assistant for Educational Programs in the Office of the Dean of Engineering. Students who wish to participate in the program should contact the Innovation Center or register for 16.671J Invention or 16.672J Entrepreneurship.

International Nutrition Planning Program

The International Nutrition Planning (I.N.P.) Program was jointly established by the Department of Nutrition and Food Science and the Center for International Studies to address explicitly the problem of malnutrition in low income countries. Individuals involved in operations of the I.N.P. Program are drawn from the Department of Nutrition and Food Science and the Center plus the Sloan School of Management, the Center for Advanced Engineering Study, and the Departments of Economics, Political Science, Urban Studies, Mechanical Engineering, and Ocean Engineering. In addition, the Program has the cooperation of individuals at Harvard University in the Development Advisory Service, the School of Public Health, the Center for Population Studies, and the Graduate School of Business Administration. The I.N.P. Program has received initial core support from the Rockefeller Foundation.

Activities of the I.N.P. Program are concentrated in three basic areas:

1
Applied, operational research to determine and refine effective integrated approaches to national and regional nutrition planning, and implementation and evaluation of programs to combat problems of malnutrition among target populations.

2
Provision of advisory services to governments and to multilateral and bilateral assistance agencies on specific aspects of nutrition planning and programming.

3
Education and training pertaining to these approaches, and designed for students, concerned persons, and institutions involved in various facets of the problem.

The I.N.P. Program coordinates multidisciplinary graduate study relating to nutrition planning, and co-sponsors, together with the Center for Advanced Engineering Study, the Advanced Study Program in International Nutrition Planning (see C.A.E.S. description following the School of Engineering). The I.N.P. Program also carries out short-term workshops focusing on specific questions or problems in international nutrition and usually pertaining to a specific geographic area. Together with Cornell University's Program on International Nutrition and Development Policy, the I.N.P. Program publishes the *Cornell–M.I.T. International Nutrition Policy Series* of international case studies and planning efforts relating to nutrition policy. the I.N.P. Program also produces a *Technical Report Series* pertaining primarily to its field activities.

Joint Center for Urban Studies of M.I.T. and Harvard University

The Joint Center was founded in 1959 as a research unit of both Harvard and M.I.T. Its primary purpose, then and now, has been to stimulate and facilitate research in urban problems at the two universities and to encourage interdisciplinary research on issues that do not fit within conventional departmental boundaries. It has no teaching program; however, the Center provides important research opportunities for faculty and advanced graduate students at Harvard and M.I.T., and each year it offers fellowships to students in any department at either institution who are completing their dissertations, or equivalent major papers, in some aspect of urban affairs. The Joint Center publishes its work through books, monographs, and working papers.

In the past, the research undertaken was largely exploratory and quite broad based. During the last few years, however, the Center decided to focus in greater depth in just a few areas. Most particularly, the choice was made to concentrate on issues of housing policy in the United States. Housing research does not now represent the entire program of the Center, but it does reflect the major emphasis for the present time. Secondary research areas of some importance include the delivery of public services, and social status and social policy. Individual projects are still undertaken in a number of other areas as well.

Issues of Housing Policy Several major research projects are currently included within this category. Among these are projections of the nation's housing needs over the next ten years and estimates of the extent of housing deprivation; analysis of consumer preferences in housing; the feasibility of housing allowances as an alternative to present forms of low-income housing subsidies; cyclical and seasonal fluctuations in residential construction; the impact of land use and environmental regulation on housing; the availability of residential financing; development of a computer-based manpower information system for the construction industry; and microeconomic models of metropolitan housing markets. Particular emphasis has been placed on two projects. The first of these has aimed at estimating the likely levels of residential construction and the extent of inadequate housing for every section of the country over the next ten years. Taken into account in the analysis are data on population growth, migration, headship rates the demand for second homes, etc. Housing inadequacy has been measured in terms of the condition of the housing units, the ability of households to pay the rent, and the existence of overcrowding. Further work will attempt to analyze as well factors of the neighborhood environment.

The second major project has been analyzing the feasibility of housing allowances. Approaching the issue from several different standpoints, aspects of the program have been focusing on the factors that affect the housing of low-income families; the lessons that can be learned from the welfare program; evaluation of the Kansas City demonstration housing allowance program; the development of models to test the different market effects of alternative formulations of an allowance program, and the effect of increased income on recipients' housing quality; and finally, an evaluation of the economic issues that would be involved in integrating a housing allowance program with existing assistance programs.

The Delivery of Public Services During the last year, focus has begun to be placed on this secondary research area;

interest in public service delivery has been a natural outgrowth of the housing studies at the Center and several research projects have been initiated. One project within this category has begun to make a comparative analysis of "street-level bureaucrats," that is, of the municipal employees whose jobs bring them into direct contact with the public, whether they be welfare workers, police, teachers, etc. Another is looking more specifically at the police as a public service bureaucracy, a third is concentrating on the special case of public service delivery in urban neighborhoods; a fourth is studying the impact of public employee unions on the costs and delivery of services; and yet another is concentrating on revenue sharing and its impact on city budgeting.

Social Stratification and Social Policy

A third general research area has to do with questions of stratification and relative deprivation in society. Work has been and is being conducted on people's attitudes toward status, their own and other people's, and on the social meaning of low income and poverty. Further research has been exploring the changing significance of class and status imagery in society and the implications for people's behavior and expectations. One specific aspect of this research has been exploring the images that people have about the housing they live in, or that they think is appropriate to their position in society, and what they may be striving toward for themselves and their familes.

The Joint Center is off the main M.I.T. campus with offices at 53 and 66 Church Street, Cambridge, Massachusetts 02138 (253-2029 or 868-1410). Further information about the program of the Center is available from the administrative officer, Peter Leavitt.

Laboratory of Architecture and Planning

The Laboratory of Architecture and Planning was created in 1973 for the purpose of fostering research which contributes to the understanding, education, and practice of architecture, planning, and closely related fields.

Projects currently housed in the Laboratory include a study of urban public safety systems using advanced simulation techniques and limited interventions into law enforcement, fire, and ambulance systems in Boston and elsewhere; an analysis of public urban space, the ways in which it is used and changes over time, and how it is represented; a study of professional and group behavior, particularly the ways in which professionals construct mental models of their professional/client situations, and the role of the human sciences in the professional education of architects and planners; and, finally, a study of the feasibility of offering a concentrated program in environmental design and evaluation to early- and mid-career professionals.

The Laboratory also provides assistance to members of the School in their research and teaching activities through four offices: the Office of Field Services performs a brokerage function among students, faculty, outside client groups, and projects in the community and helps to evaluate the educational components of those projects; the Office of Computing Services acquires and maintains software and facilitates its use by means of documentation and special instruction; the Office of Research Administration identifies potential sources of research support, provides consultation on the preparation of proposals, and administers Laboratory affiliated projects; and the Office of Educational Services attempts to integrate the research into the educational environment of the School and the Institute through the sponsorship of lectures, seminars and conferences, a program of visiting fellows, publication support, and the maintenance of a small library. The Laboratory will also participate in the exploration of new areas of interest which might be included in the School's educational and research programs.

Laboratory for Insulation Research

In the Laboratory for Insulation Research, dielectric spectroscopy over a wide frequency range is used to study the molecular structure of biological and insulating materials.

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. A 400 MeV, high-intensity electron linear accelerator, recently completed, will extend greatly the Laboratory's capabilities in this field. In addition to M.I.T. physicists, this facility is being made available to others on a nation-wide 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 Linac 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.

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 measurement 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 with civilian and military applications.

Specific programs include space communications, re-entry studies and technology, seismic detection and discrimination of earthquakes and underground nuclear explosions, computer systems and digital signal processing, design of a prototype ambulatory medical service program, educational technology, and air traffic control. Research is also 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. Joseph Mindel, Educational Director.

M.I.T. Press

Since the M.I.T. Press became a wholly independent university publishing organization in 1962, it has grown to the point that it is now among the largest scholarly publishers in the United States. Over 1,000 books have been published under the M.I.T. imprint since the Press was founded in 1933. At the present time approximately 110 new books are issued by the Press each year — most of them original hardcover editions but including a significant number of imports and paperbacks as well.

The Press consists of five operating departments: editorial acquisitions; text editorial; media (design and production); marketing; and financial (including order processing, accounts receivable, and accounting). The director of the Press is responsible to the office of the President and the Chancellor. Editorial and management boards consisting of faculty and officers of the Institute advise the Press on policy and operations. The editorial board, in particular, is charged with administering the imprint of the Press; book projects must be accepted by the board before they are published by the 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 the world at large. The Press has worldwide distribution, through its United Kingdom subsidiary and by other means; 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.

In general, the range of publication parallels the range of the Institute's own interests. Science and technology are central areas of concentration. In addition, architecture and urban planning, critical current issues, environmental studies, linguistics and information science are among the areas characterized by a notable depth of coverage in recent Press lists. The Press has a special interest in manuscripts originating at the Institute itself; among its authors, however, are members of faculties of many other universities in the United States and abroad.

Facilities The headquarters of the Press are located at 28 Carleton Street, Cambridge, Massachusetts 02142. Its warehousing facilities are in Lawrence, Massachusetts.

The Press maintains a professional staff equipped to provide manuscript appraisal and editing and full graphic design and production (the latter by subcontract to a wide variety of compositors, printers, and binders). Its marketing effort includes direct mail, space advertising, and direct sales activities, so managed as to create access to a large general audience for those books appropriate for that readership as well as awareness within the specific group of scholars to which a monograph may be directed.

A program for the rapid publication of so-called camera-ready books is available for those book projects requiring it, particularly in technical areas.

Project MAC

Project MAC is an interdepartmental laboratory for computer research and development. The name MAC is an acronym derived from several titles: man and computers, machine-aided cognition, and multiple-access computer. The broad goal of machine-aided cognition implies the development of new ways in which online use of computers can aid people in their creative work, whether it be research, engineering design, management, or education. Project MAC is closely associated with the Artificial Intelligence Laboratory which is located in the same building.

Project MAC, which is organized into four divisions, the Automatic Programming Division, the Programming Technology Division, the Systems Research Division, and the Fundamental Studies Division, is actively pursuing research in automatic programming, theory of computation, theory of finite-state automata,

design of advanced paralled-processing computers, man-computer interaction, computer graphics, management of information and computer networks. Examples of research topics that may convey an idea of the nature of MAC's undertakings are: the computer as an assistant to a mathematician accepts suggestions and carries out the mathematician's manipulations of symbolic formulas very rapidly and accurately, that would be far beyond the limits of the mathematician's capability or patience; programming languages which permit the user to interact with a computer in natural English; a system for automatic programming of business management systems which learns about the desired management systems from the user through English language interaction and then automatically produces programs that constitute the desired system; a program that teaches programming; systematic standards of format and protocol for intercomputer communication over network; security and verification of systems; complexity of computations; determination of the inherent capabilities of cellular automata; a way for designing a modular digital system that makes it possible to guarantee the correctness of operation; parallel program schemata; base language for defining semantics of programming languages; development of an advanced computer science facility in clinical cognition to aid in expert decision making in medicine.

There were 200 people at Project MAC last year: 26 faculty members, 78 graduate students, 29 undergraduates, 66 staff members and 6 guests. Most of the academic members of Project MAC are members of the Departments of Electrical Engineering, Mathematics, or the Sloan School of Management.

Project MAC 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 the undergraduate may work at Project MAC under the UROP program. Facilities are provided for thesis research and special projects to both the graduate and undergraduate students. All work at MAC is unclassified and is available to anyone wishing it.

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 ten academic departments conduct research in three broad areas: general physics, plasma dynamics, and communication sciences. At present there are approximately 30 research groups.

The research in **general physics** includes a variety of projects based primarily on atomic and molecular phenomena. The experimental techniques used in this work span most of the electromagnetic spectrum from radio wavelengths to x-rays. Other experimental requirements include the use of extremely high-frequency acoustic waves, the use of liquid helium temperatures, and extensive use of computers.

A few of the research topics in this area include the following: The development of a molecule microscope which will be used to observe biological macromolecules or to study surface effects in semiconductors or other materials. New techniques in electron microscopy are also being investigated. The microwave spectroscopy group is studying the electronic structure of metals by making surface impedance measurements of thin films. The radio astronomy group is exploiting long-baseline interferometry for high-resolution observations of distant radio sources and for the study of a number of other astrophysical problems. Observations and supporting theoretical work include studies of earth and planetary atmospheres, as well as distant radio sources such as pulsars. Gravitation research includes a variety of experiments related to gravitational interaction and measurable consequences of cosmological models. Research in microwave electronics involves the application of solid-state devices to the design of millimeter-wave receiver components. Increased sensitivity through reduction of noise is a major goal of this work.

Research using high-power CO_2 lasers includes consideration of frequency stability and methods of reducing noise. In addition, nonlinear optical phenomena are being exploited for the generation and shaping of very brief optical pulses. Physical acoustics research includes topics as diverse as the speed of sound in a semiconductor, and measurements of the characteristics of supersonic jets in a plasma wind tunnel. The nonlinear interaction between sound and liquid surfaces is also being studied. Physical electronics and surface physics is concerned with electronic processes such as thermionic emission, surface ionization, adsorption and desorption, and oxidation, at the gas-surface interface.

The **plasma dynamics** program seeks to extend the basic knowledge of ionized media with emphasis on such applications as controlled fusion, space physics, and collective phenomena in solids. The research includes methods of producing highly ionized plasmas by electron beam injection, high-powered lasers, microwaves, low pressure arcs, and so forth. Plasma diagnostic techniques involve measurements in various portions of the electromagnetic spectrum (microwave, millimeter wave, infrared, optical).

A substantial portion of the plasma effort is being devoted to studies aimed at controlled fusion as a means of power generation. In connection with this work, an experimental plasma machine called ALCATOR is being designed in collaboration with the Francis Bitter National Magnet Laboratory. Using intense magnetic fields and taking advantage of toroidal symmetry, this device will provide means of studying the high-density, highly ionized plasmas required to achieve controlled fusion.

Research in **communication sciences and engineering** spans a broad range of topics pertinent to communication processes in man-made 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.

The major areas of interest in living systems include neural and sensory physiology, auditory psychophysics, visual image processing, pattern recognition, sensory aids, speech communication, and linguistics.

The linguistics group has carried out fundamental studies of the structure of natural languages and of the semantic problems of communicating an idea unambiguously, as well as work on the relationship between the formulation of an idea and its expression in verbal or written form.

Neurophysiological and psychophysical studies of the auditory and visual mechanisms conducted over a period of years have added to the general understanding of neural organization and coding, and to behavioral aspects of these senses.

Work is also under way on the application of these and other studies to medical problems. One project concerns the development of reading machines for the blind, with printed pages as input and synthetically-generated speech as output. Such machines can also produce a Braille output or a spelled-speech output. Computer pattern recognition forms the basis for a number of related studies in biological image processing. These are aimed at automation of some of the tedious clinical laboratory work such as differential blood-cell counts, analysis of x-rays, and detection of malignant cells.

Studies of digital system design automation are aimed at computer-aided methods for handling the ever-growing complexities in digital systems.

Other communication research projects include work on coding theory, modulation theory, and detection theory, together with their applications to a variety of signal channels. Application of the principles of information theory to the organization of large communication networks is also being investigated.

Essentially 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.

Laboratory facilities include a dozen or more computers of various types, machine shops, drafting and photography shops, a publications office, and various research and administrative support services.

For additional information contact Professor Henry J. Zimmermann, Director; Professor John G. King, Associate Director; or Barbara L. McCarthy, Administrative Officer.

Sea Grant Program

Dedicated to the vital role of science and technology in ocean and coastal zone 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 the wise utilization of America's coasts and continental shelf, M.I.T. recognizes the need to solve current technological, economic, ecological, social, and political problems caused by man's increasing and conflicting uses of the seas.

M.I.T.'s Program participation began in 1970 with a Coherent Area Project on Ocean Utilization and Coastal Zone Development. Initial funds to support this came from the Henry L. and Grace Doherty Charitable Foundation, Inc., from the Institute, and from the Office of Sea Grant, a division of the National Oceanic and Atmospheric Administration in the U.S. Department of Commerce. This broadly based program now receives additional support from over fifteen industries, businesses, foundations, organizations, and non-federal government agencies. In July, 1972, the Institute's status changed with its designation as an Institutional Sea Grant Program, a mark of continuing distinguished contributions to national goals.

The philosophy motivating Sea Grant's 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 resources utilization and coastal zone development. A complex predictive modeling study of the Massachusetts Bay sea environment, presently under way, is revealing the hydrodynamic behavior of the bay and its effect on pollutant dispersion; another project investigates wastewater and sludge treatment with high energy electrons, to sterilize these wastes before their discharge from sewage plants and perhaps to convert them into a resource.

In ocean technology, currently researchers are: devising improved techniques in wet welding and metal cutting for economical underwater repairs, determining the fracture toughness of the fiberglass reinforced plastic composites now used for boat hulls of many sizes, designing better and safer hook-up blocks for the nets used by fishermen in side trawling, and planning offshore platforms which will combine a variety of ocean-related activities. Projects in marine food technology are exploring the utilization of squid for nutritious food products, and the content and composition of lipids in raw and processed fish and shellfish; mariculture research has developed a system which utilizes heated water for cultivating oysters. Whatever their foci, all the M.I.T. Sea Grant research projects represent unique combinations of disciplines and departments joined to apply the experience and progress of engineering and other technologies to marine problems.

In addition to research, the Sea Grant Program supports innovative education in ocean utilization and coastal zone development at M.I.T. Each year, an interdisciplinary systems design subject and a summer laboratory provide graduates and undergraduates with the chance to apply the knowledge they have acquired in classrooms to "real-world" situations. Students have worked on practical problems ranging from a resource study of a Massachusetts coastal town to the recov-

ery of a Revolutionary War shipwreck in Penobscot Bay; they have also invented or improved many types of instruments for oceanography, navigation, or ocean engineering. Through a joint experimental program with Harvard Law School, faculty in law and ocean engineering will be working together to identify the interacting institutions, techniques, and perspectives needed for the proper use of the sea's resources.

As the third part of the M.I.T. Sea Grant Program, the Advisory Services publish reports generated by the Institute's marine research projects. These reports reach those persons, academic institutions, government agencies, and businesses, in Massachusetts, New England, and beyond, many of whom benefit from the research results. During the year, lectures, symposia, and conferences which are open to the M.I.T. community and the public provide introductions and overviews on a variety of ocean related topics. Through the advisory services staff and through the Marine Resources Information Center, the Sea Grant Advisory Services supply comprehensive information, to all who need such knowledge, on many facets of resource development in the oceans and coastal zones, and on the theories and techniques created at M.I.T. for furthering man's marine activities.

Spectroscopy Laboratory

The Spectroscopy Laboratory has pioneered in the ruling of large, high-performance diffraction gratings and in designing, building and utilizing high-resolution spectrometers throughout the optical range of the spectrum from the vacuum ultraviolet to the far infrared. These instruments are used in studies of molecular geometry, the properties of solids and liquids and the structures and interactions of molecules of importance to biology. Investigations are in progress in the application of lasers to such problems as excitation of Raman spectra from very small samples of biochemicals, molecular double-resonance phenomena and ultra-high-resolution spectroscopy.

Stroboscopic Light Laboratory

In the Stroboscopic Light Laboratory research is conducted on the theory of pulsed electronic flash lamps and their applications in science and engineering.

Urban Systems Laboratory

The Urban Systems Laboratory, an interdepartmental laboratory, provides a framework and facility for conducting research projects in the various disciplines of engineering, management, architecture, planning, and the social sciences. While the principal focus is on urban problems, the work of the Laboratory encompasses a wide range of societal problems.

The working unit of the Laboratory is the individual sponsored research project, conducted under the supervision of a member of the faculty. The activities of the Laboratory consist of the set of projects active at any point in time and reflect a matching of faculty and sponsor interests. The Laboratory serves as the administrative unit for a number of interdepartmental research and training grant programs.

The Urban Systems Laboratory stresses the involvement of both undergraduate and graduate students in all of its projects and programs. Opportunities are provided for students to gain practical and field experience on real-world problems in parallel with the student's academic studies. While the research project result is the important short-term goal of the Laboratory, the most important long-term goal is the potential contribution to society made by those who initiate their careers in the Laboratory.

The research application areas of recent interest have included innovative transportation systems, information systems and computer modeling, building systems and housing, and environmental systems. Urban transportation has been the largest area in the past, but it is expected that the other areas will expand as funding becomes available.

To insure that the work of the Laboratory is realistic and can be implemented in the field, considerable interaction with private and public action agencies is encouraged. A subset of the Laboratory's projects are field oriented, such projects having been conducted in New York, Puerto Rico, and California as well as in a number of cities and communities in Massachusetts.

Wallace Astrophysical Observatory

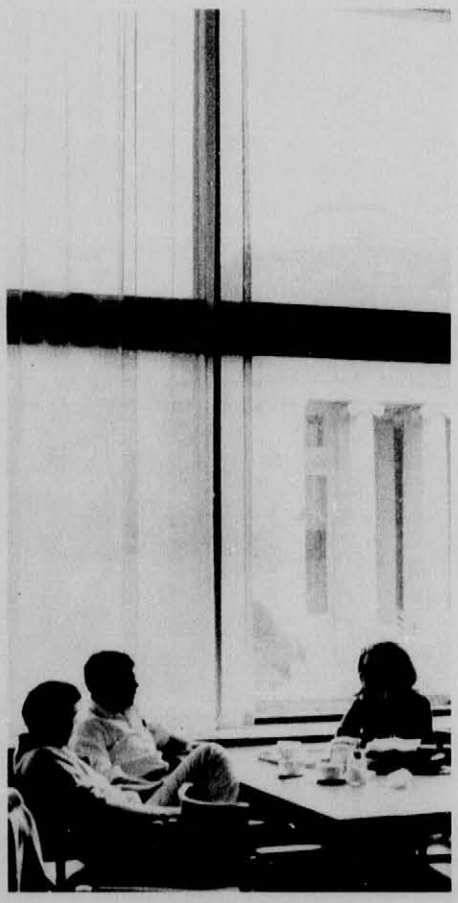
The George R. Wallace, Jr. Astrophysical Observatory is a versatile facility for research and teaching in optical astronomy, one of the oldest branches of science. It directly supports the growing student and faculty interest at M.I.T. in astronomy and related sciences.

Located in Westford, Massachusetts, the nucleus of the facility is a 24-inch optical telescope which is operated and controlled through a computer-directed system and which permits the monitoring of data outputs to a degree which has not been possible at other observatories. 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.

Campus Activities

Graduate Student Government

All graduate students are included in the Graduate Student Organization. Its executive body is an elected Council, whose membership includes 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 giving voice to ideas and suggestions of graduate students. The Graduate Student Council sends two students to represent the Organization on the Committee on Graduate School Policy, the faculty committee responsible for the administration of the Graduate School.



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 Department of Naval Architecture and Marine Engineering, maintains a fine collection of paintings, prints, photographs, ship plans, and working drawings of yachts and small craft by well-known twentieth century designers.

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

The Catherine N. Stratton Collection of Original Graphics is offered for students' use in their own living areas. These works may be borrowed at the beginning of each school year from the Committee on the Visual Arts.

The M.I.T. permanent Art Collection, which now includes nearly 300 paintings, indoor and outdoor sculpture, photography and graphics is on view throughout the Institute. Recent acquisitions include important works by Jim Huntington, Jasper Johns, Conrad Marca-Relli, Tamara Melcher, Richard Merkin, Niel Williams, and Robert Rauschenberg. Important extended loans to the collection include works by Darby Bannard, Allan D'Arcangelo, Howard Mehring, James Melchert, and a collection of graphics from the Frederick and Marcia Weisman Foundation.

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 Glee Club, Symphony Orchestra, Concert Band, Woodwind and Brass Ensembles, Schola Cantorum, Festival Jazz Band, Concert Jazz Band, and a barbershop group — the Logarhythms; there is also a Choral Society, which draws its members from the entire M.I.T. community. 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 employing faculty and students are regularly scheduled throughout the year. Other professional musical events are sponsored at the Institute by various campus organizations.



Theater

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

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

The Musical Theater Guild produces *Tech Show*, an annual 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 each year.



Lectures, Seminars, and Films

The Lecture Series Committee, an all-student group independently financed by its popular program of classic and current films, brings outstanding and controversial speakers to the campus. Such men as U Thant and Buckminster Fuller have delivered talks to the M.I.T. community. L.S.C. has also co-sponsored, with M.I.T. departments or other campus groups, events of cultural, entertainment, or educational significance.

Student Publications

Student publications at M.I.T. include *The Tech*, a student newspaper published twice each week; weeklies, *Thursday* and *Ergo; Technique,* the senior yearbook; *Tech Engineering News,* a monthly student magazine of science and engineering; *How to Get Around M.I.T. (HoToGAMIT),* the M.I.T. community guide; and *Rain,* a literary magazine. There are less formal outlets for journalism talents in the newspapers of the Institute Houses and in departmental newsletters of many kinds.



Technology Community Association

Managed by undergraduates, T.C.A. conducts a diversified program of year-round services to the M.I.T. community. A theater ticket service, a book exchange, duplicating machines for student use, a print exchange, and annual blood donor and charity drives are a few of the activities sponsored by the student members. In addition, the T.C.A. annually aids in the revision of *How to Get Around M.I.T. (HoToGAMIT)*.



Religious Organizations

The long-established programs of several student religious organizations on the campus are focused around 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 the individual and, within this environment, to provide adequate opportunity for the development of spiritual maturity and the exercise of spiritual interests.



Athletics

A major purpose of the athletic program at the Institute is to encourage all students to develop interests leading to participation 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 1,000 men and women for competition in 26 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 including sailing privileges for their families.

The intramural athletic program is noteworthy; last year over two-thirds of M.I.T. students participated in over 1,500 intramural contests. There were league competitions in touch football, cross-country, basketball, cycling, softball, volleyball, swimming, track, tennis, table tennis, sailing, badminton, hockey, golf, squash, water polo, wrestling, rifle, and bowling. Club sports, with intercollegiate competition but less formal organization than varsity teams, include badminton, bicycling, rugby, cricket, judo, white water, and weightlifting. Graduate students participate in both intramural and club programs.

Excellent facilities for these sports are provided by the du Pont Athletic Center, Rockwell Cage, the du Pont Gymnasium, Briggs Field, the Alumni Swimming Pool, indoor and outdoor tennis courts, an outdoor skating rink, and the Sailing Pavilion and Pierce Boathouse on the Charles River.

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, and "ham" radio station WIMX, WTBS (the FM local broadcasting station), and the Student Art Association.

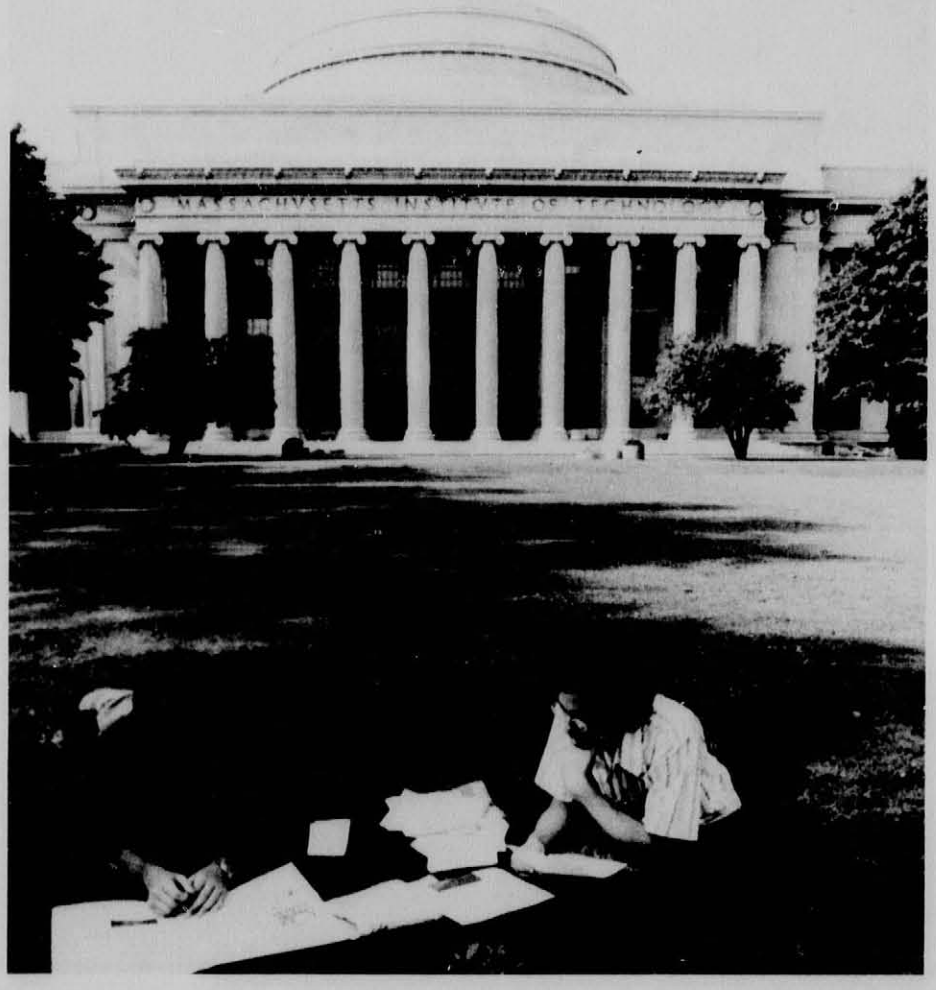
More than 500 students are actively engaged in social service work in the Greater Boston area. The M.I.T. Urban Action Program sponsors many major projects in this area, such as the Urban Fellows program in which students do major community service work for academic credit. Other groups such as the Interfraternity Council and Alpha Phi Omega, the national service fraternity, also sponsor active social service programs in the community.

The M.I.T. Black Student Union (B.S.U.) runs a variety of programs in education, culture, and black students' problems. Numerous nationality clubs sponsor programs for foreign students from various nations, including discussions and social events.

The wives of M.I.T. students, both undergraduate and graduate, form the Technology Wives Organization (TWO). A social and service organization that begins activities in mid-October, the group numbers nearly 400 and sponsors monthly programs to suit a variety of interests.

Other interest groups include bridge, folk and square dance, model rocket and railroad clubs.





Graduate Student Residence

Single Student Housing

Approximately 25 percent of the single graduate student body of 3,300 resides on the campus.

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 330 single graduate men and women in single, double, and triple rooms.

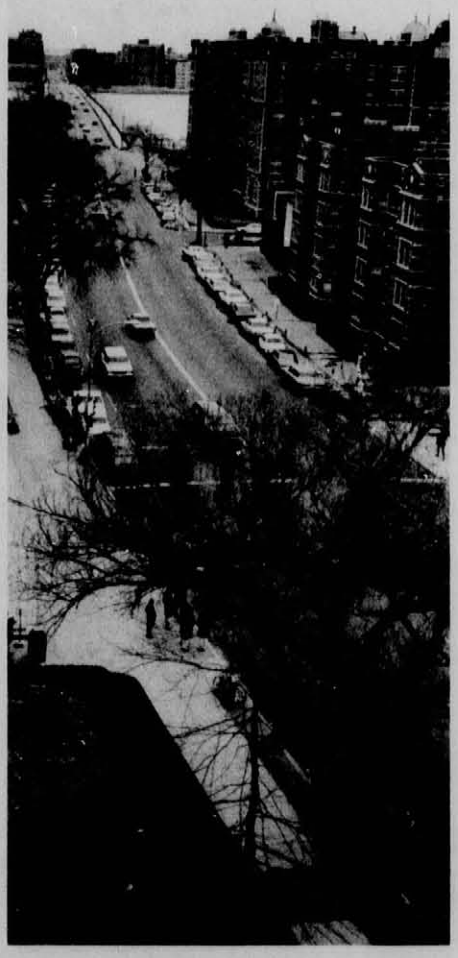
A member of the faculty who is familiar with the aims and problems of graduate students is Master of the House. A student House Executive Committee, acting with the advice and assistance of the Master, plans and operates the activities program. The many facilities for social and cultural activities in Ashdown House make it a center of graduate student activities.

Rooms in Ashdown House are engaged for a full academic year; rents average about $950 per person for the academic year.

Ping Yuan Tang Residence Hall

Tang Hall, located on the far western end of the campus, houses 400 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 twelve-month license to each occupant, beginning September 1. Rents range from $91 to $134 per occupant per month and include all utilities except telephone. Community facilities are available in this building, two tennis courts are located adjacent to it, and limited parking is available nearby at no cost.

More complete information for both residences is found in *Graduate Residence at M.I.T.*, 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 lease basis.

A nursery school, with one classroom in Westgate and two in Eastgate, is operated by Technology Nursery School, Inc., a non-profit 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 Campus Housing Office, Room E18-307, Massachusetts Institute of Technology, 77 Massachusetts Avenue, Cambridge, Massachusetts 02139. Since accommodations in Eastgate and Westgate are limited, married students are well advised to contact the Community Housing Office regarding off-campus-housing.

Westgate

This five-building complex, located at the west end of the M.I.T. campus, provides 210 apartments for married student families. The West Campus location near Memorial Drive and the Charles River is within ten minutes' walk of the Institute's main buildings.

Westgate consists of a 16-story tower with 90 one-room efficiency apartments and 30 one-bedroom units, and four three-story garden-type buildings with a total of 60 two-bedroom apartments. Community facilities are available and free parking is provided for a majority of the residents. Rents in Westgate range from $155 to $220 per month, including utilities and heating.

Eastgate

Located adjacent to Kendall Square at the east end of the M.I.T. campus is Eastgate, a 30-story apartment tower with 204 family units for married students and faculty. The site adjoins the Alfred P. Sloan Campus with the School of Management and the Departments of Economics and Political Science. It is convenient to the main campus and public transportation.

The tower building contains 96 one-bedroom apartments, 84 large one-bedroom apartments, and 24 two-bedroom apartments. About 80 per cent of the apartments are allotted to married students; the remainder are available to faculty members. Rents in Eastgate range from $158 to $251 per month including utilities and heating. Community facilities are available and free parking is provided for a majority of the residents.





Community Housing Service



Students who do not live on campus will find help in locating accommodations in the Community Housing Service. Listings of available rentals in the Greater Boston area are maintained, and the staff attempts, on an individual basis, to help students locate the type of accommodations that will best suit individual preferences and financial resources and to advise on many additional aspects of off-campus living. All correspondence should be addressed to Community Housing Service, Box 42, M.I.T. Branch Post Office, Cambridge, Massachusetts 02139.





Graduate Student Services

Counseling

The Institute offers a variety of 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 likely to be of help. Counseling, as the word is used here, refers to casual conversations and to scheduled appointments; it runs from the providing of information to skilled psychotherapy.

Other publications including *The Graduate School Manual* and *How to Get Around M.I.T.*, list in detail the counseling resources. Only a short summary is given here. Each student has a faculty advisor. 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. Several offices specialize in particular areas, such as the Student Financial Aid Office which includes student employment, the Office of the Foreign Student Advisors, the Religious Counselors, and the Placement Office. The Campus Patrol is frequently of help to students.

The office of the Dean for Student Affairs has several members whose time is almost entirely devoted to student counseling, whether the situation is academic or personal or both. The Graduate School Office also is involved in counseling.

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 Services

The Institute maintains a well-equipped Medical Department staffed by specialists, centrally located in the Homberg Memorial Clinic building, a wing of M.I.T.'s main buildings. In addition to general medical care given by specialists in internal medicine and surgery, the Medical Department provides consultants in allergy, dentistry, dermatology, gynecology, obstetrics, neurology, ophthalmology, orthopedics, otolaryngology, pediatrics, psychiatry and urology. Except in emergencies, visits are by appointment. The Infirmary, with 28 beds, is located on the campus between Baker House and McCormick Hall. Facilities of the Boston and Cambridge hospitals are used in cases involving major operations or critical illnesses, after which students may return to the Infirmary for convalescence.

The Student Health Program consists of two parts. The first part covers ambulatory and infirmary care provided by the M.I.T. Medical Department and is required for full-time students at an annual cost of $130. This does not cover dental services, eye refractions or pediatric clinic visits which are on a fee for service basis. The second part covers hospitalization (other than in the M.I.T. Infirmary) due to accidents or illness at an annual cost of $60. This portion of the program is required for foreign students, and optional for American students. However, all students are urged to purchase this coverage unless they have equivalent insurance, as hospital care is very expensive. A medical insurance plan for the spouse and children of a student is also available. The additional cost of coverage for the spouse, which includes care in the M.I.T. Medical Department and outside hospital care with a $300 maternity benefit, is $245. Hospital coverage for children may be purchased for $55.

	M.I.T. Medical Department	Outside Hospital	Both
Student	$130	$60	$190
Student Spouse	$130	$115	$245
Children, one or more	Fee for Service	$55	—

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, nor is it underwritten by the Student Health Program. Students requiring such treatment will be referred to private psychiatrists or psychiatric clinics in the area.

A dental service which offers complete dental treatment for students and their spouses is available on a fee for service basis, but because of limited space, not all student dental needs can be met. A pediatric clinic is also available on a fee for service basis. They are located in the M.I.T. Infirmary at 350 Memorial Drive.

Prior to matriculation, every student, undergraduate or graduate, is required to submit a report from his or her own physician recorded on an Institution medical form, which is to be mailed by the physician to the Associate Medical Director, stating that he or she is free from active tuberculosis as evidenced by an intradermal skin test or chest x-ray or both. This is a public health measure and cannot be waived. Immunization against tetanus is also required before entrance.

Career Planning and Placement

The Career Planning and Placement Office serves students seeking information and advice on employment, opportunities of further study and careers. It works in close cooperation with the Office of the Dean for Student Affairs, the Office of the Dean of the Graduate School, the Foreign Study Advisor, the placement counselors in the departments, and the faculty advisors on careers in education, law, and medicine.

The Office staff are happy to talk with students on an individual basis about career plans. The Office also arranges seminars at which alumni 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 of work and study abroad.

Over 200 companies, government agencies, and graduate schools make recruiting visits to the Career Planning and Placement Office each year. Their 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 continuous 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 and Education

The office of Preprofessional Advising and Education, Room 10-186, extension 3-4158, serves students who are interested in entering medicine, public administration, law, education, and/or related fields. The director of this office also 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 advising in these areas may be found earlier in this Chapter.

Foreign Study Advising

The Foreign Study Office assists those seeking foreign study and research opportunities on various levels. Files are maintained on opportunities all over the world and application forms are available. The Foreign Study Advisor is the M.I.T. representative for such foreign fellowship and scholarship programs as Churchill, Marshall, and Fulbright. Many other less well known sources of support exist for graduate and postdoctoral study and research overseas. Since deadlines for the following year are in the summer or early in the fall, planning should begin in the spring. Interested students are encouraged to consult the Foreign Study Office, Room 7-133, extension 3-5243.







Admissions

Regular Graduate Admissions

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 an academic staff 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 is considered for admission as a Graduate Student in competition with other applicants during the fourth undergraduate year.

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. His or her academic record and other credentials must indicate ability to accomplish satisfactorily an approved program of study and research. Admission to each department is by competition among the applicants for the places available.

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 unusually 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. At the time of registration the student decides, with the advice of the department, for what degree he or she will register.

Undergraduate Requirements for Advanced Degrees

In line with the Institute's conception of a broad undergraduate curriculum with emphasis in mathematics and science, most departments require the following preparation:

Mathematics: Preparation substantially equivalent to that provided by the Institute subjects 18.01, 18.02, and 18.03 (calculus and differential equations).

Physics: Preparation substantially equivalent to that provided by the Institute subjects 8.01, 8.02, and 8.03 (particles, Newtonian mechanics, relativity, oscillations and waves, electricity and magnetism).

Chemistry: Preparation substantially equivalent to that provided by a course in general chemistry (elementary atomic and molecular structure, chemical equilibrium and reaction kinetics).

Humanities and Social Science: M.I.T. departments recommend at least six term subjects in the humanities or social sciences equivalent in scope to those included in the undergraduate humanities curricula of the Institute. Departments may ask that deficiencies be satisfied by completing appropriate subjects from fourth-year or graduate electives in the humanities and social sciences.

Languages: Several departments require a candidate for the doctor's degree to demonstrate competence in one or more foreign languages. A prospective doctoral candidate is urged to include language study in his or her college preparation.

Professional subjects: Requirements of individual departments are given in each department's statement on graduate education.

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 proceeding with graduate work dependent on them.

If an applicant lacks so many undergraduate requirements that work toward an advanced degree is likely to be unduly protracted, it may be advisable to postpone application until some of these deficiencies have been made up.

In an exceptional case, the Committee on Graduate School Policy will entertain a departmental proposal for altering admission requirements.



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 Department of Psychology does not admit students in February.

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 by students who are not also candidates for financial aid may be considered if vacancies still exist. Candidates for admission in June or September who are also applicants for financial aid should be careful to 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 should be submitted to the Director of Admissions, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139. A $20 application fee should accompany the application form. Payment should be by check or money order, payable to the Cashier, 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 after a lapse of less than two years.

Notification about admission is sent as soon as action is taken (usually before April 1). 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.

Correspondence concerning admission, including 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, 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

Applicants for admission to graduate study in the Department of Biology, Political Science, 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 Metallurgy requires Graduate Record Examination scores from all foreign applicants. The Department of Biology will accept such test scores resulting from the advanced test in either chemistry, physics, or biology. The Department of Psychology requires the Aptitude Test for Verbal and Quantitative Ability, as well as the appropriate Advanced Test of the Graduate Record Examination. It is recommended that the Miller Analogy Test be taken. The Department of Physics does not require, and makes no recommendation regarding these examinations. 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, as well as Course XIII-C (Shipping and Shipbuilding Management), require applicant scores on the Admission Test for Graduate Study in Business. 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 can 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.

Foreign Graduate Admission

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 leaflet entitled, "Information for Prospective Foreign Students" and the Final Application for Admission from Foreign Citizens may be obtained from The Director of Admissions, M.I.T., 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 paragraphs on Admission of undergraduate foreign students.

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. Candidates will wish to 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 registered as a candidate for a degree. Normally such a student will have received a Bachelor's degree. The applicant's qualifications for the specific program desired will be evaluated by the Chairman of the Graduate Committee of the department which best corresponds with the major area of interest. Admission is valid for only one term; a student must seek readmission each term to continue at the Institute. To be allowed to continue as a Special Graduate Student, grades satisfactory to the Committee on Graduate School Policy must be maintained.

Admission as a Special Student does not imply any commitment on the part of the Graduate School toward an individual's admissibility to Regular Student status. If a Special Graduate Student is subsequently admitted as Regular Graduate Student subjects completed may be offered 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, from whom application material may be obtained. Applications must be filed at least three weeks prior to the beginning of the term.

Graduate School Admission for O. S. P. Staff

In view of their full-time responsibilities on assigned research and corresponding non-academic salary scales, staff members of the Office of Sponsored Programs do not enjoy full academic privileges 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. No graduate student may present as thesis any material based in whole or in part upon work done while holding an O. S. P. 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 meet the residence requirement by becoming a Regular Graduate Student at some time during the degree program.

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 and 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 Committee and the O. S. P. to the Dean of the Graduate School, be permitted to enjoy the status of Limited Graduate Student for the following purposes:

1
To undertake general doctor's or comprehensive Engineer degree examinations;

2
To undertake language examinations prescribed for advanced degrees;

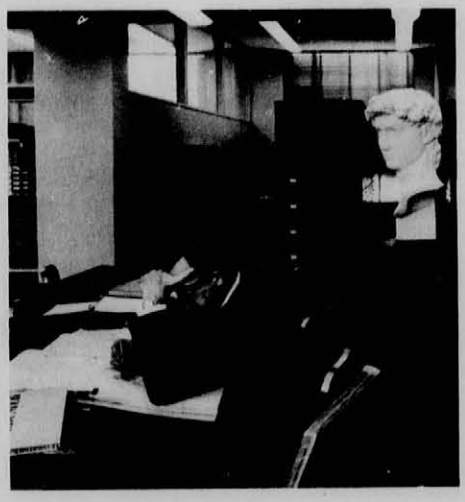
3
To register or remain registered for thesis with simultaneous enrollment on a degree list, provided the student submitted the archive and library copies of the thesis before appointment in O. S. P., Lincoln Laboratory, or Draper Laboratory became effective;

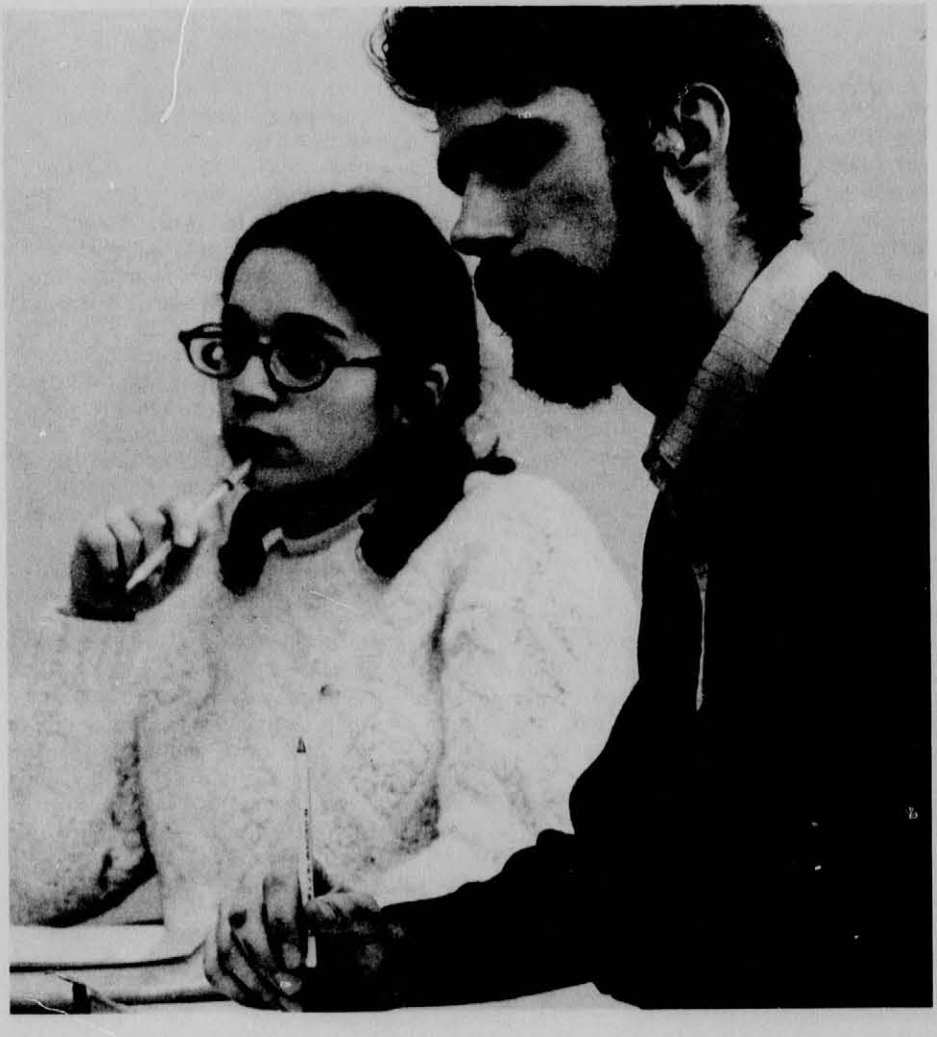
4
To enroll on a degree list in one subject.

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, not those applying to students holding academic staff appointments.

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.







Costs

Tuition

M.I.T. is an independent, endowed institution; the tuition paid by each student covers less than half the cost of facilities and teaching. The balance is met by income from endowment and by gifts.

The following list gives an estimate of the average graduate student's basic costs for the academic year at M.I.T.:

Tuition	$3,350
Board and room	2,019
Books and Materials	200
Health Service Fee	130 ($190 Foreign)
Total	$5,699

In addition to these costs, there are variable personal expenses and costs for transportation. Typical costs for clothes, laundry, recreation, optional medical insurance and personal necessities average about $800 per academic year; but there is a great range, depending on interests and tastes. Cost of travel obviously varies significantly and is not included in the above. Following admission to the Graduate School each applicant will be furnished a current estimate of the cost of study in Cambridge for budget planning purposes.

The tuition for all regular full-time students, including academic and graduate student staff, in the first and second terms is $1,675 per term. The two-term tuition fee for full-time students who are registered both terms covers the January Independent Activities Period. The regular term tuition for full-time students who are registered only one term covers the January Independent Activities Period. The tuition for graduate fellows, trainees, and academic staff in the 1974 Summer Session is $1,120. 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 (including M.I.T. sponsored-research staff) will be charged at the rate of $54 per unit taken either for credit or not for credit. Under special circumstances regular students other than fellows, trainees, and graduate student staff or students on a degree list, who are permitted by their Faculty Counselors and Dean of the Graduate School to take only a few subjects in the first or second term, will be charged a special tuition rate. The unit fee applies up to a maximum of $1,675 per term and is subject to the following minimum fees:

Members of the M.I.T. Community*	$325
Other Special Students	$485

Special graduate students in the Alfred P. 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 $78 per unit of registration, with a minimum charge of $780. There is a maximum charge of $3,075 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 Alfred P. Sloan School of Management with regard to fees.

Any graduate student making progress on a thesis is expected to register for thesis 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 must be paid;** but if the student was registered in the immediately preceding term, regular or summer tuition for thesis will be adjusted after delivery of the completed document on the basis of a charge of $140 per week from the starting date of the term, with a minimum of $140 for the Master's or Engineer degree and $280 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 in the previous regular term, the minimum tuition for thesis is $835. If the immediately preceding term was the first term and if the graduate student was not registered for thesis in that first term, full tuition for thesis in the second term with no tuition adjustment for early completion of thesis must be paid. 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.

The tuition fees for cooperative programs are as follows:

Electrical Engineering
Course VI-A
July 1 to June 30
$3,350

Ocean Engineering
Course XIII-C
June–August (15 months)
$3,350

In each case, the first $1,675 is due on the date when the first-term tuition is normally due, and the additional $1,675 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 for an unusual case.

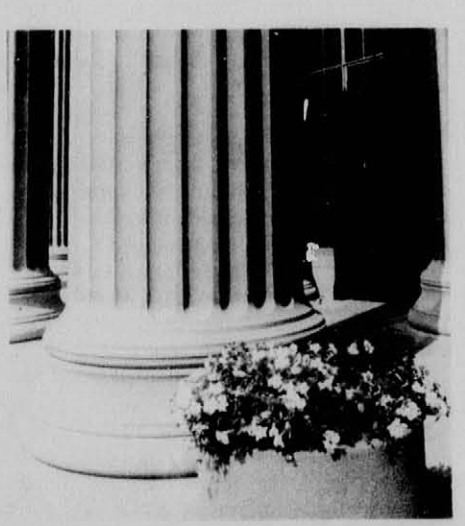
Students withdrawing during the first or second term are charged one-twelfth of the stated tuition for the term for each week from the starting date of the term, with a minimum two-week charge. A student is financially obligated to the Institute for the fees appropriate to the program approved by the 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.

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

Payments

Institute House Rentals and Meals

All term rentals for Ashdown House and Tang Hall 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.



Miscellaneous Fees

Anyone who files a final application for admission as a regular graduate student, or as a beginning special student, is required to pay a $20 application fee. This fee is not required of a student who applies for readmission as a candidate for the same degree, or, in the case of a graduate student, for a higher degree after a lapse of less than two years.

If, in complying with the doctoral degree language requirement, a graduate student requests a written examination in French, German, Russian, or Spanish at an unscheduled time, he or she is required to submit with the application a receipt from the Cashier's Office indicating that he or she has paid 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.

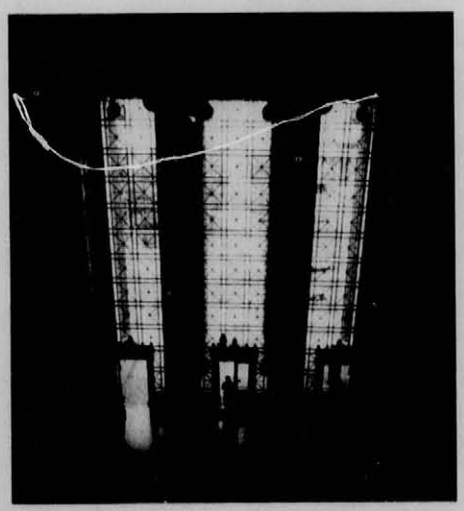
The fees for the Student Health Service Program are listed under Medical Services earlier in this Chapter.

Fines are imposed: $20 for each scheduled payment missed or received late; $5 for late registration. Registration is *not complete* until all fees are paid in full or a suitable payment plan has been approved by the Student Accounts Office.

There is a $5 charge for each change in a student's program (addition, cancellation, or change of units) which is made in the last two weeks of a regular term.

All payments are to be made to the Massachusetts Institute of Technology, 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 will be 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 student or his or her parents may arrange with the Student Accounts Office by mail or in person to defer his payments over the term. For this service, an administrative fee of $10 will be charged to cover the cost of the additional handling. Information on this plan will be included in the Financial Registration mailing prior to the opening 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, and loans. Resident tutorial positions in undergraduate Institute Houses and fraternity houses provide room and board. Application for a tutorial 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. The plan described under "Payments" and student employment are available to students with few exceptions. Prospective students are strongly urged to explore all the sources of aid available as they consider the means of financing their graduate education.

A fellowship or traineeship is a grant 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 a grant 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 in the pursuit of their studies. No services are expected in return. Under Section 117 of the U. S. Internal Revenue Code of 1954, such grants, held by degree candidates, are not subject to income tax.

The Institute is fortunate to have received funds from individual donors and corporations which provide for the support of about 200 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 institutions for award by them to students. Fellowships available under these national programs, including fellowships and traineeships granted by national agencies for award by M.I.T., are summarized in the following section. About 350 graduate students at M.I.T. have fellowships or other grants from national agencies for the academic year 1974–75.

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 regular academic year, beginning with the fall term, 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 award is not considered further for a fellowship or traineeship by M.I.T.

Notices of award by the Institute are 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 cancelled.

Every student holding a fellowship, traineeship, or scholarship for graduate study at the Institute is expected to register as a regularly enrolled student for the period of the award, pursuing a full program of studies. If a student with an award which is paid through M.I.T. withdraws from the Institute before tenure expires, the Institute will consider him or her to have relinquished the award, and the student will be required to make such refund of any sum already paid as the Dean of the Graduate School deems appropriate. An award will be terminated for failure to maintain a satisfactory standard of scholarship.





Teaching and Research Assistantships

M.I.T. employs about 500 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 at least comparable to fellowship stipends, and are 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 average time taken by doctoral students who have held teaching assistantships is not significantly different from the time taken by doctoral students who have had other forms of support during the same period.

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 to a graduate program.

Each year about 1,000 graduate students at M.I.T. hold part-time 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.

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; the stipend is then adjusted.

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.

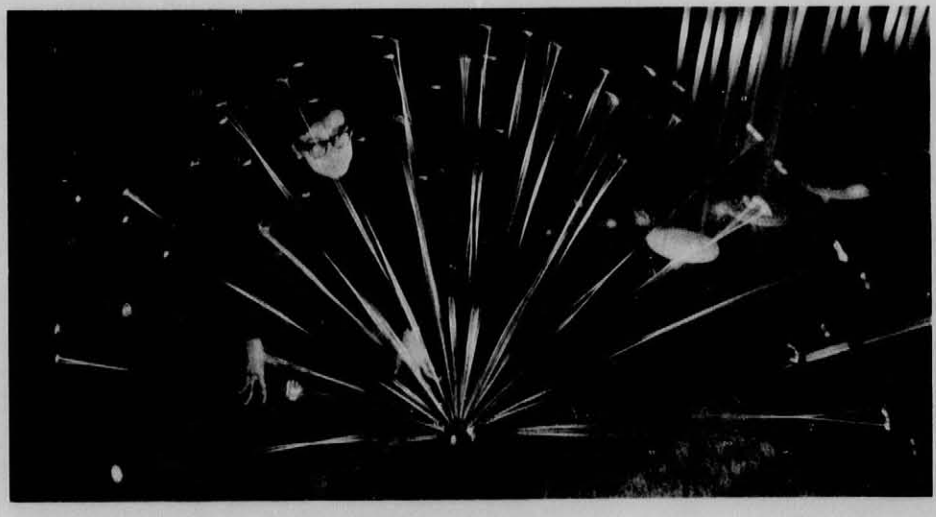
Appointments to research assistantships are made by the department head in the same manner as appointments to teaching assistantships.

Loan Funds

The Institute administers a loan program under which financial assistance is available to all graduate students. A student may borrow to support a modest budget for which he or she has insufficient resources. Graduate students are expected to have explored all other sources of aid (including employment opportunities and home-state Federally Insured Loan Programs) before requesting loan funds from the Institute. To be considered, a student must submit a budget giving evidence of his or her need. Application should be made to the Director of Financial Aid, from whom forms may be obtained.

The Federal Insured Student Loan Program is designed to aid students in meeting the expenses of their education. M.I.T. urges each applicant for aid to apply for loan assistance under that Program, which is administered by the several states. The loans are obtained through local banks and other lending agencies under certain conditions, and 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 by design more favorable than standard commercial terms.

M.I.T.'s Technology Loan Fund, established in 1931, was the first major loan fund established by a college; today it is the nation's largest. Since its founding, M.I.T. students have benefited from



more than $10,000,000 in loans from this fund. Awards are made on the basis of financial need and, where possible, are made under the terms and conditions of the Federal Insured Student Loan Program authorized by the current Federal legislation. In the interest of its students, M.I.T. sets reasonable limits on the annual amounts borrowed from the fund, and on the total indebtedness accumulated by each borrower.

M.I.T. also administers loan awards under the National Direct Student Loan Program, using need and eligibility criteria established by the U.S. Department of Health, Education and Welfare.

Repayment rates for loans acquired directly through the Institute will be established in each case by M.I.T. on graduation or termination of enrollment. NDSL and FISLP regulations established by the Federal government state a maximum repayment period of ten years on those notes. The regulations further outline a minimum annual repayment of $360 on these notes.

Repayment commences six months after graduation. Students may apply for deferment of repayment if they enter a graduate school, military service, or the Peace Corps. A maximum of three years' deferment is allowed in the latter two cases.







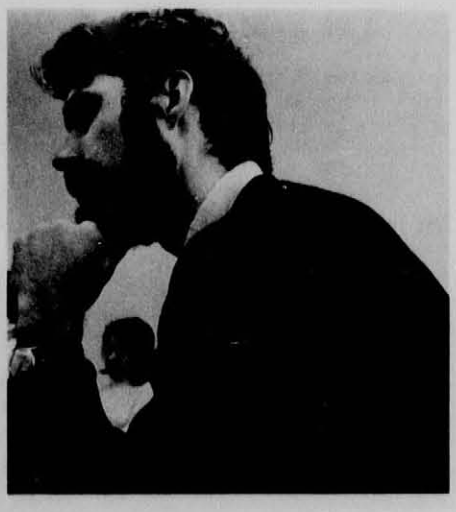


Scholarships and Fellowships for Graduate Students

Listed here are fellowships and scholarships which have been generously given by individuals and corporations. About 200 awards are made from these funds each year. Students should not apply directly to the Graduate School for their support. But those who file an Application for a Graduate Fellowship, Traineeship, or Scholarship with a department are considered for any awards for which they are eligible.

The Graduate School has initiated two special fellowships drawn from its endowment resources. One is the Marron W. Fort Fellowship established to recognize an outstanding graduate of the Institute who is a member of an American minority and who will be continuing his or her graduate education at M.I.T. The second, the Collamore-Rogers Fellowship will be awarded to an outstanding woman graduate student at the Institute. Notices for these two fellowship competitions appear during the early winter.

A number of fellowships exist to support graduate study abroad. Several of these are described in the following section. Any questions concerning these fellowships or foreign study in general should be addressed to the Foreign Study Advisor.



National Fellowships for Graduate Study

Atomic Energy Commission
Grants of the Atomic Energy Commission provide for a limited number of traineeships for U. S. citizens to meet the increasing manpower demands for nuclear engineers at the graduate level. Tuition plus stipend determined by the department. Application on standard fellowship form to the Department of Nuclear Engineering.

Danforth Fellowship
About 100 fellowships annually to students graduating from U. S. colleges who seek to become teachers. Tuition and fees for an academic year plus $2,025 for a single student, $2,200 if married, with dependency allowances for children. Renewable for four years of study. Nomination in early fall by the student's undergraduate college to the Danforth Foundation, 222 South Central Avenue, St. Louis, Missouri 63105. Also, a special program for graduate women.

National Science Foundation
About 500 fellowships awarded annually to U. S. graduate students for study in the mathematical, physical, medical, biological, and engineering sciences, anthropology, economics, geography, the history and philosophy of science, linguistics, political science, psychology, and sociology. Twelve months' tuition plus $3,600 stipend. Awarded for three years maximum. Application in the fall to the National Science Foundation, Washington, D.C. 20550. Watch for NSF announcements on dates.

Other
Other programs exist. These include the Ford Foundation Dissertation Fellowships, and the Hertz Foundation Fellowship Program for support in specific fields of graduate study, based on M.I.T. nominations. See Graduate School Office for details.

Aid for Foreign Study

Churchill Scholarship Program
Provides approximately 10 scholarships to U. S. citizens for study at Churchill College, Cambridge University in the natural sciences, engineering and mathematics. Awards are offered for one year, leading to a Diploma or Certificate, or for three years, leading to a Ph.D. M.I.T. nominates two candidates to compete with applicants from 28 institutions. Consult the Foreign Study Office, Room 7-133, Ext. 3-5243 for details and applications.

German Academic Exchange Service (DAAD)
Offers scholarship assistance to an M.I.T. student for study or advanced training in the Federal Republic of Germany. Recipients must have their bachelor's degree at the time the scholarship begins. Awards are for all fields except the following: chemical engineering, pharmacy and specialized areas of agriculture. Consult the Foreign Study Office, Room 7-133, Ext. 3-5243 for details and applications.

Institute of International Education
Administers scholarships for U. S. citizens for graduate study abroad in all fields; includes U.S. government Fulbright-Hays Full and Travel Grants; Foreign Government Grants; and Private Foundation Grants. Consult the Foreign Study Office, Room 7-133, Ext. 3-5243 for details and applications.

Luce Scholars Program
Approximately 15 U.S. citizens, men and women, will be nominated each year as Luce Scholars for a full year of study, work, and travel in the countries of East and Southeast Asia. Scholars will be selected from 60 cooperating colleges and universities. Candidates should be recent college graduates or professional school students and graduates with a high potential for accomplishment in fields unrelated to Asian specialties. See Prof. Eugene B. Skolnikoff, Room E53-473, Ext. 3-3140.

Marshall Scholarships
Approximately 30 scholarships offered by the British government to U.S. graduates for two-year study for a degree in any United Kingdom university. Fields unrestricted. Consult the Foreign Study Office, Room 7-133 for details and applications.

Rhodes Scholarships
For U.S. male graduates who exhibit scholarship, character, leadership and physical vigor to study at Oxford University. Fields generally unrestricted. See Prof. Lester Thurow, Room E52-252D, Ext. 3-2932.

Others
Numerous other fellowships exist for both graduate and post-doctoral study abroad. For an inclusive listing of international fellowships consult the Foreign Study Office, Room 7-133, Ext. 3-5243. All of the above scholarships have early fall deadlines.

Aid for Study in Various Fields

Edward Austin
Bequest of $360,000, the income for needy meritorious students and teachers to assist them in paying academic expenses.

William Sumner Bolles
Bequest of $25,000 by William P. Bolles in memory of his son, to support a fellowship, travelling scholarship, or resident scholarship, the recipient of which must have character, ability, or promise.

Helen Collamore
Bequest of $10,000, the income for aid to women students in post-graduate courses.

Alfred Willard French
Founded in memory of Alfred Willard French '89 by the French Oil Mill Machinery Company, for a graduate student in engineering (preferably mechanical) or business administration, with preference to a student from within a 100-mile radius of Piqua, Ohio.

Frank M. Greenlaw
Bequest of $74,000 by Frank M. Greenlaw '90 the income to establish a fellowship for research in physics or chemistry or related fields of learning.

Joint Center for Urban Studies
Doctoral fellowships to graduate students in any department of either Harvard or M.I.T. writing a doctoral dissertation in some aspect of urban affairs. Special attention given to studies in the field of housing. Award including stipend up to $5,500.

John A. Lyons
Under the will of the late John A. Lyons, several fellowships are available for the support of graduates of Boston College, subject to the following provisions: the recipients must be of the Roman Catholic faith; they must have been born within a radius of 20 miles of the Massachusetts State House; preference will be given to applicants whose father and mother were of Irish descent; the fellowships are only for those who do not consume alcohol in any form; they must live at the Institute during the academic year. The fellowships will cover tuition and will provide a stipend to help meet living expenses. They will be renewable from year to year.

Henry Bromfield Rogers
Bequest of $20,000 by Anna Perkins Rogers, the income for a fellowship or scholarship for women graduates of M.I.T. or other colleges whose graduate work is carried on at M.I.T.

Henry Saltonstall
Bequest of $10,000, the income to aid one or more needy students.

James Savage
Bequest of $10,000, the income for scholarships in the institution "where my son-in-law, William B. Rogers, is President."

Susan H. Swett
Bequest of $10,000, the income to support a graduate scholarship.

Gerard Swope
Gift of $100,500 by Gerard Swope '95, the income to support fellowships for graduate students of exceptional ability and promise.

United States Steel Foundation
A fellowship for student who shows interest in graduate program relevant to a career in management based on a science or engineering background.

Thomas Upham
Bequest of $409,000 by Marcella B. Upham, the income for assisting poor and deserving students or graduates of the Institute.

Jonathan Whitney
Bequest of $525,000 by Mrs. Francis B. Green, the income to assist poor and deserving young men and women in obtaining an education at M.I.T.

Aeronautics and Astronautics

Donald W. Douglas
Gift of $73,725 in honor of Donald W. Douglas '14, Honorary Chairman of the Board of Directors of the McDonnell Douglas Corporation, the income to be used to support deserving graduate students in aerospace and related fields.

Richard C. du Pont
Memorial fellowship in aeronautics and astronautics, for a graduate student in any year of his work toward an advanced degree; tuition plus $2,500.

Lester D. Gardner
Fellowship in memory of Lester D. Gardner '98; tuition plus $2,500.

Architecture and Planning

Avalon Foundation
Gift of $250,000, the income to support fellowships and scholarships for graduate students in the School of Architecture and Planning.

Francis Ward Chandler Memorial Fund
Bequest of $100,000; net income to be used to provide scholarship assistance to graduate or undergraduate students with first preference being given to undergraduate students in architecture.

W. Danforth Compton Memorial
Gift of $90,000 in memory of W. Danforth Compton '47, the income to support fellowships in the Department of Architecture.

William Emerson Fund
The income of the bequest of $29,000 of the late William Emerson, Dean of the School of Architecture, is used for fellowships in the Department of Architecture.

William Emerson
Gift of $5,000 by Dean William Emerson, the income to support graduate students in Urban Studies and Planning.

William and Frances Emerson
Gift of $100,000, the income to aid graduate and special students in the School of Architecture and Planning.

Samuel A. Marx
Established by gifts of $33,900 in memory of Samuel A. Marx '07, the income for an annual fellowship in the Department of Architecture.

Floyd Naramore Architectural Memorial Fund
Bequest of $50,000. The income to be used for scholarships and fellowships for students and graduate students in the field of architecture.

Chemical Engineering

American Cyanamid Company
For graduate students attending the School of Chemical Engineering Practice. Award is adjusted to pay a portion of tuition and expenses while at the Bound Brook Station.

Esso Research and Engineering Company
For a graduate student in chemical engineering; tuition plus $1,350 per term.

Halcon International, Inc.
For a graduate student in chemical engineering; tuition plus $1,350 per term.

Arthur D. Little
Fellowship in memory of Arthur D. Little '85, for a candidate for a doctorate; tuition plus $1,350 per term.

Chemistry

Lewis Paul Chapin
Bequest of $100,000 by Mrs. Mary Richardson Chapin in memory of her husband Lewis Paul Chapin, formerly Assistant in Inorganic Chemistry, the income to assist worthy postgraduate students in the Department of Chemistry.

Goodyear Tire and Rubber Company
Fellowship for a graduate student in chemistry; tuition plus $2,500.

Arthur D. Little
Fellowship in memory of Arthur D. Little '85, for a candidate for a doctorate in chemistry; tuition plus $3,000 for 12 months.

Forris Jewett Moore Memorial
Gift of $24,000 by Mrs. Forris Jewett Moore in memory of her husband, formerly Professor of Organic Chemistry, the income to assist a graduate in his studies at M.I.T. or elsewhere with preference given to a student in organic chemistry; tuition plus $2,500

James Flack Norris
Bequest of $65,000 by James Flack Norris, formerly Professor of Organic Chemistry, the income to support a graduate fellowship; tuition plus $2,500.

Texaco, Inc.
Fellowship for a graduate student in chemistry; tuition plus $3,000 for 12 months.

Uniroyal Foundation
For the support of graduate training in research; $3,400.

Earth and Planetary Sciences

Chevron (Standard Oil Company of California)
Tuition and stipend for a graduate student interested in geophysics, especially exploration geophysics.

Economics

Ford International Fellowships
For two Ph.D. candidates emphasizing international aspects of economics; tuition plus stipend.

Clarence J. Hicks Memorial
For a graduate of not more than five years (exclusive of military service) since his baccalaureate from a college or university in the U.S. or Canada, who is a candidate for a doctorate at M.I.T. in the field of industrial relations; tuition plus stipend.

Joseph N. Scanlon
In memory of Joseph N. Scanlon, formerly a Lecturer at M.I.T. in industrial relations; tuition plus stipend.

Graduate Economics Alumni Fellowship
Gift of graduate alumni in economics; for a Ph.D. candidate in economics; tuition plus stipend.

Electrical Engineering

Grass Instrument Company
An endowment established by the Company and Dr. Albert M. Grass '34, the income for fellowship in electrical engineering, preferably for foreign students. Awards are made as often as sufficient income has accumulated to provide an appropriate grant to a student.

Schlumberger Foundation
For a graduate student in electrical engineering; tuition plus a stipend of not less than $3,200.

Management

Sloan School of Management
For college graduates seeking the doctor's degree who have demonstrated substantial academic competence and leadership promise. A number of fellowships and scholarships.

Mechanical Engineering

Wilfred Lewis
Gift of $5,000 by Mrs. Emily Sargent Lewis in memory of Wilfred Lewis '75, the income to be applied for the support of a graduate student in Mechanical Engineering.

Metallurgy and Materials Science

Allegheny-Ludlum Industries, Inc.
For a graduate student in metallurgical engineering; tuition plus stipend.

Allied Chemical Foundation
For a graduate student in electronic materials who is a U.S. or Canadian citizen; tuition plus stipend.

American Metal Climax Foundation
For three graduate students in the areas of deformation, non-ferrous metallurgy, and physical metallurgy; tuition plus stipend.

ASARCO Foundation
For a graduate student in chemical metallurgy who is a U.S. or Canadian citizen; tuition plus stipend.

Bethlehem Steel Corporation
For a graduate student in physical metallurgy; tuition plus stipend.

Copperweld Steel Company
For a graduate student in chemical metallurgy; tuition plus stipend.

International Copper Research Association, Inc.
For a graduate student in chemical metallurgy; tuition plus stipend.

International Nickel Company, Inc.
For a graduate student in materials science and engineering; tuition plus stipend.

Owens-Illinois, Inc.
For a graduate student whose research is in the field of glass science; tuition plus stipend.

Nuclear Engineering

Babcock and Wilcox Fellowship
For a graduate student in nuclear engineering; tuition plus required medical fees and stipend of $2,700 for the academic year and $900 for summer study.

Sherman R. Knapp Fellowship in Nuclear Power Engineering
For a graduate student planning a career in nuclear power engineering in the United States; tuition plus $2,700 for an unmarried student, $3,200 for a married student, for 9 months. At the end of the period, the Fellow is required to obtain three months of practical experience as a summer employee of Northeast Utilities.

Theos J. Thompson Memorial Fellowship
Memorial fellowship in honor of Professor Theos J. Thompson and his deeply felt interest and concern in the education of young and creative engineers; tuition and compulsory medical fees plus $2,700 for nine months.

General Electric Foundation
For a graduate student in Nuclear Engineering; tuition and fees plus $2,700 for nine months.

Nutrition and Food Science

Bernard E. Proctor Memorial
Scholarship in memory of Professor Bernard E. Proctor '23, formerly head of the Department; tuition.

Ocean Engineering

Gulf and South American Steamship Company
Fund established by Gulf and South American Steamship Company from which scholarship grants may be made upon initiative of the Department of Ocean Engineering. Preference is given to students in the fifth year in Shipping and Shipbuilding Management (Course XIII-B).

Special Loan Funds

Physics

Karl Taylor Compton Fellowships in Physics
For a graduate student in physics: tuition plus stipend of $3,000 for the academic year and $1,000 for summer study.

Kennecott Copper Corporation
For a graduate student in physics: tuition plus not less than $1,800 single or married without children. $2,000 married with one or more children.

Research Laboratory of Electronics

RCA
For graduate work in electronics, tuition plus stipend.

RLE
For graduate work in electronics, tuition plus stipend.

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
This fund is governed by the same conditions as the Technology Loan Fund and is available to students in financial need.

Anna J. and Francesco Casaretta Loan Fund (1966)
Established in memory of Anna J. and Francesco Casaretto, to be operated as a loan fund for the benefit of needy and worthy students regardless of race, creed or color.

Francis W. Chandler Loan Fund (1927)
This fund was established as a loan fund to assist worthy and needy students in the Department of Architecture.

Ruth Hornblower Churchill Memorial Loan Fund (1958)
Established by a gift in the name of Ruth Hornblower Churchill, this loan fund is used to help needy students at M.I.T.

Class of 1917 Loan Fund (1937)
The income and principal of this fund is used to assist deserving students, preference given to direct descendents of members of the Class of 1917. Beneficiaries are expected to issue notes agreeing to repay the face value, without interest, of amounts received.

Daunis Family Fund (1971)
This fund established by Mr. Alexander Daunis '32 as a loan fund administered under terms of the Technology Loan Fund.

George Freydberg Fund (1972)
This fund established by Irwin G. Freydberg '38 in memory of his father, George Freydberg, is for the purpose of student loans and administered similarly to the Technology Loan Fund; with emphasis on student need and not grades.

Ethel I. Fryer Scholarship Loan Fund (1951)
This fund was a gift of Herbert Fryer '11 to establish a loan fund for deserving students from the states of Washington, Oregon, and California. Grants are limited to $600 per student and are repayable within five years of graduation.

Jerome C. Hunsaker Loan Fund (1970)
This fund was established by Professor Jerome C. Hunsaker '12 for the purpose of making loans to students in the Department of Aeronautics and Astronautics, under the same terms as the Technology Loan Fund.

Rebecca R. Joslin Loan Fund (1924–36)
This fund is open to undergraduate and graduate students in chemical engineering and is restricted to students who are residents of Massachusetts and who abstain from using tobacco in any form.

Klock-Overton-Mills-Roberts-Longyear Loan Fund (1961)
This loan fund, established by Felix S. Klock '36, on the 25th anniversary of his graduation from M.I.T. in recognition of the people who significantly influenced and guided him in his education, functions on the same basis as the Technology Loan Fund. In granting awards, the Committee gives preference to needy and worthy students who are children of the employees of the Klock Corporation.

Lamson-Virgin Loan Fund (1946)
This bequest from Elizabeth H. Lamson is used in aiding a worthy student of excellent character who "must have shown not only respect for his parents but also proper consideration for the rights of others." Students thus aided shall repay if and when they find themselves able to do so.

Anthony P. Mathesius Loan Fund (1970)
This fund was established as a memorial to Anthony P. Mathesius '08 by members of his family. The principal and interest are used for loans in the same manner as are those of the Technology Loan Fund. First preference among recipients is given to students who are members of Phi Beta Epsilon.

George H. May Loan Fund (1914)
A gift from George H. May '92 provides a fund "to assist graduates of the Newton High Schools who are students at M.I.T. and who have been recommended as eligible by the Superintendent and Headmaster of the Newton High Schools." Beneficiaries under this fund are expected to issue notes agreeing to repay, without interest, the amounts received.

Helen and Leo Mayer Loan Fund (1967)
Established by a gift of the Helen and Leo Mayer Charitable Trust, the principal and interest of this fund are administered in the same manner as those from the Technology Loan Fund.

Arthur T. Nelson, Jr. Memorial Loan Fund (1962)
Established by a gift of Mrs. Arthur T. Nelson and the Trustees of Arthur T. Nelson, Jr., this fund is used for loans administered under the regular procedures adopted by the Institute to students residing in certain states.

Michael Joseph Pollock Loan Fund (1962)
The income of this memorial fund, established by the parents, relatives, and friends of Michael Joseph Pollock '59, is available for loans to deserving students.

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.

Ellen H. Richards Loan Fund (1964)
This fund, established by a gift from the Eastern Massachusetts Home Economics Association as a memorial to Ellen H. Richards, is used to provide loans, preference being given to women students in chemistry relating to food processing and food technology.

M. H. Rogers Loan Fund (1945)
This bequest of Minnie Hempel Rogers '90 is for loans to worthy students.

Lillie C. Smith Fund (1965)
Income from this fund in memorial of an early alumna is administered by the Association of M.I.T. Alumnae for aid to women students.

Gertrude W. Swartz Memorial Student Loan Fund (1971)
This bequest of Gertrude W. Swartz to be used as a loan fund for needy students.

Technology Matrons Loan Fund (1960)
This gift of the Technology Matrons is used to assist needy and worthy students with loans.

Robert Kelley Thulman Loan Fund (1963)
The gift of the wife of Robert Kelley Thulman '22, this fund is designated for loans to students.

Timbie Memorial Fund (1954)
This fund was established by graduates of the Cooperative Course in Electrical Engineering (VI-A) in the name of William H. Timbie. It is used to provide loans for students in the Cooperative Course.

F. B. Tough Fund (1924)
Established by a gift of Mr. F. B. Tough, this fund is used to provide loans "for the purpose of extending financial assistance to worthy students while pursuing their courses."

Frank P. Wakefield Loan Fund (1955)
One-fourth of the income of this fund is available for loans to needy and worthy students majoring in chemistry, chemical engineering, and biology.

American Institute of Chemists Award (1957)
The American Institute of Chemists offers annually two medals, one to a student in chemistry and one to a student in chemical engineering. The medals are given to students who show outstanding professional promise.

Avery Allen Ashdown Award
Awarded to a resident of the Ashdown House who carries on the tradition and spirit of service through participation in the affairs of the House.

Karl Taylor Compton Prizes (1951)
These prizes are awarded in recognition and encouragement of outstanding contributions in promoting high standards of performance and good citizenship within the Institute community. They are awarded from the income of a fund composed of gifts by members and friends of the Boston Stein Club.

The Goodwin Medal
The Goodwin Medal together with a cash prize may be awarded in any year (but not necessarily in every year) to a graduate student who is also a member of the academic staff of the Massachusetts Institute of Technology, in recognition of conspicuously effective teaching. Candidates for this award are nominated through departmental channels or by the Student-Faculty Committee to the Dean of the Graduate School. The award is in memory of Dr. Harry Manley Goodwin, the first Dean of the Graduate School, through a fund given by Mary B. and Richard H. Goodwin.

Military Prizes
A number of individual prizes are awarded to selected outstanding cadets in the Department of Air, Military, and Naval Science on the basis of technical and professional proficiency.

Scott Paper Foundation Leadership Award
This award of $1,500 is made annually to a student in the spring of his junior year for senior and first-year graduate study. It is presented in recognition of demonstrated high character, actions on behalf of the welfare of colleagues, and potential for making outstanding contributions to the professional aspects of engineering in business or industry.

William L. Stewart, Jr. Awards (1964)
These awards are given to individual students and student groups for outstanding contributions to extracurricular life. They are made from an annual gift by the W. L. Stewart, Jr. Foundation in memory of Mr. Stewart, member of the Class of 1923, member of the M.I.T. Corporation from 1952 to 1963, and long-time friend and benefactor of the Institute.

Stratton Prizes (1930)
Awards presented yearly for outstanding skill in organized debating. They are made possible by the income of a fund established by the late President Samuel W. Stratton.

Aeronautics and Astronautics

Luis de Florez Awards (1960)
The late Admiral Luis de Florez, distinguished engineer and alumnus of the Department of Mechanical Engineering, Class of 1911, endowed awards totaling $1,000 or more to recognize "original thinking or ingenuity" demonstrated by students in Aeronautics and Astronautics.

Henry Webb Salisbury Memorial Award (1941)
Established by the family and friends of Henry Webb Salisbury '33, this award, consisting of books chosen by the recipient, is given for outstanding work in the Department of Aeronautics and Astronautics.

Architecture and Planning

Student Medal of the American Institute of Architects (1914)
This medal is awarded on the recommendation of the Department of Architecture to the member of the graduating Master of Architecture class with the best record for the Course.

Civil Engineering

Tucker-Voss Award (1953)
Gift of the alumni and friends of the late Professors Ross F. Tucker and Walter C. Voss, former heads of the Course in Building Engineering and Construction, this prize is awarded annually to an undergraduate or a graduate student with high scholastic standing, leadership, and professional promise in the building field.

Richard Lee Russel Prize (1967)
This scholarship award of $500 for graduate study in civil engineering at M.I.T. is for an outstanding senior selected by the faculty of the Department. The award is supported by the Richard Lee Russel '89 Fund established in 1904 by Mr. Theodore E. Russel.

Electrical Engineering

Supervised Investors' Services, Inc., Awards (1957)
Four prizes of $500 each are awarded to graduate students who are members of the teaching staff of the Department of Electrical Engineering. They are given to honor those who have demonstrated an interest and proficiency in the field of teaching and to help defray the expenses of graduate study for advanced degrees.

Carlton E. Tucker Awards for Excellence in Teaching (1962)
Two prizes of $500 each, awarded to graduate students who are members of the teaching staff of the Department of Electrical Engineering, are given to honor those who have demonstrated an interest and proficiency in the field of teaching and to help defray the expenses of graduate study for advanced degrees. The Awards honor Professor Carlton E. Tucker, the Department's Executive Officer for 24 years, for his dedication to and interest in high teaching standards; they are supported in part from funds given in memory of Professor Tucker and Professor William H. Radford.

David T. Schultz Award (1969)
An award made annually to an assistant professor in the Department of Electrical Engineering for outstanding accomplishment in teaching undergraduate students. The David T. Schultz Award for Excellence in Teaching in Electrical Engineering was established in 1969 by a gift from Baird-Atomic, Inc. of Cambridge of 1,000 shares of its common stock. The award honors Mr. David T. Schultz who is Chairman of the Executive Committee of the company.

Management

The Brooks Prize in Management
The E. P. Brooks Master's Thesis Prize of $100 is awarded each year for the thesis judged to be the best submitted for the Master of Science in Management. Nominations may be made by the chairman of any Master's thesis Committee to the Sloan School of Management's Prize Committee.

Editorship of the Sloan Management Review
The editorship of the journal of the Sloan School of Management is awarded annually to selected graduate students in management who have achieved distinguished records of scholarship and leadership in the School.

Mechanical Engineering

Luis de Florez Awards (1957)
The late Admiral Luis de Florez, distinguished engineer and alumnus of the Department of Mechanical Engineering, Class of 1911, endowed these awards to recognize "outstanding ingenuity" demonstrated by students in mechanical engineering. Prizes totaling $1,000 or more are awarded each year.

Silent Hoist and Crane Company Materials Handling Award (1950)
These annual prizes, totaling more than $500, are awarded for the best papers or theses submitted on subjects in the field of production, materials handling, or machine design related to materials handling equipment, on the basis of a competition held each year. The award is a gift of the Wunsch Foundation, Inc.

Engineering Projects Laboratory—Showcase Awards
Undergraduate and graduate students are encouraged to offer exhibits of their work at any time throughout the year. Prizes of about $25 to $50 are offered at the end of the year for exhibits judged most effective by a panel.

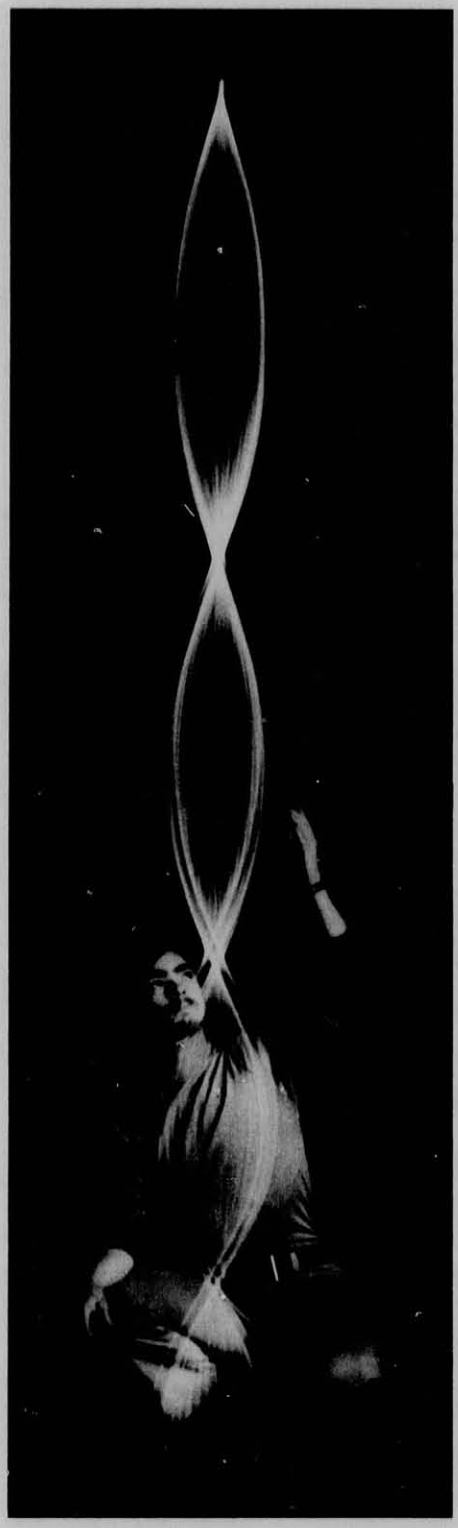
Meteorology

The Carl-Gustav Rossby Award in Meteorology
This award was established in part, by the gift of Julius Honig '53 in memory of Professor Carl G. Rossby who established the course in meteorology at M.I.T. The award of $100 is made in any year for the most outstanding graduate thesis submitted to the Department of Meteorology.

Metallurgy and Materials Science

Metallurgy and Materials Prize (1963)
The sum of $150 is awarded to an outstanding junior in the Department. The award was established by graduate students and associates of Professor Morris Cohen in recognition of his significant contributions to undergraduate education in materials. It is presently supported by the Boston Section, A.I.M.E.

American Metal Climax Foundation Prize (1969)
The sum of $300 is available for awards to students who perform outstanding laboratory projects.



Other Information

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. Therefore, it is M.I.T.'s policy to have as few rules and regulations as are consistent with efficient administration and general welfare.

Fundamental to the principle of independent learning and professional growth is the requirement of honesty and integrity in the performance of academic assignments, both in the classroom and outside, and in the conduct of personal life. Accordingly, M.I.T. holds its students to the highest standards of intellectual integrity and thus the attempt of any student to present as his or her own any work which he or she has not performed or to pass any examinations by improper means is regarded by the faculty as a most serious offense and renders the offender liable to immediate expulsion. The aiding and abetting of a student in any dishonesty is also held as a grave breach of conduct.

At the graduate level, no formal student judicial system exists. The majority of cases calling for disciplinary considerations resulting from infractions within the Institute community are handled by the Student's Graduate Registration Officer in consultation with the Dean for Student Affairs and the Dean of the Graduate School. More serious cases are considered by the Faculty Committee on Discipline.

It should also be noted that the Institute reserves the right to dismiss at any time a student whom it deems undesirable for any reason. Unethical conduct, wherever it may occur, is held to be sufficient grounds for dismissal.

If a student's infraction involves both Institute judicial proceedings and court proceedings, and if an Institute decision might prejudice his or her court case, the Institute will hold its decision in abeyance until after the court proceedings have been concluded.

The Office of the Dean for Student Affairs is responsible for all matters pertaining to general student welfare.



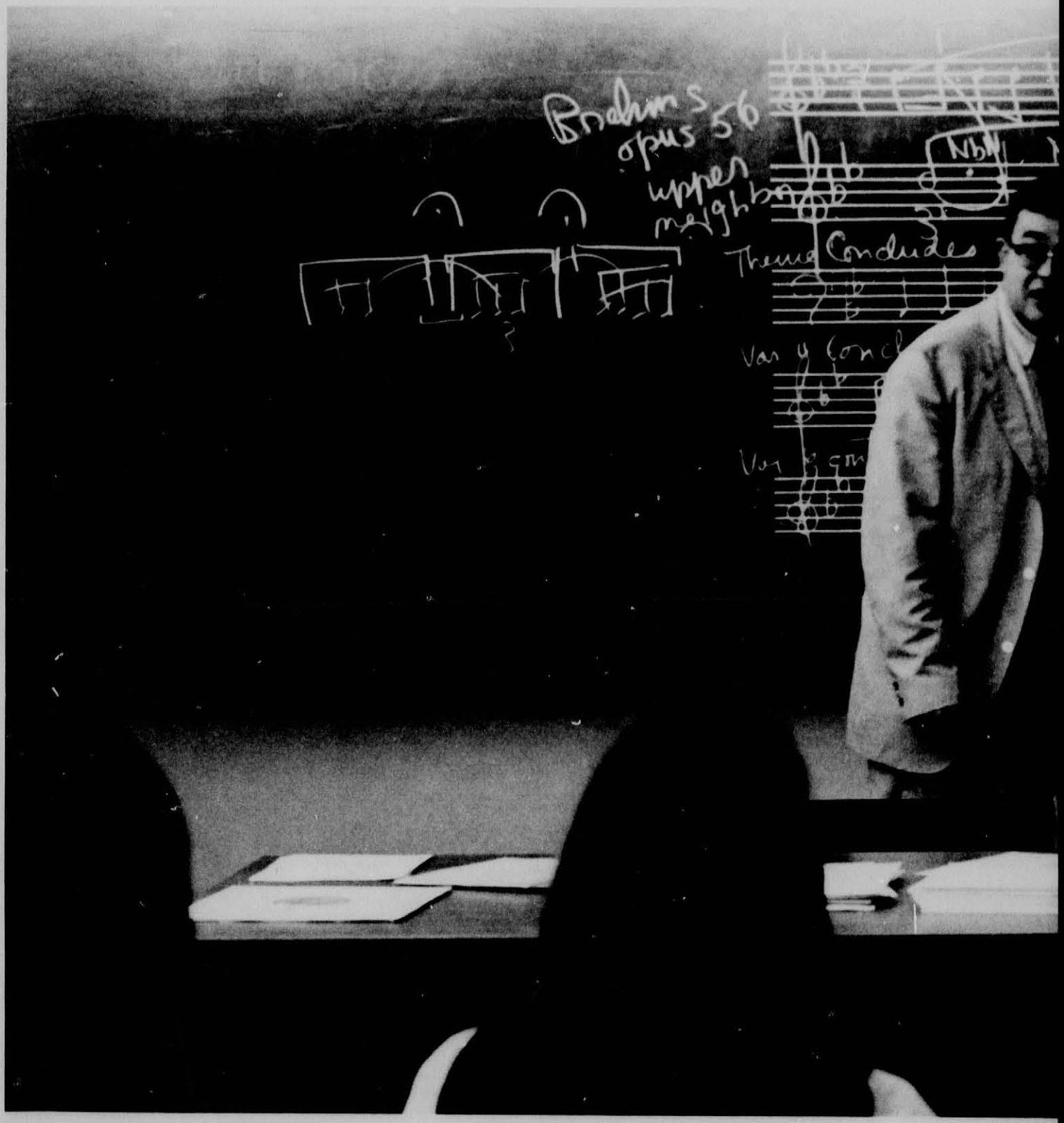
Motor Vehicles

All motor vehicles operated by students must be registered each term with the Campus Patrol within 30 days after Registration Day. Students should also note the requirement that out-of-state automobiles operated by M.I.T. students must be registered with the M.I.T. Campus Patrol.

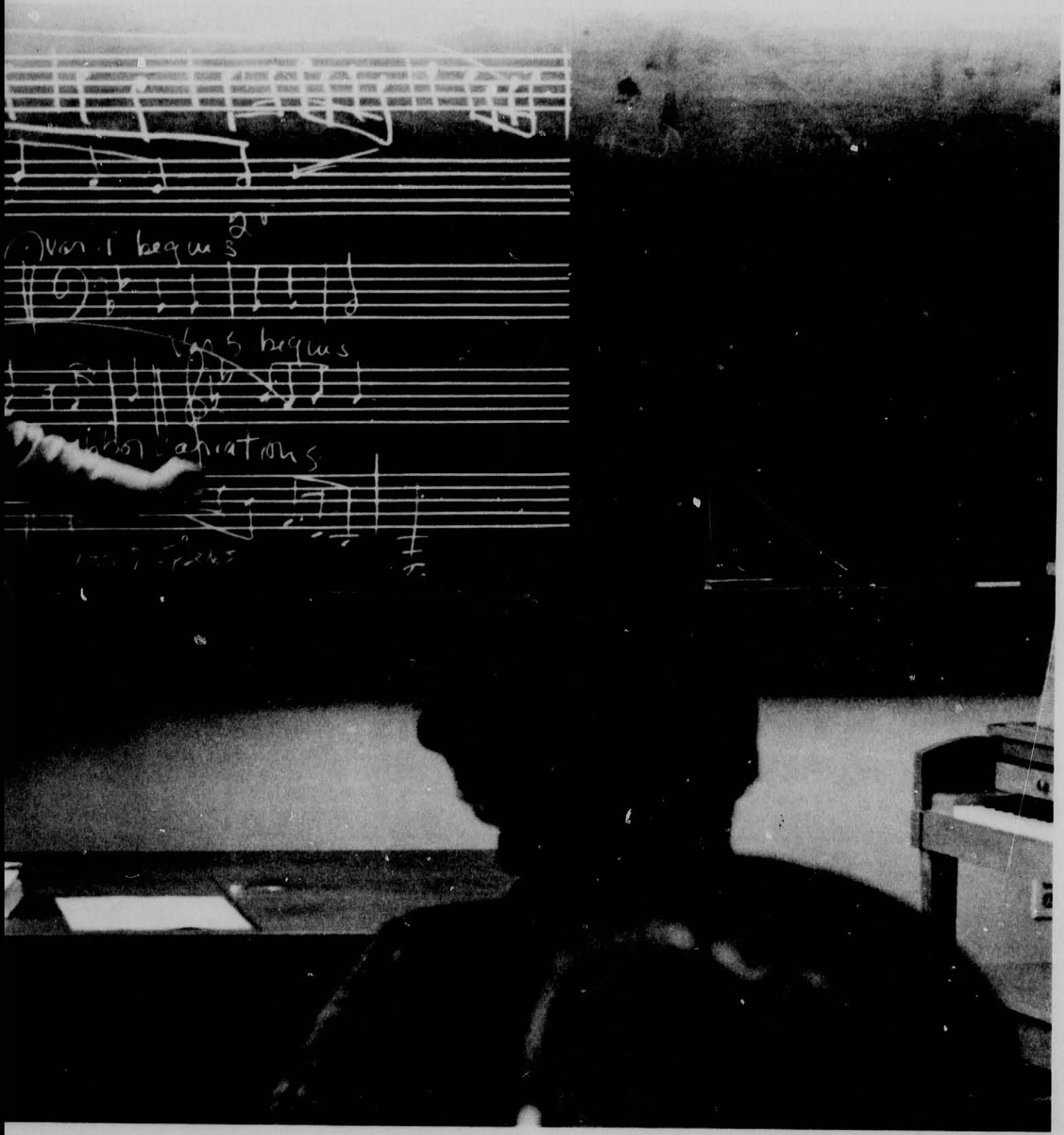
Parking facilities at M.I.T. are limited. In general, the Institute cannot provide parking for the use of resident students. A limited number of spaces are available for assignment with the approval of the Dean for Student Affairs to students with physical handicaps demanding use of an automobile and to a few other undergraduates.

Because demand for student parking far exceed supply, the matter is under study at the present time. A system of paid parking may be instituted. Students who plan to bring motor vehicles to Cambridge should take careful note of the information regarding pertinent Massachusetts laws which is mailed with their registration material.



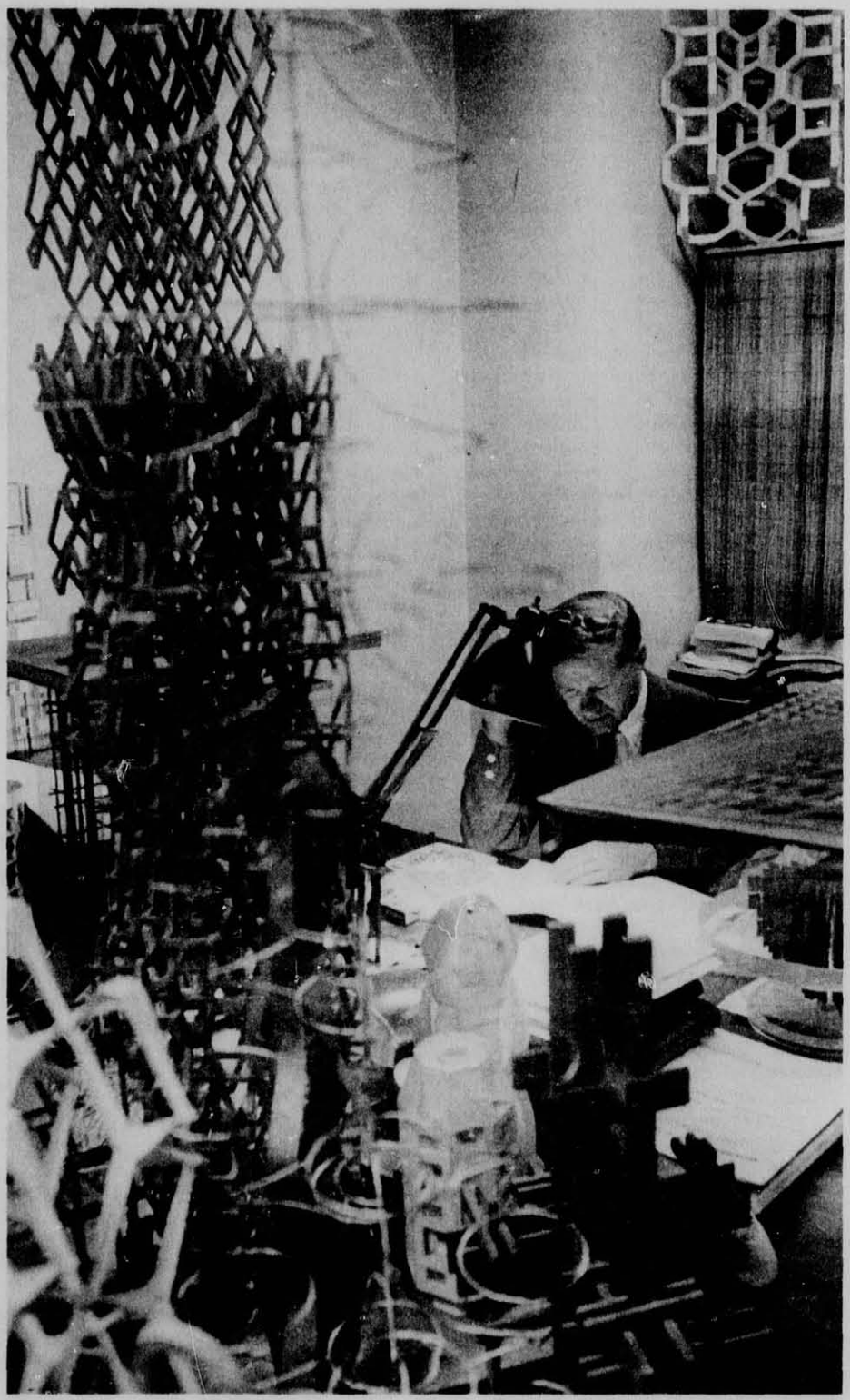

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IV Departmental Programs and Requirements





School of Architecture and Planning



The concern of the School of Architecture and Planning is for the quality of human experience. The School is interested in a more human environment, a higher quality environment, one which is satisfying not only for the everyday life of all citizens, but one which satisfies a full range of experience, including that which is aesthetically pleasing and spiritually ennobling. The School has no illusion that the skills which fall within its domain will permit the transformation of the environment to the conditions desired without substantial changes in society, over many of which the School has little influence. The School of Architecture and Planning, nevertheless, has the opportunity to make some contribution by developing the understanding, creativity, and skills necessary to bring about change in areas which touch on architecture and planning.

These areas in society where graduates of this School can most appropriately make an impact are increasing in number and diversity, and this increase is reflected in recent changes in the School. These changes have been especially conspicuous in the academic programs during the last nine years. Since 1965, the enrollment in Planning, which had been growing at a slow rate, and in Architecture, which had seemed to be in a slow decline, have increased dramatically. Now there are twice as many students in Architecture (almost 300) and three times as many in Planning (approximately 200) as in 1965. Students who enter the graduate programs in the School come from a wide variety of undergraduate backgrounds and majors, and a great many have had some previous professional or preprofessional experience in architecture or planning.

During the academic year 1973–74, 59 undergraduates in the Department of Urban Studies and Planning majored in urban studies, 66 students were enrolled in the Master in City Planning program, and 46 were enrolled in the doctoral program. In addition, the Community Fellows Program and the Special Program for Urban and Regional Studies in Developing Countries (SPURS) consistently have brought to M.I.T. approximately two dozen outstanding individuals each

year from diverse backgrounds and life situations. These two programs are designed to allow mid-career practitioners, who work in urban and regional development in minority communities and in developing countries, respectively, to carry out a nondegree program of independent study and research for one academic year.

In the Department of Architecture during 1973–74, undergraduate majors numbered 136, Master of Architecture candidates 91, and Master of Architecture in Advanced Studies candidates 39. There is currently a small but growing number of students concentrating in the environmental arts. Additionally, a limited number of nondegree "special students" are admitted to each Department each term for the study of particular subject areas and the development of specialized skills.

The School is encouraging shifts in its composition in response to the social need it perceives for minorities and women to become effective architects, planners, artists, researchers, and teachers. In the Department of Urban Studies and Planning this year, 29 out of 112 graduate students, and in the Department of Architecture, 16 out of 130 graduate students, are from minority groups, including Puerto Ricans, Blacks, Chicanos, and American Indians. Women graduate students, 29 in Planning and 39 in Architecture, represent 28.1 percent of the total graduate student population. On the faculty and research staff, more members of minority groups and more women have appointments than ever before: there are nine minority group members and nine women in Planning, two minority group members and seven women in Architecture.

Under constant review and revision are the areas of specialization within the two Departments. Existing programs in the School such as urban economics, housing in developing areas, history, theory and criticism of art, and architecture and urban form are being strengthened, and new programs, such as health planning and management, and quantitative methods in architecture and urban planning, have been added. Teaching and research activities in several areas such as transportation, energy, communications, law, operations research, and the arts are linked to other parts of the Institute across departmental lines. For example, subjects in urban economics are offered jointly by the Departments of Economics and Urban Studies and Planning; building construction is offered jointly by the Sloan School of Management, the Department of Civil Engineering, and the Departments of Architecture and Urban Studies and Planning.

Other interdisciplinary offerings include Science, Technology and Ritual, taught by an art historian, an historian, and a physicist; Aesthetic Perspectives in Science and Technology, which is composed of lectures on the aesthetics of concepts, processes, forms, materials, and products by professors in several departments; and Undergraduate Research Opportunities (U.R.O.P.), in which all students at the Institute are given the opportunity to propose their own topics and to receive support in the form of money or credit for research done in collaboration with faculty members.

Within the School itself, the Environmental Design Program bridges the two Departments. In addition, a number of faculty members hold appointments in more than one department — two hold joint appointments from the two Departments in the School, and others hold joint appointments with departments outside the School, such as the Departments of Economics, Psychology, Civil Engineering, and Humanities.

A number of programs and subjects reflect the considerable educational innovation which is taking place in the School. Professors from the Schools of Architecture and Planning, Humanities and Social Science, Science, and Engineering, for example, in the past have given the Interdisciplinary Freshman Project Year, which was a joint program for freshmen, covering traditional subject matter as part of the larger process of exploring a topic such as Cities and Building. Freshman Project Year was created to combat compartmentalization of knowledge and the overly analytical approaches often encountered in the freshman year, and was intended to expose students to the interdependency of skills and knowledge necessary to formulate and solve problems arising out of complex issues in modern society.

Reinforcing the importance of cultural and aesthetic insights, an important section in the School is concerned with a broad perspective of the visual arts. This includes the scholarly study of the history and criticism of art and architecture as well as studio experiences in several forms of direct visual expression. The Center for Advanced Visual Studies in the Architecture Department offers an opportunity for students to work on various projects related to art on an environmental scale. The presence of this nucleus attracts students from every part of the Institute and offers possibilities for undergraduate concentration in the visual arts.

Faculty and students have been devising new units of instruction that complement the term-long subjects. Short subjects, or "mini-courses," are offered both during the regular academic terms and during the January Independent Activities Period. They cover such topics as media and the city, solar energy, electrographic printmaking, land use models, analysis of professional planning practice, and basic computer languages oriented to architecture and planning. The faculty of both Departments also offer tutorials, research seminars, special studies, and other instruction tailored to individual need.

Research has grown in amount and importance in relation to the teaching programs. From very little funded research in the early 1960s, the School now houses more than $1 million in research per year, offering an extremely important new set of educational opportunities for students. A wide spectrum of student and faculty interests is reflected in the areas of current research: analysis of urban public service systems; 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; bio-climatology and the thermophysical control of building materials; computer graphics for design; environ-

ment and urban growth strategies; multi-regional input/output analysis of transportation; revenue sharing; and national housing goals.

Design for special clientele has been the focus of several projects in the Department of Architecture. Studio and tutorial settings have been used for the study and demonstration of the role of the architect for groups which traditionally have been handicapped in their use of the environment or in their access to professional design services. Clients have included American Indians, the handicapped (blind and paraplegic), and the elderly.

Research, particularly in the field of housing policy, is conducted at the M.I.T./Harvard Joint Center for Urban Studies, with the extensive participation of faculty and students not only from this School but from many other departments of the two universities as well.

An important new center for research activities was created last year in the School — the Laboratory of Architecture and Planning. The Laboratory fosters research which contributes to the understanding, education, and practice of these and closely related fields. The focus of the Laboratory's research is on projects which combine abstract modelling with limited interventions in the social and physical environment. Projects now housed in the Laboratory include Urban Public Safety Systems, a study of law enforcement, ambulance, fire, and other systems in Boston and elsewhere; Public Urban Space, a study of the design professional's representations of public space, urban form, and human activity; Professional and Group Behavior, a study of the mental models which professionals construct of their professional/client situations in particular, and, in general, the role of human sciences in professional education in the School of Architecture and Planning; and the Concentrated Program in Environmental Design, a study of the feasibility of offering a one-year program in environmental design to early- and mid-career professionals, under the direction of the Environmental Design Program of the two Departments. The Laboratory also offers assistance to other research and teaching activities in the School through its offices of Computing Services, Field Services, Research Administration, and Educational Services.

Also important is the emergence of research on the educational process and on the professions for which students are preparing at the School. A current study of the professions, conducted by two professors who are affiliated both with the School and with the Institute's new Division for Study and Research in Education, is focusing on the nature of professional behavior and of professional practice. Research on professional education has focused in its early phases on an analysis of what takes place educationally in field linked education — that is, education which depends on the student's direct involvement with activities outside M.I.T., activities which are part of the regular business of society.

There has been a great increase in the number and variety of opportunities for students to include "real world" or field related experiences in their curricula, since the first such opportunities were made available at the Institute in the mid-1960s. These field related experiences focus on carefully controlled settings in which the student can obtain knowledge of and feeling for the workings of complex social institutions, for individual and group motivations, and for a wide diversity of life-styles. The student can test skills developed in the academic setting and obtain a sense of what sort of career line he or she might follow.

One of the first community design centers in the United States, the Community Projects Laboratory, was created in the Department of Architecture to offer design services to groups which lack the means to acquire other professional assistance. Projects have included renovations to create community facilities, design and construction of playgrounds, and teaching in elementary and high schools. Other field related opportunities in the School include serving as staff to the members of the Cambridge City Council; working in a public agency as part of the HUD Minority Internship Program in the Department of Urban Studies and Planning; and providing assistance through the Health Advocacy Program to organized consumer groups, social service agencies, and government officials involved in serious efforts to improve health care. Architecture students also have the opportunity to "intern" in professional offices.

In the School of Architecture and Planning, traditions stem from architecture, European town planning, and social science, and to a lesser extent, from civic art, landscape architecture, and civil engineering. Architects and planners whose concerns are for the physical city are certainly prominent among the professionals who graduate from M.I.T., but the School also wishes to train those who will specialize in other aspects of these fields, such as public policy analysis, housing and community development, urbanization and economic development in developing areas here and abroad, building technology, visual and environmental arts, and history and criticism of architecture and art. The School is deeply committed to training individuals for service to groups in society which presently are disadvantaged and voiceless, and to training for new kinds of social intervention and expression through new uses of the media and civic art.

In each of these and other related areas, the professional who graduates from this School must have the requisite knowledge, skills, and attitudes to be effective; he or she must have an understanding of the requirements for membership (but not for acquiescence) in various private and public sector organizations in which he or she will work and an ability to contribute to community values and to reform them. Perhaps most challenging of all, the professional must have the capacity to grow and to adapt with integrity in a rapidly changing world.

Dean of the School of Architecture and Planning

Department of Architecture

Donlyn Lyndon, M.F.A.
Professor of Architecture
Head of the Department

Leon Bennet Groisser, Sc.D.
Associate Professor of Structures
Executive Officer

Professors

Wayne Vesti Andersen, Ph.D.
Professor of the History of Art
Chairman of the Committee on the Visual Arts

Lawrence Bernhart Anderson, M.Arch.
Professor of Architecture, Emeritus
Dean of the School of Architecture and Planning, Emeritus
Senior Lecturer

Stanford Anderson, Ph.D.
Professor of History and Architecture

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

Horacio Caminos, Arq.
Professor of Architecture

Eduardo Fernando Catalano, M.Arch.
Professor of Architecture

Albert George Henry Dietz, Sc.D.
Professor of Building Engineering, Emeritus
Senior Lecturer

Imre Halasz, Dipl. Arch.
Professor of Architecture

Richard Leacock
Professor of Cinema

Henry Armand Millon, Ph.D.
Professor of History and Architecture
(Absent)

John Randolph Myer, B.Arch.
Professor of Architecture

Otto Piene, M.A.
Professor of Visual Design

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

Minor White
Professor of Photography, Emeritus
Senior Lecturer

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

Associate Professors

Edward Blair Allen, M.Arch.
Associate Professor of Architecture

William Hoskins Brown, M.Arch.
Associate Professor of Architecture

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

Jonathan William Green, M.A.
Associate Professor of Photography

Tunney Lee, M.Arch.
Associate Professor of Architecture and Urban Planning

Nicholas Peter Negroponte, M.Arch.
Associate Professor of Architecture

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

Edward Pincus, A.B.
Associate Professor of Cinema

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

John Ames Steffian, M.Arch.
Associate Professor of Architecture

Richard Chester Tremaglio, B.Arch.
Associate Professor of Architecture

Judith Wechsler, Ph.D.
Associate Professor of the History of Art

Assistant Professors

Arthur Bernhardt, M.C.P.
Assistant Professor of Architecture

Richard Martin Britain, M.A.
Assistant Professor of Architecture

Whitney Chadwick, M.A.
Assistant Professor of the History of Art

Gary Hack, M.C.P., M.Arch.
Assistant Professor of Architecture and Urban Planning

Dolores Hayden, M.Arch.
Assistant Professor of History and Architecture

Timothy Edward Johnson, S.M.
Assistant Professor of Architecture

Donald Anthony Preziosi, Ph.D.
Assistant Professor of the History of Architecture

John Horace Terry, B.Arch.
Assistant Professor of Cinema
(Absent)

Jan Wampler, M.Arch.
Assistant Professor of Architecture

Sean Wellesley-Miller, B.Sc.
Assistant Professor of Environmental Controls (Visiting)

Research Associate

Sandra Howell, Ph.D.

Lecturers

Myron Guran, B.Arch.
Carl Koch, M.Arch.
Gunter Nitschke, Dipl. Arch.
William A. Southworth, M.A.T.

Instructors

Nan Arghyros, M.A.
Reinhard Goethert, M.Arch.
Ronald MacNeil, S.B.
Maria K. Ogrydziak, B.Arch.
Robert J. Slattery, B.Arch.
Lawrence W. Speck, M.Arch.
Jane Weinzapfel, B.Arch.

Technical Instructors

Nishan Bichajian
Ignacio Garabieta-Orueta, Dipl.
Peter B. Laytin, B.A.

Technical Assistants

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Andrew B. Lippman, B.S.

Administrative Officer

Anne Shepley, B.A.

Administrative Assistant

Ena C. Squires

Professors Emeriti

Lawrence Bernhart Anderson, M.Arch.
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Dean of the School of Architecture and Planning, Emeritus
Senior Lecturer

Herbert Lynes Beckwith, M.Arch.
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Gyorgy Kepes, M.A.
Institute Professor, Emeritus
Professor of Visual Design, Emeritus
Director, Center for Advanced Visual Studies, Emeritus

Henry Latimer Seaver, A.M.
Professor of History, Emeritus

Minor White
Professor of Photography, Emeritus
Senior Lecturer

Department of Architecture

Undergraduate Study

The Department of Architecture takes as its fundamental charge education for change in relationships between people and their environment. Faculty and students share concerns for the quality, character, and nature of the visual and physical surroundings on intimate and large scales. They express a commonality of commitment to understanding ways in which people conceptualize the built and natural environment and their roles in making and using that environment.

Undergraduate and graduate students work closely with each other and with the faculty. They develop competences in architectural programming and designing, in building technology and process, in visual communications and design methods, and in the analysis of symbolism and structure in art and architecture. Education in theoretical and practical modes among a diversity of attitudes and media enriches a student's experience in the Department and proposes a variety of alternatives for career paths.

In the environmental arts the awareness developed stems from understanding the potentialities and the technical imperatives of the media employed. These are examined through direct involvement 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 the technical demands the student acquires the ability to form and transmit new discoveries about the environment.

Faculty and students in architecture also foster studies of the changing relation between humans and the environment through examination of the potentialities of building and the activities of the architect in a changing society. There is a similar concern for developing perceptions and responses to the physical, social, and psychological environment, as well as for acquiring the ability to realize in specific actions a variety of evolving views about people and environment. Architectural design studies include the building process, additive processes of designing built form, the co-designing of institutional and physical form, and design for special client groups.

The Department offers two undergraduate courses of study: Course IV, leading to the Bachelor of Science in Art and Design, and Course IV-B, leading to the Bachelor of Science.

Bachelor of Science in Art and Design Course IV

Course IV is a flexible program for students whose primary interest falls within the subject area of the Department. There are four possible areas of concentration: visual arts (including visual design, photography, and film making); architectural design; building technology (including structures, building process, and environmental control); and history, theory, and criticism of art and architecture. Within a broad framework, students develop individual courses of study best suited to their needs and interests.

The requirements for the B.S. in Art and Design curriculum are intended to establish a basis for common understanding among the students majoring in the Department. The Restricted Electives

Bachelor of Science in Art and Design Course IV

	General Institute Requirements	Total units
	Specific science and humanities and social science subjects[1]	132
	Science Distribution Requirement	36
	Laboratory Requirement	12
	Departmental Program	
	Restricted Electives One subject from each of the following six groups:	at least 54
	Group 1 Introductory Subjects	
4.001	Introduction to the History, Theory and Structuring of Form 3 0 6	
4.002	Representations of Place 2 2 5	
	Group 2 Arts	
4.01	Creative Seeing 3 0 6	
4.031	Form and Design I 2 4 6	
4.051	Creative Photography I 2 6 1	
4.062	Art and the Environment 3 0 6	
4.091	Introduction to Film Making 4 6 2	
	Group 3 Architecture	
4.26	Built Form Observations 2 3 4	
4.27	Analysis of Precedent 2 2 5	
4.28	Building Design Techniques 2 3 7	
	Group 4 Environmental Technology	
4.201	Geometry and Computation in Architecture 4 0 4	
4.30	Basic Structural Theory[2] 3 3 6	
4.402	Basic Building Construction 3 3 6	
4.45	Uses of Energy in Buildings 4 0 5	
	Group 5 History of Art and Architecture	
4.601	Topical Studies in the History and Theory of Art I 3 0 6	
4.602	Topical Studies in the History and Theory of Art II 2 3 4	
4.606	Introduction to the History of Architecture I 3 0 6	
4.607	Introduction to the History of Architecture II 3 0 6	
4.641	Painting in the Nineteenth Century 3 2 6	
4.651	Painting in the Twentieth Century 3 0 6	
	Group 6 Social Context	
4.74J	Introduction to City Design and Environmental Policy 3 0 6	
	An approved subject in Course XI	
	Planned Electives A coherent set of subjects (in addition to a restricted elective in the area of concentration) within one of the following areas of concentration which, together with other parts of the student's program, is aimed at a well-defined educational goal	66
	Visual Arts, the 4.0 series	
	Architectural Design, the 4.1 and 4.2 series	
	Building Technology, the 4.3, 4.4 and 4.5 series	
	History, Theory and Criticism of Art and Architecture, the 4.6 series	
	Unrestricted Electives	up to 60
	Total Units Required for the S.B. Degree	360

1
The following subjects may **not** be used for the humanities and social science requirement: for areas of concentration in Architectural Design and Building Technology, those subjects in Visual Arts and Design, History of Art and Architecture, and Urban Studies used in fulfillment of the Departmental Program; for areas of concentration in Visual Arts and History, Theory and Criticism of Art and Architecture, all subjects in Visual Arts and Design and History of Art and Architecture.

2
4.30 Basic Structural Theory partially fulfills this requirement and will also be credited towards the Science Distribution Requirement, thereby providing 12 additional units of Unrestricted Electives.

begin with one of two introductory subjects that deal with concepts of form and place respectively. These two subjects are of common concern in the Department and many members of the faculty participate in them. They are 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. In addition, students should submit, no later than the beginning of the spring term of their junior year, a statement of educational goals and a list of the restricted and planned electives selected to achieve these goals. Subsequent to approval of this list, substitutions of similar subjects may be permitted.

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 are normally able to satisfy the requirements for the M. Arch. in two years if they include in their undergraduate program a sufficient number of subjects in the M. Arch. program. This will require careful use of 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.

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, etc., creating a coherent program of study especially designed to meet individual needs and interests.

In following this curriculum, students are required to fulfill the General Institute Requirements, departmental restricted electives, and planned electives selected by the student. Students desiring to follow this curriculum must submit to the Department, not later than the beginning of the fall term of their junior year, a statement of educational goals, including a list of the restricted, planned, and unrestricted electives selected to achieve these goals. At an earlier date, interested students should discuss their interests and intended programs with faculty members in the Department.

Bachelor of Science Course IV-B

General Institute Requirements	Total units
Specific science and humanities and social science subjects[1]	132
Science Distribution Requirement	36
Laboratory Requirement	12
Departmental Program	
Restricted Electives One subject each from five of the following six groups:	at least 45

	Restricted Electives (continued)	
	Group 1 Introductory Subjects	
4.001	Introduction to the History, Theory and Structuring of Form	3 0 6
4.002	Representations of Place	2 2 5
	Group 2 Arts	
4.01	Creative Seeing	3 0 6
4.031	Form and Design I	2 4 6
4.051	Creative Photography I	2 6 1
4.062	Art and the Environment	3 0 6
4.091	Introduction to Film Making	4 6 2
	Group 3 Architecture	
4.26	Built Form Observations	2 3 4
4.27	Analysis of Precedent	2 2 5
4.28	Building Design Techniques	2 3 7
	Group 4 Environmental Technology	
4.201	Geometry and Computation in Architecture	4 0 4
4.30	Basic Structural Theory[2]	3 3 6
4.402	Basic Building Construction	3 3 6
4.45	Uses of Energy in Buildings	4 0 5

	Restricted Electives (continued)	
	Group 5 History of Art and Architecture	
4.601	Topical Studies in the History and Theory of Art I	3 0 6
4.602	Topical Studies in the History and Theory of Art II	2 3 4
4.606	Introduction to the History of Architecture I	3 0 6
4.607	Introduction to the History of Architecture II	3 0 6
4.641	Painting in the Nineteenth Century	3 2 6
4.651	Painting in the Twentieth Century	3 0 6
	Group 6 Social Context	
4.74J	Introduction to City Design and Environmental Policy	3 0 6
	An approved subject in Course XI	
	Planned Electives A coherent set of subjects which, with other parts of the program, is aimed at a well-defined interdisciplinary goal. Each program must be approved by the undergraduate curriculum committee or by the Department.	84
	Unrestricted Electives	up to 51
	Total Units Required for the S.B. Degree	360

1
Subjects in Visual Arts and Design, History of Art and Architecture, and Urban Studies used in fulfillment of the Departmental Program may **not** be used for the humanities and social science requirement.

2
4.30 Basic Structural Theory partially fulfills this requirement, and will also be credited towards the Science Distribution Requirement, thereby providing 12 additional units of Unrestricted Electives.

Graduate Study

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 graduate study programs at two levels — the Master of Architecture and the Master of Architecture in Advanced 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. Both programs are designed as a preparation for practice and may also attract students who are preparing for teaching, writing, or research.

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 are normally 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 are admitted with a Bachelor's degree from other institutions. Those who have not yet studied in a department of architecture usually require three and one-half years of residence to fulfill the requirements for the M. Arch.

Master of Architecture in Advanced Studies

This program, open only to students who have earned the first professional degree, is designed to promote study in depth. Candidates with the Institute's degree of M. Arch., who have already completed 96 units of "A" subjects, can fulfill the requirements for the M. Arch. A.S. upon satisfactory completion of an approved program of 66 units, of which 42 units must be in "A" subjects and an acceptable thesis. Candidates with degrees from other institutions are required to be in residence for two academic years and to complete approved programs substantially greater than the minimal requirements stated above.

Inquiries

Further information concerning academic programs in the Department, admissions, financial aid, assistantships, etc. may be obtained from: Ena Squires, Room 7-303, M.I.T., Cambridge, Massachusetts 02139, (617) 253-7791.

Subjects in Architecture*

(A) following the name of a subject indicates that it is an approved subject for a graduate degree and is given primarily for graduate students.

4.U.R.	Undergraduate Research in Architecture
4.001	Introduction to the History, Theory and Structuring of Form
4.002	Representations of Place
4.01	Creative Seeing
4.011	Graphics Laboratory I
4.012	Graphics Laboratory II
4.013	Graphic Composition
4.014	Messages and Means
4.019	Special Problems in Graphic Communication
4.021	Visual Design Problems I
4.022	Visual Design Problems II
4.023	Visual Design Projects
4.029	Special Problems in Visual Design
4.031	Form and Design I
4.032	Form and Design II
4.033	Form and Color I
4.034	Form and Color II
4.041	Environmental Light and Color I (A)
4.042	Environmental Light and Color II (A)
4.051	Creative Photography I
4.052	Creative Photography II
4.053	Documentary Photography
4.054	Photo-Graphics I
4.055	Photo-Graphics II
4.056	Evaluating Photography
4.057	Creative Audience
4.058	Special Projects and Selected Topics in Photography
4.059	Special Projects and Selected Topics in Photography(A)
4.062	Art and the Environment
4.063	Projects in Environmental Art (A)
4.064	Environmental Art
4.065	Advanced Visual Design (A)
4.066	Advanced Visual Design (A)
4.069	Special Problems in Environmental Art (A)
4.071	Painting
4.081	Plastic Composition
4.091	Introduction to Film Making
4.092	Advanced Film Making I
4.093	Advanced Film Making II
4.094	Special Topics in Motion Picture Production (A)
4.096	Movies: An Introduction I
4.097	Movies: An Introduction II
4.098	Special Topics in Film History and Criticism (A)
4.121	Architectural Design: Built Form
4.122J	Environmental Design I
4.123	Architectural Design: Building Project Laboratory
4.131	Architectural Design
4.132	Architectural Design
4.143	Architectural Design (A)
4.144	Architectural Design (A)
4.155	Architectural Design (A)
4.156	Architectural Design (A)
4.160	Urban Settlement Design in Developing Countries (A)
4.161	Urban Settlement Design in Developing Countries (A)
4.162J	Collaborative Design (A)
4.163	Advanced Design (A)
4.164	Systems and Industrialization (A)
4.165	Systems and Industrialization (A)
4.17	Special Problems in Architectural Design
4.171–4.175	Special Problems in Architectural Design
4.19, 4.191	Special Problems in Architectural Design (A)
4.20	Introduction to Information Processing (A)
4.201	Geometry and Computation in Architecture
4.21	Design Information: Structures and Models (A)
4.23J	Analysis of Urban Design (A)
4.24	Computer-Aided Urban Design (A)
4.25	Machine Intelligence in Design (A)
4.26	Built Form Observations
4.27	Analysis of Precedent
4.271	Advanced Topics in Environmental Precedent (A)
4.28	Building Design Techniques
4.281	Drawings by Which Buildings Get Built
4.29	Special Topics in Design Information (A)
4.30	Basic Structural Theory
4.311	Framed Structures I
4.312	Framed Structures II
4.313	Funicular and Membrane Structures
4.321	Structural Design and Application I (A)
4.322	Structural Design and Application II (A)
4.331	Synthesis of the Behavior of Structural Systems (A)
4.332	Industrialization of Structural Systems (A)
4.39	Special Problems in Structural Design (A)
4.402	Basic Building Construction
4.404	Practical Workshop in the Technology of Construction
4.409	Special Problems in Building Technology (A)
4.42	Materials
4.43	Environmental Control — Acoustics
4.431	Special Problems in Architectural Acoustics (A)
4.45	Uses of Energy in Buildings
4.46	Solar Architecture and Integrated Utility Systems (A)
4.49	Special Problems in Environmental Controls (A)
4.50	Organization of the Building Industry
4.51	Introduction to Industrialization of Building (A)
4.52	Seminar in Industrialization of Building (A)

*Full descriptions of all subjects are given in the catalogue entitled **Courses and Degree Programs, 1974–75**, which may be obtained by writing to the Institute Information Services, Room 7-111, M.I.T.

4.53J	Project Organization and Control (A)
4.56J	The Construction of Buildings (A)
4.57	Policy Alternatives for Development of the Building Industry (A)
4.58	Special Topics in Industrialization of Building
4.59	Special Topics in Industrialization of Building (A)
4.601	Topical Studies in the History and Theory of Art I
4.602	Topical Studies in History and Theory of Art II
4.603	Aesthetic Perspectives in Science and Technology
4.606	Introduction to the History of Architecture I
4.607	Introduction to the History of Architecture II
4.611	Selected Topics in Greek Art
4.612	Selected Topics in Etruscan and Roman Art
4.616	Selected Topics in Architecture of the Ancient World
4.621	Selected Topics in Medieval Art
4.626	Selected Topics in Architecture in the Middle Ages
4.631	Selected Topics in Renaissance and Baroque Art
4.636	Selected Topics in Architecture 1400–1750
4.641	Painting in the Nineteenth Century
4.642	Modern Art from Post-Impressionism to Cubism
4.643	Advanced Study in Nineteenth Century Art (A)
4.646	Origins of Contemporary Architecture in the Eighteenth Century (A)
4.647	Selected Topics in Architecture 1750 to the Present
4.651	Painting in the Twentieth Century
4.652	Sculpture in the Nineteenth and Twentieth Centuries
4.653	Modern Architecture in Europe from 1895 to the Bauhaus (A)
4.655	American Painting and Sculpture: 1940 to 1970
4.656	Dada and Surrealist Imagery in the Arts (A)
4.657	History and Theory of Caricature (A)
4.658	Advanced Study in Twentieth Century Art (A)
4.659	Advanced Studies in Iconography and Symbolism (A)
4.661	Theory and Method in the History of Art and Architecture
4.662	Meaning in Architecture (A)
4.663	Form in Architecture (A)
4.664	Physical Considerations in Architecture (A)
4.665	Criticism of Architecture (A)
4.666	Studies Toward a Theory of Architecture (A)
4.667	Studies Toward a Theory of Environmental Design and Form (A)
4.668	Studies in Environmental Symbolism (A)
4.669	Pragmatic Considerations in Architecture (A)
4.671	History of Urban Form (A)
4.672	Elements of Urban Evolution
4.673	Seminar in Urban Communal Space (A)
4.675	The Architecture of American Socialist Communities (A)
4.681	Introduction to Building in East Asia
4.682	Structure and Development of the City in East Asia: India–China–Japan (A)
4.683J	Science, Technology and Ritual
4.691–4.695	Special Studies in the History, Theory and Criticism of Art (A)
4.696–4.699	Special Studies in the History, Theory and Criticism of Architecture and Urban Form (A)
4.70	User and Community Involvement in Housing
4.71J	Laboratory in Urban Technology
4.73	The Architect as Activist
4.74J	Introduction to City Design and Environmental Policy
4.76J	Coastal Zone Management (A)
4.762J	Planning and Design of Health Facilities (A)
4.77	Special Problems in Architecture and Social Change
4.78	Issues in Architectural Education
4.79	Special Problems in Architecture and Social Change (A)

Department of Urban Studies and Planning

Langley Carlton Keyes, Ph.D.
Associate Professor of City and Regional Planning
Head of the Department

Lawrence Susskind, Ph.D.
Associate Professor of Urban Studies and Planning
Assistant Head of the Department

Professors

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Professor of Urban Land Development
(Visiting)

Alvin W. Drake, Ph.D.
Professor of Electrical Engineering
Associate Director, Operations Research Center

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

Bernard Joel Frieden, Ph.D.
Professor of City Planning
Director, Joint Center for Urban Studies of M.I.T. and Harvard University

Frank Sidney Jones, M.B.A.
Director, Community Fellows Program
Ford Professor of Urban Affairs

Kevin Andrew Lynch, B.C.P.
Professor of City Planning

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

William Lyman Porter, Ph.D.
Professor of Architecture and Urban Planning
Dean, School of Architecture and Planning

Martin Rein, Ph.D.
Professor of Sociology

Lloyd Rodwin, Ph.D.
Ford International Professor
Director, Special Program for Urban and Regional Studies (SPURS)
(On Leave)

Donald Allen Schon, Ph.D.
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Associate Professors

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Philip Barnard Herr, M.C.P.
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Hubert Jones, M.S.W.
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Richard Charles Larson, Ph.D.
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Tunney Lee, M.Arch.
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Associate Director, Joint Center for Urban Studies of M.I.T. and Harvard University

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Assistant Professors

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Suzann Thomas Buckle, Ph.D.
Assistant Professor of Urban Studies and Planning

Kent Colton, Ph.D.
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Joseph Ferreira, Ph.D.
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Charles Libby, M.F.A.
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Thomas Nutt, Ph.D.
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Michael O'Hare, M.Arch., Ph.D.
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Alana Cohen, M.C.P.
Marion Edelman, J.D.
Peter Edelman, J.D.
Hilbert Fefferman, J.D.
Justin Gray, M.C.P.
Michael Joroff, M.C.P.
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Associate Director of the Community Fellows Program
Wren Meyer McMains, S.B.
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Zmarak Shalizi, M.C.P.
Nancy Crémer, M.A.
Anastasia Shkilnyk, M.A.
Keith Stephenson, Ph.D.

Administrative Officer

Rolf R. Engler, A.S.A.

Professors Emeriti

Frederick Johnstone Adams, B.Arch.
Professor of City Planning, Emeritus

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

John Tasker Howard, M.C.P.
Professor of City Planning, Emeritus

Department of Urban Studies and Planning

Opportunities for Specialization

In the last decade, the concerns of planners have changed significantly. Emphasis has expanded from a focus on the physical environment — analysis, design, and control of land uses, circulation systems, and community facilities — to a broader, more explicit concern for environmental policy, social policy, and the analysis and design of urban systems. Interest in planning and urban and regional studies is now focused on specialized areas such as housing, income distribution, health, education, community development, regional planning, environmental psychology, and development in economically depressed regions. Research and action now encompass: the formulation of international, national, regional, and local development strategies for enhancing the environment and improving the quality of public services available to all groups, especially the disadvantaged; the interpretation of interactions between the physical environment and behavior, attitudes, and satisfaction of various client groups; and the fashioning of more powerful analytical methods for describing and analyzing various approaches to problems of mobility and communication. The Department seeks to train professionals and scholars who as managers, advisors, or policy analysts will be able to deal with processes of urban and regional development, as well as advocate the interests of underrepresented constituencies.

Students have several options in training for work in these fields. They may focus on some special area or approach to urban studies or they may pursue a broader program, developing competence as general practitioners. However, the core knowledge which all students are expected to develop includes the following elements: 1) a general understanding of the interactions between the social, economic, spatial, and political aspects of contemporary society; 2) skill in the techniques for analyzing urban and regional communities — their social and economic characteristics, spatial patterns, political structure, behavioral impact, and processes of change; and 3) skill in the synthesis of urban policy including development of techniques for analyzing the needs of urban and regional communities and for planning change in the operations of economic and political structures, spatial patterns, and social service delivery systems. This latter element includes the statement of problems, the formulation of objectives, the generation and evaluation of alternative plans and policies, and the implementation, management, and evaluation of programs for social, economic, and environmental change.

Subjects offered by the Department are clustered under several commonly selected areas of specialization. Students are also encouraged to take relevant subjects in other M.I.T. departments.

Housing, Community Development, and Urban Economics Course work in this area includes the study of housing programs and policies, housing technologies and the housing production system, land development economics, real estate and housing markets, and client analysis and user involvement in housing design and management. A special focus on urban economics is encouraged through joint work with the Department of Economics. Connections between the problems of housing design and development, the provision of community services, and the regulation of land use patterns receive attention.

Environmental Design and Spatial Policy The Department offers training in the field of environmental design — the spatial organization of activities and the shaping of the physical environment at the city and regional scale, with special reference to aesthetic and sensuous qualities and to the importance of behavioral and psychological processes. Training and research in this area offer a focus on the environment rather than on the architectural project; however, work is conducted jointly with students and faculty in the Department of Architecture. The Department seeks to develop a basic competence in environmental planning and in the methods of design at the city scale, as well as a more special competence in understanding and analyzing experimental and ecological consequences of environment form. Of special interest are situations in which it is possible to change the spatial, physical environment while also modifying its associated institutions.

Developing Countries and Regional Planning This specialization is for students interested in problems of cities and regions in developing areas. Special consideration is given to programming urban and regional development in the context of national development policy, migration and social change, problems of squatters, social and cultural transformation implied by urbanization and economic development, and various policy issues posed by these trends.

Social Policy and Planning for Institutional Change A concentration is available focusing on design and evaluation of complex urban problems involving both social and environmental action, with emphasis on problems of inequality, race, distribution of income, and political power. Subjects of interest include income maintenance as well as the governmental, legal, and institutional settings for policy making. Specialized work in the fields of health planning and the social components of housing policy are available.

The Analysis and Design of Public Systems Quantitative methods are important for the analysis of urban problems and the formulation of public policy. Subjects, seminars, and laboratories in decision analysis, information flows and processing, formal models, simulation, statistical research techniques, and computer aided design explore the uses and limitation of such methods. Advanced work and research opportunities are available in this Department and in several other departments for those particularly interested in developing a strong competence in public systems design and analysis.

Students have the option of selecting and shaping still **other areas of specialization** in consultation with members of the faculty, consistent with their academic background and career objectives. For example, a student interested in regional planning might select a range of subjects including Regional Economic Analysis, Models of the Metropolis, National and Regional Growth Issues in Developing Countries, and Metropolitan Planning in Developing Countries, as well as pursue independent reading and research in conjunction with members of the Urban Studies and Planning staff and the faculty from the Department of Economics. A specialization focusing on the problems of minorities in the city might be arranged drawing together such subjects as Issues and Strategies in Community Development, Social Policy, Planning and Poverty, Urban Social Structure and Process, Institutional Change in Urban America, and Educational Policy and the Community, in addition to work in the Departments of Political Science, Humanities, and Economics.

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. Examples include grantsmanship, industrial development, media and the city, and planning in China. 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.

Students are encouraged to engage in **field work activities** in greater Boston and occasionally outside the area. Internships in state and local government, as well as placements with neighborhood groups and social action agencies can often be arranged through the Department. In all cases, special efforts are made to integrate internships and field placement with academic assignments. In monitoring and evaluating fieldwork activities, the Department relies heavily on feedback and criticism provided by students. Students are expected to play a significant role in shaping future field linked programs in the Department.

Undergraduate Study

Bachelor of Science in Urban Studies and Planning
Course XI

The undergraduate program leading to the Bachelor of Science in Urban Studies provides a general education as well as professional training. The urban studies program offers an opportunity to explore various social change strategies through involvement in field projects, independent research, or community service. In addition, it can serve as a stepping stone to advanced study in law, the social sciences, or environmental planning. The program is also designed to give undergraduates, whatever their career objectives, an understanding of the role that cities play in society, the nature of urban systems, the application of technology to urban and environment problems, and alternative approaches to the formulation of public policy.

A series of restricted electives helps to outline the scope and methods of urban studies and planning. A core sequence of two or three subjects is suggested in each area of concentration: environmental design; urban planning and development; law, urban institutions, and social change; human resource development and health care delivery; and public systems and urban management. A sixth design-your-own-program option is also available. Course work in each area of specialization is developed in conjunction with a faculty advisor. In addition, undergraduate majors are expected to complete 48 units in their area of concentration as well as two integrative colloquia and a thesis. Work in a student's chosen field of concentration typically spans subject offerings in several M.I.T. departments. Concentrations can focus on a disciplinary or skill oriented approach to urban and environmental planning; a single problem or system within the urban environment; or a comparative analysis of problems and responses in a number of urban systems. Many students also incorporate field research, independent study, internships, and community service into their programs of study.

Bachelor of Science in Urban Studies and Planning
Course XI

	General Institute Requirements	Total units
	Specific science humanities, and social science subjects	132
	Science Distribution Requirement	36
	Laboratory Requirement (11.801 is suggested)	12

	Departmental Program		
	Required Subjects		32
11.02	Perspectives on Urban Issues	3 0 6	
11.03	Urban Problems in American Society: Responses and Strategies	3 0 6	
	Thesis	14	
	Restricted Electives (At least four of the following)		at least 36
11.04	Models and the Metropolis	4 0 8	
11.05	Urban Social Structure and Process	3 0 6	
11.06J	Politics, Planning, and Public Policy	2 0 7	
11.09	Technology and the City	3 0 6	
11.15	The Political Economy of Urban Poverty	3 0 6	
11.171	Environmental Policy and Controls	3 0 6	
11.18	The Writer and the City	3 0 6	
11.19	The Urban Neighborhood	Arr.	
11.301	Understanding the Urban Environment	3 0 6	
11.553	Law and Social Change: Application of the Fourteenth Amendment to Selected Public Policy Issues	3 0 9	
11.591J	American Urban History	3 0 6	
11.81	Social Research Methods	3 0 6	
14.51	Urban Economics	3 0 6	

	Restricted Electives (continued)		
	Areas of Concentration (A coherent selection of at least five subjects that constitutes a field of concentration. Concentrations must be developed in conjunction with a faculty advisor. (*) indicates core subjects suggested in each area of concentration.)		at least 48
	Environmental Design		
11.301J	Understanding the Urban Environment	3 0 6	
11.302	Case Studies in Large Scale Environmental Planning	3 0 6	
11.371J	Environmental Design I	0 9 11	
	Urban Planning and Development		
11.401	Introduction to Urban Planning and Development	3 0 6	
11.402	Urban and Regional Development Theory	3 0 6	
	Law, Urban Institutions, and Social Change		
11.551	Urban Institutions and Social Change	3 0 6	
11.552	Seminar on Urban Institutions	3 0 6	
11.553	Law and Social Change: Application of the Fourteenth Amendment to Selected Public Policy Issues	3 0 9	
	Human Resource Development and Health Care Delivery		
11.540	The Sociology of Medical Care	3 0 6	
11.543	Policies and Politics of Health Planning	2 0 7	
11.571	Human Resource Development and the Helping Professions	2 0 7	
	Public Systems and Urban Management		
11.601J	Quantitative Models and Public Policy	3 0 6	
11.73	Managing Urban Systems	2 0 7	
	Unrestricted Electives		64
	Total Units Required for the S.B. Degree		360

The required junior year colloquium, 11.02 Perspectives on Urban Issues, provides analytical and normative perspectives on the contributions of various disciplines to the interpretation of urban problems. The senior colloquium, 11.03 Urban Problems in American Society: Responses and Strategies, focuses on the study of national urban policies and programs, implementation strategies, and the role of policy analysis in public decision making.

During the senior year undergraduate urban studies majors are expected to prepare a thesis (14 units). In general, the thesis should investigate an issue or hypothesis of particular interest, demonstrate the validity of the methods of investigation used, indicate the relationship of the findings to other work in the field, and specify the implications of the conclusions for urban policy. To assist students in developing thesis topics the Department expects seniors to register for four units of thesis preparation during the fall term. Registration for the remaining credits during the spring term is conditional upon submission of an acceptable thesis proposal.

The problem-solving and integrative nature of the field of urban studies calls for a considerable degree of student initiative, both in the selection of specific subjects and in the determination of a suitable program in a given field of concentration. An advisory system has been designed which encourages student initiative and, at the same time, insures that students develop coherent programs and receive continuing guidance in carrying out independent work. Whenever possible advisors are assigned on the basis of shared interests in research topics. Each student-faculty relationship is developed voluntarily but students may, after discussion with the faculty members involved, shift advisors at any point during their academic careers.

Independent research activities and departmental projects also present an important program component. There are three ways in which students can participate in research: student-initiated projects can be developed through the Department's Undergraduate Research Program; students may contact members of the faculty whose research interests coincide with theirs; or students may prepare proposals in conjunction with a member of the faculty or staff. Students are eligible to receive academic credit or limited funding for expenses or wages through the Institute-wide Undergraduate Research Opportunities Program. Also, students are encouraged to take advantage of the Department's tutorial program, in which two to five students and a staff member organize small-scale projects or informal reading seminars. Tutorials are intended to constitute a light work load and to supplement the formal program by providing a vehicle for students and faculty to investigate areas which are not represented in the curriculum.

Five-Year S.B.–M.C.P. Option

Undergraduate urban studies majors may apply for admission to the Department's Master in City Planning program at the beginning of their senior 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. A special admissions committee is empowered to admit up to five students each year. Only those students who have demonstrated exceptional professional promise and who clearly stand to benefit from further study at M.I.T. are likely to be admitted. More information on the five-year program can be obtained from the Director of the Undergraduate Urban Studies Program.

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, landscape architecture, civil engineering, economics, sociology, law, management, and public administration all offer suitable preparation. Applicants from other fields are also accepted.

Entrance Requirements for Graduate Study

Undergraduate preparation for urban studies and planning usually differs from that required for the scientific degrees. The following are prerequisites for graduate study: four one-term college subjects in one or more of the fields of mathematics and the physical and natural sciences; at least six terms of work in English, history, economics (or allied subjects), and other humanities subjects equivalent in scope to those included in the undergraduate curricula of the Institute; a broad, sound general education, with competence in communication through oral, written, and graphic expression and through mathematics; and a previous specialization in some related field. College level statistics, calculus, and introductory economics are strongly recommended. Deficiencies in any of the areas may be removed by taking comparable subjects at M.I.T.

Master in City Planning

The typical program leading to the Master in City Planning (M.C.P.) requires two years of study at M.I.T. In order to complete the degree requirements, students are expected to take a minimum of 30 credit units each term, completing a total minimum of 120 credit units plus thesis. Each student, whether through previous experience, formal subjects, or independent study, is expected to acquire an understanding of a core of fundamental knowledge and skills and to develop competence in a specialized area.

In order to meet these qualifications, students are required to submit a program statement at the end of their first term which describes the purposes and goals of their study, their projected schedule of subjects, their approach to meeting the Department's core requirements, as well as an indication of a possible thesis topic. Although no program of required subjects is prescribed, students must, in relation to their area of specialization, demonstrate competence in six areas — political science, sociology, economics, spatial organization, analytical skills, and problem solving. Students can either take recommended subjects in these areas or they can substitute previous experience or academic work. The program statement and the approved core selection of requirements are subject to review by a faculty advisor and the Department's M.C.P. committee. The statement can be modified at any time subject to their review.

Most students who have not earned undergraduate degrees in interdisciplinary urban studies or planning programs may need to include the equivalent of between one and two terms of preliminary subject work such as is listed above under Restricted Electives for the Bachelor of Science. Students may choose one of the fields described under Opportunities for Specialization or some other area related to urban or regional development in which this Department together with other M.I.T. departments offers advanced work. An original thesis is required which takes at least one term to complete.

Doctor of Philosophy

Advanced students, especially those seeking research or teaching careers in planning or urban studies, may apply for admission to the doctoral program. Admission requirements are substantially the same as for the Master's degree; however, more emphasis is placed on academic preparation in the student's proposed area of specialization.

Subject to the approval of a faculty advisor and the doctoral committee of the Department, a Ph.D. candidate engages in a course of study which provides a broad background in urban studies and advanced work in some area of specialization. This area may be in any field related to urban studies or planning in which this Department together with other M.I.T. departments offers strong support.

After successful completion of a required first-year doctoral seminar and general examinations, each Ph.D. candidate must prepare a written doctoral dissertation evincing the capacity to do independent research. To be eligible for financial aid, students in the Ph.D. program must complete at least 30 credit units each term.

Doctoral candidates who already hold the Master in City Planning usually require at least two terms of study in residence before beginning their dissertations. Other candidates may require up to six terms, depending on prior preparation. In order to be eligible for the Ph.D., a student must complete 180 credit units. Previous work at M.I.T. or elsewhere may be counted toward the degree. The general requirements for the Ph.D. are specified in Chapter III of this Catalogue.

Interested and qualified students can undertake joint doctoral programs with the Department of Political Science and the Department of Economics. Doctoral students in urban studies may be associated with the research program of the M.I.T.–Harvard University Joint Center of Urban Studies or the School's Laboratory of Architecture and Planning.

Dual Degrees in Urban Studies and Architecture

Students who have been admitted to either the Department of Urban Studies and Planning or the Department of Architecture are invited to propose programs for joint work in the two fields leading to dual degrees. Degree combinations may be M.C.P./M.Arch. or M.C.P./M.Arch. in Advanced Studies. Program proposals must be made prior to the student's final academic year in the first degree program and are considered during the spring admissions process. Normally, students are expected to meet the core requirements of both degrees, but may submit a joint thesis and count some subjects completed for one degree towards the other, thus decreasing the overall time required for the two degrees.

Dual degree programs may include an innovative combination of work in any of the fields of specialization of the two departments. They may represent preparation for professional roles which bridge the two fields or the definition of new roles which are needed but not yet defined. Students pursuing dual degrees work with advisors in both departments.

Special Student Status

A limited number of nondegree students are admitted to the Department each term. They are permitted to enroll in a maximum of three subjects per term. (Special student status is not available to any individual for more than two terms except under extraordinary circumstances.) Special student status is especially designed for mid-career professionals interested in developing specialized skills, but it is also available to others interested in participating in the activities of the Department on a limited basis. Although a person may be admitted to the Department as a special student, permission to register in each subject must be granted separately by the instructors involved. Students applying for admission to regular departmental degree programs are not eligible for special student status.

Inquiries

Community Fellows Program

The Community Fellows Program provides an opportunity for a limited number of especially capable persons to spend a year at M.I.T. studying aspects of institutional innovation, program administration, and the management of social change. All Fellows are expected to develop specific proposals or programs aimed at dealing with a particular problem or meeting a critical need in their organization or community. The program is oriented primarily toward independent study and is deliberately flexible. Fellows will be registered officially as special nondegree students in the Department of Urban Studies and Planning. Academic credit will be awarded, if desired, for course work taken.

The program is designed for mature individuals who have already embarked upon their careers and who have had significant experience in the problem areas most relevant to the needs of minority communities. The program is open to men and women throughout the United States, although approximately half the Fellows accepted each year will be from the greater Boston metropolitan area. The interests and experience of prospective Fellows may be in such diverse fields as community organization, housing development and renovation, health planning, educational planning, social services delivery, food technology, communications and public media, or environmental management. Principal criteria for admission are individual ability and experience; applicants need not have a college degree.

The primary objective of the Community Fellows Program is to assist each Fellow in developing a specific community or agency related program or proposal. To this end, the formal resources of M.I.T. are available to participants in the Program, and each Fellow has a faculty advisor. Fellows also participate in two special seminars — the first, during the fall term, deals with community development issues and strategies, and the second, during the spring term, focuses on individual projects of the participants.

Special Program for Urban and Regional Studies of Developing Areas

This program provides an opportunity for a small number of unusually qualified persons 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 varied fields such 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.

The program is flexible, and Fellows are encouraged to tailor their work to their own individual requirements. They are generally permitted to select subjects offered at M.I.T. normally available to graduate students, subject to the approval of the instructor. Fellows may also pursue their own research or, when feasible, participate in ongoing research programs in the Department.

Further information concerning academic programs in the Department, admissions, financial aid, etc. may be obtained from the Undergraduate or Graduate Registration Officer, Department of Urban Studies and Planning, Room 7-338, M.I.T., Cambridge, Massachusetts 02139, (617) 253-2022.

Subjects in Urban Studies and Planning*

(A) following the name of a subject indicates that it is an approved subject for a graduate degree and is given primarily for graduate students.

11.U.R.	Undergraduate Research
11.01	The Planning Process
11.02	Perspectives on Urban Issues
11.03	Urban Problems in American Society; Responses and Strategies
11.04	Models and the Metropolis
11.05	Urban Social Structure and Process
11.06J	Politics, Planning and Public Policy
11.07	Economic Theory and Urban Planning
11.08	Urban Transportation Planning (A)
11.09	Technology and the City
11.10	New Communities and National Urban Growth Strategies (A)
11.12	Introduction to Urban Law
11.131	Urban Law: The Allocation and Development of Housing and Land Resources through Public Control
11.14	Development Policy and the Legislative Process (A)
11.15	The Political Economy of Urban Poverty
11.161	Planning Organizations and Bureaucracy
11.162J	Human Interactions in Project Management (A)
11.171	Environmental Policy and Controls
11.172J	Coastal Zone Management (A)
11.18	The Writer and the City
11.19	The Urban Neighborhood
11.20	Introduction to Housing Problems
11.22J	The Construction of Buildings (A)
11.231	Financial Analysis in Urban Planning
11.232	Urban Land Development (A)
11.242	Housing Analysis and Public Policy (A)
11.25	Housing and Community Development
11.261	Issues and Strategies in Community Development
11.262	Seminar in Community Development
11.271J	Urban Economic Analysis I (A)
11.272J	Urban Economic Analysis II (A)
11.281	Manpower and Economic Development in the Cities I (A)
11.282	Manpower and Economic Development in the Cities II (A)
11.301J	Understanding the Urban Environment
11.302	Case Studies in Large-Scale Environmental Planning
11.31	Site Planning
11.321	Urban Landscape
11.322	City Design (A)
11.331	Environmental Programming (A)
11.332	Applied Environmental Programming (A)
11.34J	Analysis of Urban Design (A)
11.351	Psychology of the Environment
11.371J	Environmental Design I
11.372	Environmental Design (Total Studio)
11.373J	Collaborative Design (A)
11.38	Theory of City Form (A)
11.391J	Laboratory in Urban Technology
11.401	Introduction to Urban Planning and Development
11.402	Urban and Regional Development Theory
11.403	Urban and Regional Growth Issues in Developing Countries (A)
11.404	Seminar on Environment Issues and Urban Growth
11.41	Metropolitan Planning in Developing Countries
11.421	Self-help Housing, Squatters and Social Change (A)
11.422	Seminar in Self-help Housing, Squatters, and Social Change (A)
11.43	Social Aspects of Development (A)
11.44	Regional Economic Analysis (A)
11.46	Economic Development Strategies, Choice of Technologies, and Urbanization Patterns in Developing Societies
11.47	Planning in Socialist Countries (A)
11.48	Applications of Regional Economic Theory
11.50	Seminar on Sociological Aspects of Public Policy
11.501	Urban Planning and Social Policy (A)
11.502	Seminar in Urban Social Policy (A)
11.511	Seminar on Social Science and Public Policy
11.512	Social Policy Studio (A)
11.513	Race and Ethnic Relations
11.521	Social Service Systems (A)
11.522	Social Service Systems (A)
11.524	The Planning and Delivery of Services in Minority Communities
11.532	Educational Policy and the Community (A)
11.533	Planning for the Criminal Justice System (A)
11.534	Issues and Policies in Health Care Delivery
11.540	The Sociology of Medical Care
11.541	Fundamentals of Community Health Planning (A)
11.542	Seminar in Community Health Planning (A)
11.543	Policies and Politics of Health Planning
11.544	Workshop in Community Health Planning (A)
11.545	Quantitative Methods in Health Planning (A)

*Full descriptions of all subjects are given in the catalogue entitled **Courses and Degree Programs, 1974–75**, which may be obtained by writing to the Institute Information Services, Room 7-111, M.I.T.

Continued on next page

11.546	The Human Life Cycle: Institutions, Agencies and Unmet Needs
11.547J	Planning and Design of Health Facilities (A)
11.548	Client Perspectives and Experience in Medical Care
11.549	Technology Assessment in Health Care Delivery
11.55J	Suburban and Metropolitan Politics (A)
11.551	Urban Institutions and Social Change
11.552	Seminar on Urban Institutions
11.553	Law and Social Change: Application of the Fourteenth Amendment to Selected Public Policy Issues
11.561	Institutional Change in Urban America (A)
11.571	Human Resource Development and the Helping Professions
11.572	Advocacy for Institutional Change
11.573	Tactics for Social Change
11.584J	Urban Politics and Public Policy
11.591J	American Urban History
11.592J	American Urban History
11.60	Formal Models and Public Policy
11.601J	Quantitative Models and Public Policy
11.602	Static Linear Deterministic Models
11.603	Static Non-Linear Deterministic Models
11.604	Dynamic Deterministic Social Systems
11.605	Modeling Uncertainty in Social Systems
11.606	Modeling Uncertainty in Social Systems
11.607	Modeling Uncertainty in Social Systems
11.61	Analysis of Public Systems
11.62	Decision Theory and Policy Analysis (A)
11.63J	Advanced Markov Models and Their Applications (A)
11.64J	Analysis of Urban Service Systems (A)
11.65	Laboratory in Urban Models (A)
11.66J	Transportation Policy Analysis (A)
11.661J	Introduction to Operations Research (A)
11.662J	Introduction to Operations Research (A)
11.712	Community and Regional Planning Methods (A)
11.72	City Planning Techniques
11.73	Managing Urban Systems
11.731	Project Management Techniques
11.732	Information Systems for Planning and Management
11.74	Seminar on Urban Management and PPBS (A)
11.801	Urban Studies Laboratory
11.802	Decision and Inference I: Probability and Statistics
11.81	Social Research Methods
11.831	Introduction to Computer Usage
11.832	Research Seminar in Computer Applications
11.85	Special Topics in Computer Applications
11.901	Research Seminar: Topics in Urban Studies and Planning (A)
11.902	Research Seminar: Topics in Urban Studies and Planning (A)
11.911	Reading Seminar in Urban Studies and Planning (A)
11.912	Reading Seminar in Urban Studies and Planning (A)
11.921	Undergraduate Tutorial in Urban Studies
11.922	Undergraduate Tutorial in Urban Studies
11.931	Preparation for Thesis
11.932	Preparation for Thesis (A)
11.941–11.946	Special Studies in Urban Studies and Planning (A)
11.951	Special Topics in Urban Studies and Planning
11.952	Special Topics in Urban Studies and Planning
11.961	Urban Field Work and Internships
11.962	Urban Field Work and Internships (A)
11.981	Graduate Tutorial
11.982	Graduate Tutorial
11.983	Doctoral Seminar I (A)
11.984	Doctoral Seminar II (A)

School of Engineering



Engineering is concerned with the intelligent utilization of materials and forces for the benefit of mankind. Man has come to depend increasingly on engineering because it incorporates these materials and forces into the complex systems which provide energy, transport, communications, food, security, environmental protection and other needs of society. The development and applications of sciences and technologies to make these systems possible is clearly the central activity of engineering.

Engineering is always carried out within a societal context. Therefore it is subject to society's needs and is tempered by physical, economic, political and legal bounds. This then is the real challenge of engineering: to develop and utilize scientific knowledge and technology in meeting the needs of a complex society, and to do so in ways which are sensitive to the constraints which that society imposes.

This challenge has never been more real nor the opportunities more exciting than they are today. The impact of resource limitations and environmental constraints coupled with the desire of society for an ever improving quality of life have further increased the importance of the engineer's role. This has created a large demand for engineering graduates to enter the professional practice of engineering and has strengthened the value of engineering curricula as preprofessional education for entry into law, medicine, business, administration, management, and government service.

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
Metallurgy and Materials Science

VI
Electrical Engineering

X
Chemical Engineering

XIII
Ocean Engineering

XVI
Aeronautics and Astronautics

XXII
Nuclear Engineering

Departments in the School of 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.

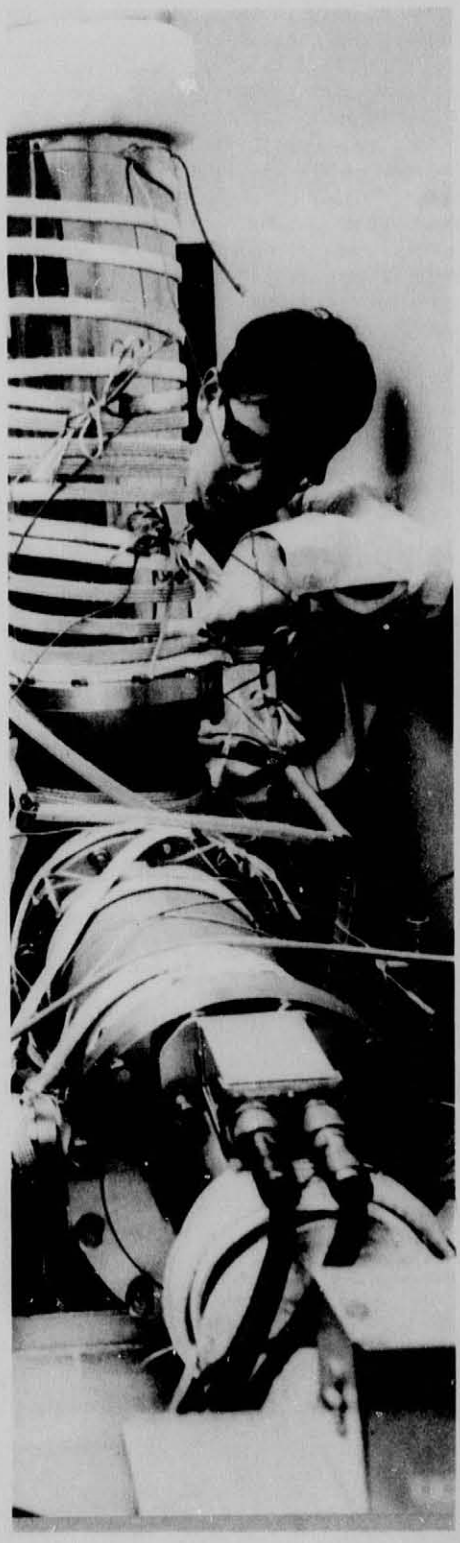
Applications / Departments	Civil Engineering	Mechanical Engineering	Metallurgy and Materials Science	Electrical Engineering	Chemical Engineering	Ocean Engineering	Aeronautics and Astronautics	Nuclear Engineering
Energy	•	•	•	•	•	•	•	•
Transportation	•	•	•	•		•	•	
Communication			•	•		•	•	
Manufacturing		•	•	•	•		•	
Construction	•		•			•		•
Materials	•	•	•	•	•	•	•	•
Environment	•	•	•	•	•	•	•	•
Medicine		•	•	•	•		•	•
Governance	•	•		•		•	•	•



Interdisciplinary Centers, Projects, and Laboratories Connected with the School of Engineering

In addition, there exist at M.I.T. a large number of interdisciplinary centers, projects, and special 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.

- Artificial Intelligence Laboratory
- 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
- Cryogenics Laboratory
- Division for Study and Research in Education
- Electric Power Systems Engineering Laboratory
- Energy Laboratory
- Environmental Laboratory
- Francis Bitter National Magnet Laboratory
- Fuels Research Laboratory
- Gas Turbine Laboratory
- Health Sciences and Technology Program (with Harvard University)
- Information Processing Center
- Laboratory for Nuclear Science
- Lincoln Laboratory
- M.I.T. Research Reactor
- M.I.T. Sea Grant Program
- Operations Research Center
- Project Intrex
- Project MAC
- Rehabilitation Engineering Center
- Research Laboratory of Electronics
- Technology Adaptation Program
- Urban Systems Laboratory



Degree Programs in Engineering

Through its departments and various interdisciplinary 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 typically 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 interdisciplinary fields as indicated in the following table.

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 an opportunity to pursue a program of studies which is broader than could be accommodated within a normal four-year departmental program.

For undergraduates the curriculum of the first year encompasses study of the basic sciences, 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. Students may choose to affiliate with a particular department or designated program as early as the beginning of their sophomore year, and from that time on work closely with an advisor from that Department or Program. Or, students may elect to delay this choice until the start of their junior year without necessarily delaying their graduation beyond four years.

However, students with an interest in engineering are strongly encouraged to become involved with one of the engineering departments even during their freshman year, and may, for example, request that their freshman advisor be assigned from a particular department. Guidance in making such early contacts can be obtained through the Undergraduate Research Opportunities Program, the Freshman Seminar Program, the Dean of Engineering's Special Assistant for Educational Programs, or through the individual departments. Details of the particular departmental programs and their degree requirements are presented in Chapter IV.

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 advisors.

As indicated in the table, the School of Engineering offers formal graduate degree programs in both the departmental areas and in a number of interdisciplinary areas. In addition to those which are listed, numerous other interdisciplinary 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 interdisciplinary program will find it helpful to study the departmental descriptions and also to read the specific sections covering interdisciplinary 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.

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 Dean of Engineering's Special Assistant for Educational Programs or to the head of the appropriate department.

Dean of the School of Engineering



	S.B.[1] (designated)	S.B. (undesignated)	S.M.	Engineer	Ph.D./Sc.D.
Departmental					
Civil Engineering	•	•	•	•	•
Mechanical Engineering	•	•	•	•	•
Metallurgy and Materials Science	•	•	•	•	•
Electrical Engineering	•		•	•	•
Chemical Engineering	•	•	•	•	•
Ocean Engineering	•	•	•	•	•
Aeronautics and Astronautics	•	•	•	•	•
Nuclear Engineering	2		•	•	•
Interdisciplinary[3]					
Biomedical Engineering	4				•
Environmental Studies	4			•	•
Instrumentation	4				•
Operations Research	4		•		•
Materials	4			•	•

1
Accredited by the Engineers' Council for Professional Development.

2
The Department of Nuclear Engineering does not award undergraduate degrees. However, programs can be designed to provide a minor or a joint undergraduate degree for students enrolled in other engineering departments.

3
In addition to the specific interdisciplinary programs which are listed, many other opportunities exist through numerous interdisciplinary centers and ad hoc groups, and by individual student initiatives.

4
Undergraduate programs which emphasize these and other special fields can be developed by special arrangement.

Department of Aeronautics and Astronautics

Rene Harcourt Miller, M.A.
H. N. Slater Professor of Flight Transportation
Head of the Department

Professors

Judson Richard Baron, Sc.D.
Professor of Aeronautics and Astronautics

Secor Delahay Browne, A.B.
Professor of Aeronautics and Astronautics (Visiting)

Eugene Edzards Covert, Sc.D.
Professor of Aeronautics and Astronautics

Charles Stark Draper, Sc.D.
Institute Professor, Emeritus
Professor of Aeronautics and Astronautics, Emeritus
Senior Lecturer

John Dugundji, Sc.D.
Professor of Aeronautics and Astronautics

Morton Finston, Ph.D.
Professor of Aeronautics and Astronautics

Robert Louis Halfman, S.M.
Professor of Aeronautics and Astronautics
Associate Dean for Student Affairs (Visiting)

Norman Douglas Ham, Sc.D.
Professor of Aeronautics and Astronautics

John Vincent Harrington, Sc.D.
Professor of Aeronautics and Astronautics
Professor of Electrical Engineering (Absent)

Jerome Clarke Hunsaker, Sc.D., Eng.D.
Professor of Aeronautical Engineering, Emeritus

Karl Uno Ingard, Ph.D.
Professor of Aeronautics and Astronautics
Professor of Physics

Jack Leo Kerrebrock, Ph.D.
Professor of Aeronautics and Astronautics

Marten Teodor Landahl, Tekn.D.
Professor of Aeronautics and Astronautics

Yao Tzu Li, Sc.D.
Professor of Aeronautics and Astronautics

Jean Francois Louis, Ph.D.
Professor of Aeronautics and Astronautics

James Wah Mar, Sc.D.
Professor of Aeronautics and Astronautics

Winston Roscoe Markey, Sc.D.
Professor of Aeronautics and Astronautics

John Francis McCarthy, Jr., Ph.D.
Professor of Aeronautics and Astronautics
Director, Center for Space Research

James Elliot McCune, Ph.D.
Professor of Aeronautics and Astronautics

Theodore Hsueh-Huang Pian, Ph.D.
Professor of Aeronautics and Astronautics (Absent)

Robert Warren Simpson, Ph.D.
Professor of Aeronautics and Astronautics

Edward Story Taylor, S.B.
Professor of Flight Propulsion, Emeritus
Honorary Lecturer

Leon Trilling, Ph.D.
Professor of Aeronautics and Astronautics (Absent)

Wallace Earl Vander Velde, Sc.D.
Professor of Aeronautics and Astronautics

Harold Yehuda Wachman, Ph.D.
Professor of Aeronautics and Astronautics

Henry Philip Whitaker, S.M.
Professor of Aeronautics and Astronautics

John R. Wiley, S.B.
Professor of Aeronautics and Astronautics (Visiting)

Emmett Atlee Witmer, Sc.D.
Professor of Aeronautics and Astronautics

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

Laurence Retman Young, Sc.D.
Professor of Aeronautics and Astronautics

Associate Professors

Louis Lawrence Bucciarelli, Jr., Ph.D.
Associate Professor of Aeronautics and Astronautics (Absent)

Renwick Eugene Curry, Ph.D.
Associate Professor of Aeronautics and Astronautics

Shaoul Ezekiel, Sc.D.
Associate Professor of Aeronautics and Astronautics

Wesley Leroy Harris, Sr., Ph.D.
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Associate Professor of Ocean Engineering

Walter Mark Hollister, Sc.D.
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Albert Lafayette Hopkins, Jr., Ph.D.
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Elmer Eugene Larrabee, S.M.
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Amedeo Odoni, Ph.D.
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David Anthony Oliver, Ph.D.
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Dieter Joseph Sigmar, Ph.D.
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Associate Professor of Nuclear Engineering

Sheila Evans Widnall, Sc.D.
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Assistant Professors

Charles McMaster Oman, Ph.D.
Assistant Professor of Aeronautics and Astronautics

Nawal Koshore Taneja, Ph.D.
Assistant Professor of Aeronautics and Astronautics

Joseph Francis Vittek, Jr., L.L.M.
Assistant Professor of Aeronautics and Astronautics

Lecturers

Richard Horace Battin, Ph.D.
Philip Nathaniel Bowditch, S.B.
Theodore Neil Edelbaum, B.A.E.
Donald C. Fraser, Sc.D.
Arthur Grossman, B.S.
Stephen James Madden, Jr., Ph.D.
Oscar Orringer, Sc.D.
Edwin Henderson Porter, Jr., S.M.
Rudrapatna V. Ramnath, Ph.D.
Jason Lee Speyer, Ph.D.
Robert Gottlieb Stern, Ph.D.
John Pascal Vinti, Sc.D.
William Soule Widnall, Sc.D.
Joseph Yamron, S.B.

Technical Instructors

John Barley
Allan Ralph Shaw

Administrative Officer

John Ronald Martuccelli, S.M.

Senior Research Associates

Philip Kenyon Chapman, Sc.D.
Howard Theodore Hermann, M.D.
John Hovorka, Sc.D.

Research Associates

Charles Waldo Haldeman, Sc.D.
Ralph J. Markson, Ph.D.
Manuel Martinez-Sanchez, Ph.D.
Alan Natapoff, Ph.D.
Albert Solbes, Ph.D.
Alfred David Weiss, M.D.

Research Affiliates

Jacob Leon Meiry, Sc.D.
Lawrence Ames Shepard, Ph.D.

Department of Aeronautics and Astronautics

Professors Emeriti

Frank Kingsley Bentley
Assistant Professor of Aeronautics and Astronautics, Emeritus

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Professor of Aeronautics and Astronautics, Emeritus

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Jerome Clarke Hunsaker, Sc.D., Eng.D.
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Associate Professor of Aeronautics and Astronautics, Emeritus

Shatswell Ober, S.B.
Professor of Aeronautical Engineering, Emeritus

Edward Story Taylor, S.B.
Professor of Flight Propulsion, Emeritus
Honorary Lecturer

Aeronautical and astronautical engineers are concerned with air transportation, exploration and utilization of space, and related technological fields. The continued development of a balanced air transportation system can provide a fast, safe, and comfortable means of transporting people and goods between cities, countries, and continents. Creating near-earth satellite systems makes possible communication and environmental and resource surveying on a global scale. Building the capability for space exploration helps both to increase knowledge of the universe and to provide one of the keys that may well help secure the long-term future of mankind. Thus, in common with other engineering disciplines, this field offers great potential for improving the quality of life on planet Earth.

Aeronautics and astronautics is characterized by a very high level of technology as evidenced, for example, by the large proportion of aerospace expenditures devoted to research and development (over 15 percent, compared to less than 3 percent for all manufacturing industries). The aerospace engineer is likely to operate on the forefront of scientific discoveries, often stimulating these discoveries and providing the inspiration for the creation of new scientific concepts. Meeting these demands requires the imaginative use of many disciplines including fluid processes, structural and material engineering, control and guidance, power engineering, biomedical engineering, and other related fields. The successful integration of all these disciplines into an economical and operationally reliable system requires skill in the techniques of systems analysis in order to arrive at a total system optimally responsive to the needs of society, whether these be for transportation, defense, or space exploration.

The variety of interests and specialties of the faculty make it possible for the Department to offer a balanced engineering education combined with great flexibility which meets individual needs and talents. Ample scope is provided both for those students wishing to concentrate in one field or for those interested in design, systems integration, and optimization.

Department Divisions of Teaching and Research

In order to deal effectively with the wide range of subject matter and research interests, the faculty of the Department organizes its teaching and research into five divisions of instruction, representing certain well-defined disciplines fundamental to both aeronautics and astronautics. The five divisions are: Mechanics and Physics of Fluids; Structures, Materials, and Aeroelasticity; Energy Conversion and Propulsion; Instrumentation, Guidance, and Control; and Aeronautical and Astronautical Systems.

Mechanics and Physics of Fluids The professional focus of the activities of the Department is on the design and operation of flight vehicle systems. Since such vehicles operate in a fluid environment, continuously for airborne vehicles and during flight into and out of the atmosphere for space vehicles, students are expected to become familiar with the principles of fluid mechanics. These principles govern the forces generated on the vehicle during flight, such as lift and drag, the aerodynamic heating during atmospheric entry and the effects induced by the vehicle on its environment, such as noise and changes in atmospheric chemistry. Fluid mechanics has applications in many fields of engineering, including aerodynamics, energy conversion, ocean engineering, civil and mechanical engineering, and acoustics and chemical engineering, where fluids are used to carry materials, energy, or information. In aeronautics, a better understanding of the mechanics of low-speed flight is essential if air transportation is to realize its potential for short-haul urban and suburban transportation. Promising methods are being developed for alleviation of the sonic boom by configuration modifications and by increasing flight speeds to permit operation at higher altitudes. As we extend our planetary exploration programs, both reentry into the earth's atmosphere at increasing speeds and satellite behavior require a better understanding of the physics of gas surface interaction. All of these problems ensure a continuing emphasis on this discipline in aerospace engineering.

Research in fluid mechanics is carried on in several departmental laboratories. Gas dynamic research facilities include the hypersonic (M=7.5) and supersonic wind tunnel at the Aerophysics Research Laboratory. Molecular beam techniques are employed in the Fluid Dynamics Research Laboratory to study interactions of the environment with vehicle surfaces, to simulate combustion processes, and to investigate contrail and cloud formation. At the other end of the speed spectrum, the VTOL Technology Laboratory operates a large low-speed wind tunnel. This tunnel is used for research on conventional aircraft, helicopter rotor dynamics and aerodynamics, and problems associated with wind loads on buildings and structures. Another wind tunnel is equipped with an anechoic chamber for acoustical research on conventional and VTOL aircraft. A small, low-speed, low-turbulence wind tunnel is available for fluid mechanics research.

Structures, Materials, and Aeroelasticity One of the many contributions of aerospace engineering has been the development of lightweight, reliable structures capable of operating over a wide range of temperatures and under a variety of loading conditions. The extreme importance of minimizing the inert weight of aircraft and spacecraft has required intensive effort on the part of the aerospace engineer directed towards the development of new structural concepts, of improved materials such as the fibrous composites and of a better understanding of fracture and fatigue properties. At the same time, development of the advanced structural concepts such as the highly loaded shell structures typical of aircraft and spacecraft has required the development of new analytical techniques whose availability has stimulated advances in many other areas of structural design besides aerospace structures. The need to understand the dynamic response and the potential instabilities of slender flexible wings operating at high speeds has introduced the new field of aeroelasticity. The need to protect the crew and contents of space capsules from the extreme heating associated with reentry into the earth's atmosphere has required the development of new thermal protection systems and analytical techniques.

For undergraduate students who are especially interested in Structures, Materials and Aeroelasticity, it is suggested that advanced subjects such as 16.21 or 16.27 in analysis, 16.25 in design, and 16.91 in dynamics be taken. It is also highly recommended that they take a sequence of subjects in applied mathematics, starting with 18.075, in their junior and senior years.

A cooperative effort within the School of Engineering offers a special opportunity to study in Structural Mechanics for Nuclear Power Engineering. This effort, while serving a major current need, is also looking forward to the mechanics and materials problems of future energy systems. A joint subject with the Department of Nuclear Engineering introduces the engineering problems. Students studying in this and other aspects of mechanics and materials may take advantage of subject offerings in many other departments of the School.

Research activities of this Division are conducted primarily in the Aeroelastic and Structures Research Laboratory, where equipment is available for structural dynamic research including vibration testing, blast and impact effects, fatigue properties of materials, as well as conventional equipment for structural testing under static loadings.

Energy Conversion and Propulsion Progress in atmospheric and space flight has been paced by the development of more efficient, lighter propulsion systems. More efficient gas turbines have made possible significant airport noise reductions in civil aircraft without too severe performance penalties. Progress in solid and liquid propellant rockets has enabled more reliable and economical manned and unmanned space missions including the Space Shuttle now under development.

The advancements in technology derived from development of these systems have wide application in energy production which almost universally involves high-temperature gases and plasmas. Research and teaching in the Department is directed both at advancing the technology and at applying it to new requirements. Thus it includes research on fluid dynamics of compressors and turbines, on pollutant production in combustion, and on noise generation by aircraft engines, as well as study of the application of gas turbines to commercial power generation. Research in magnetohydrodynamic (MHD) power generation is directed at more efficient power production from both nuclear and fossil fuels, in particular from coal, and is carried on by an interdepartmental, interdisciplinary group. Work in low-density plasma physics is motivated by fusion power plants as well as the magnetosphere.

Instrumentation, Guidance, and Control The need for precise control of flight vehicles has resulted in the development by the aerospace engineer of a new discipline involving highly complex navigation equipment in closed loop systems which measure, guide, control, or enhance the performance of flight vehicles and other complex systems. The ability to operate aircraft under all weather conditions and to control spacecraft in all phases of flight are examples of the application of these systems. Faculty members in the Division teach and perform research in control theory and its applications, navigation systems instrumentation, man-machine interactions, biological systems, lasers, digital systems, and other related topics.

Aeronautical and Astronautical Systems One of the keys to the success of aerospace engineering has been the development of the now-popular concept of systems engineering. The high levels of expenditure involved in the development of aeronautical and astronautical systems, their complexity and their dependence on a variety of disciplines (evident from the above divisional descriptions), the high degree of interaction between these disciplines which prevents their being analyzed and optimized independently of each other, have all required the development of some method for integrating the total system and the development of formal analytical tools to optimize it as a whole rather than by parts. From this need has grown the concept of systems engineering whose successful application to the space program and to the analysis of transportation systems has amply demonstrated its effectiveness as an engineering tool.

The broad coverage of systems engineering clearly implies that the responsibilities of the engineer include far more than the design synthesis and construction of devices and facilities. The engineer must be aware of the social implications of his or her work and design, not only for maximum efficiency and safety, but also for minimum disruption of the environment. The engineer's capabilities can contribute significantly to the solution of society's problems, such as urban growth, resource allocation, and environmental control, but only if skilled in a range of disciplines.

Students interested in working in **aeronautics and astronautics** should therefore place primary emphasis on a broad educational base which should include subjects in most of the divisions described above. In addition the student should obtain training in the disciplines which support systems analysis, such as probability and statistics, operations research, economics, and computer science, and should also maintain an awareness of the external disciplines which help shape society, such as economics, law, and social sciences. Most of this material necessarily would be obtained in the graduate program. However, the undergraduate student can become prepared by judicious choice of subjects for a more effective graduate program.

Educational experience in these and other fields can be greatly enriched by a student's association with laboratory research or project oriented work. A number of laboratories provide ample opportunity for students to participate in the vigorous research program of the Division.

One primary focus for the activities of the Division is the **Draper Laboratory**, which maintains close contact with the Department. Many of its faculty and students are actively involved in research programs in this laboratory on guidance systems and components for all types of flight vehicles. Inertial guidance receives special attention in laboratories equipped with advanced facilities for research on all phases of control and guidance. In the past this work has resulted in the development of many flight vehicle systems including the Apollo spacecraft navigation and control systems. Present projects include guidance and control systems for the proposed space shuttle vehicle, inertial instrument research, digital control computer development, industrial production control, biomedical instrumentation, and control theory research. These projects offer many opportunities for student participation.

The **Measurement Systems Laboratory** is engaged in research in interplanetary navigation systems and in the flight testing of systems for celestial observations from stations in the upper atmosphere. Other programs in the laboratory are concerned with aircraft digital autopilots, air traffic control, inertial navigation systems, aircraft wake vortex detection, and the control of flexible vehicles.

The **Man-Vehicle Laboratory** applies control and instrumentation disciplines to biological and psychological problems. In addition to flight simulator studies on man in the loop, vehicle display and control, and air traffic control research, the laboratory works on bio-instrumentation, physiological control systems and clinical applications of the aerospace sciences. Activities include modeling of the human visual and vestibular system, ride comfort, flight simulation, and work on diagnostic instrumentation for diseases of the eye and ear.

The **Laser Systems Laboratory** pioneers in the development and application of laser technology. Specific activities include laser frequency stabilization, fluid flow measurement, holographic techniques for nondestructive testing and high power pulsed ion laser development.

Laboratory experience for all students is recommended. Any of the department laboratories described above would provide a suitable background, or experience could be obtained in one of this Division's laboratories, the **Flight Transportation** or the **VTOL Technology Laboratory**. The Flight Transportation Laboratory conducts research in many aspects of flight transportation, including transportation systems optimization, analysis of the flow in transportation networks, scheduling of aircraft and crew routing, airport and ground facilities design and siting, and the impact of high-speed short-haul air transportation on urban and suburban growth. The VTOL Technology Laboratory works on problems associated with vertical flight, including aerodynamic and aeroelastic problems of rotors, rotor noise, and jet VTOL control and performance. The laboratory utilizes the **Wright Brothers Wind Tunnel** and the **Acoustic Tunnel**.

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 careers in aerospace activity, ranging from scientific research to responsible engineering direction of large enterprises.

The Department has a well-defined set of engineering activities associated with aeronautics and astronautics. This set of activities provides students with opportunities to study a variety of separate disciplines from the standpoint of an underlying engineering goal. As a result of this focus, and because subjects in design and systems analysis are closely related to projects likely to be of importance in the near future, students are prepared to begin meaningful professional activity either in industry or in government upon receipt of the Bachelor of Science.

The course of study is based on a core of two 24-unit subjects in Unified Engineering, each of which is registered for as two 12-unit subjects. This set of core subjects presents the essentials of engineering in a unified way, with a balanced exposure to analysis, empirical methods, and design. Students are assigned desks in a common room reserved for the subject and used for recitations and design sessions. The room is available for student use throughout the week.

Unified Engineering may be taken in the sophomore year, leaving two years during which students may select from a variety of Restricted Electives which deal more intensively with subjects in the 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, completing the Departmental requirements, which include three Restricted Electives selected from the above areas, and one subject in aeronautical and astronautical systems, during the fourth year.

Electing Unified Engineering during the sophomore year offers students the opportunity to study one or more areas in considerable depth or to gain greater breadth by taking a variety of subjects. The second option allows students a full two years at the Institute before selection of a department. Either option will provide a well-rounded engineering education and excellent preparation for graduate study.

Bachelor of Science in Aeronautics and Astronautics
Course XVI

	General Institute Requirements	Total units
	Specific science and humanities and social science subjects	132
	The subjects 3.141, 8.03, and 18.03, which are required in the Departmental Program, appear in the list of Science Distribution Subjects and can be used to satisfy the Science Distribution Requirement.	
	The subject 16.62, which is required in the Departmental Program, appears on the list of Laboratory Subjects and can be used to satisfy the Laboratory Requirement.	

	Departmental Program		
	Required subjects		**114**
3.141	Engineering Materials Laboratory[1]	1 6 5	
6.071	Introduction to Electronics	4 2 6	
8.03	Physics III	5 0 7	
16.001	Unified Engineering I	4 3 5	
16.002	Unified Engineering II	4 3 5	
16.003	Unified Engineering III	4 3 5	
16.004	Unified Engineering IV	4 3 5	
16.62	Experimental Projects	2 6 4	
16.83	Introduction to Aeronautics and Astronautics	3 0 3	
18.03	Differential Equations	4 0 8	
	Restricted Electives		**48**
	Either		
16.84	Flight Vehicle Engineering	2 3 7	
	or		
16.85	Space Systems Engineering	4 0 8	
	One subject chosen from each of three of the following four groups		
16.01	Physics of Fluids	4 0 8	
16.02	Aerodynamics	4 2 6	
16.53	Rocket Propulsion	3 1 8	
16.54	Aircraft Engines	3 1 8	
16.20	Structural Mechanics	4 0 8	
16.30	Principles of Automatic Control	3 0 9	
16.40	Principles of Flight Guidance	3 1 8	
	Unrestricted Electives[2]		**66**
	Total Units Required for the S.B. Degree		**360**

1
This requirement may be satisfied by taking 3.091 and the laboratory portion of 3.141.
2
Schedules of students in Course XVI may be arranged to leave available 24 units of unrestricted electives in the second year.

Bachelor of Science in Aeronautics and Astronautics
Course XVI-B

The cooperative program in Aeronautics and Astronautics provides undergraduates the opportunity to spend about seven months in an aerospace organization before the senior year. This industrial practice enables students to advance to more professionally rewarding experience than is usually gained in summer employment. The program permits completion of requirements for the Bachelor of Science in four years. Students in this program become regular employees during their period of employment, are subject to the regulations of the company, and are paid at prevailing rates. Students pay their own expenses while away from the Institute.

A student interested in the program should apply to the professor in charge for details and an interview and, also, 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 spent at M.I.T. is usually necessary.

The curriculum requirements for this degree are the same as for Course XVI with the addition of required plant work, 16.80 Industrial Practice, in place of the 8 units of elective.

Undergraduates wishing to specialize as fully as possible in aeronautics and astronautics should choose subjects recommended by the Department, thereby gaining flexibility and elective freedom in the upper years. These subjects are in varied fields, so that this course of action is consistent with a desire for a program of diversity and breadth. For example, an undergraduate student who wishes to concentrate in **fluid mechanics** and its applications to aerospace or to another field of engineering might consider including 5.60 Chemical Equilibrium or 3.91 Introduction to Solid-State Chemistry in the first year; and 16.02 Aerodynamics and 18.075 Advanced Calculus for Engineers or another mathematics subject in the third year, together with another elective in applied aerodynamics or fluid mechanics such as 1.60 Introduction to Water Resources, 16.53 Rocket Propulsion, 2.203 Applications in Fluid Mechanics, 10.39 Energy Technology, 12.21 Physical Oceanography, or 19.70 Elementary Physics of the Atmosphere. In the fourth year one or two more advanced subjects could follow up the field of interest suggested by the third-year elective choice.

For undergraduate students who are especially interested in **structures, materials, and aeroelasticity,** it is suggested that advanced subjects such as 16.21 Plates, Stability, and Thermoelasticity or 16.27 Finite Element Method, 16.26J Structure Mechanics in Nuclear Power Technology and 16.91 Structural Dynamics be taken. It is also highly recommended that students take a sequence of subjects in applied mathematics, beginning with 18.075 Advanced Calculus for Engineers, in their junior and senior years.

A suggested program for undergraduates concentrating in **energy conversion and propulsion** would include 16.004 Unified Engineering IV or 16.002 Unified Engineering II or 8.611 Introduction to Physics of Fluids and Plasmas followed by combinations of 16.53 Rocket Propulsion, or 16.54 Aircraft Engines.

An undergraduate program concentration in **instrumentation, guidance, and control** should include 16.30 Principles of Automatic Control and 16.40 Principles of Flight Guidance, along with the Institute and departmental requirements.

Finally, for those students interested in **aeronautical and astronautical systems** the Department would recommend the following: 16.81 Aerospace Engineering and 16.821 A Management View of Engineering Seminar in the freshman and sophomore years, in addition to a two-term sequence of humanities which should be selected with a view to understanding the growth and structure of society. For example, 17.02 Man and Society could be included in the first two years. In the third and fourth years Economics, is recommended.

For professional work three fields could be identified: **Space Systems, Aircraft Systems, and Flight Transportation.** In Space Systems, 16.30 Principles of Automatic Control, 16.53 Rocket Propulsion, and 16.85 Space Systems Engineering would be recommended. Students interested in Aircraft Systems could include in their junior and senior years 16.54 Aircraft Engines, 16.30 Principles of Automatic Control and 16.84 Flight Vehicle Engineering. In the area of Flight Transportation, recommended subjects would be 16.54 Aircraft Engines, 16.30 Principles of Automatic Control and 16.84 Flight Vehicle Engineering.

Inquiries

For additional information concerning academic and research programs in the Department, admissions, samples of suggested undergraduate programs, 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) 253-2260.

Graduate Study

Advanced study in the Department leads to the Master of Science in Aeronautics and Astronautics; the Engineer in Aeronautics and Astronautics; the Materials Engineer; the Doctor of Science; or the Doctor of Philosophy.

Entrance Requirements for Graduate Study

In addition to the general requirements for admission to the Graduate School, all applicants must have a strong undergraduate background in fundamentals of mechanics, thermodynamics, and electrical science. Additional undergraduate preparation is a prerequisite for specialization in particular fields. Some prerequisites may be completed early in a graduate program.

Master of Science in Aeronautics and Astronautics

The general requirements for the Master of Science are given in Chapter III. In order to complete the requirement of at least 66 subject units, of which 42 units must be in "A" subjects, in addition to an acceptable thesis, students must normally be in residence one full academic year. Also two terms of advanced mathematics beyond 18.03 Differential Equations or its equivalent must be included in each candidate's program.

The Master's candidate customarily emphasizes a single professional field, however, excessive specialization is not encouraged. Programs are individually selected without restriction as to department and under the guidance of a faculty advisor with related interests. There is no language requirement for the Master of Science.

Engineer in Aeronautics and Astronautics

The general requirements for the Engineer's degree are given in Chapter III. The minimum program of 162 subject units and an acceptable thesis usually requires two years beyond the Bachelor of Science. 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. There is no language requirement for the Engineer degree.

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, as well as the judgment and skill needed to apply technology to the synthesis of the complex operational systems. In order to obtain the breadth of knowledge required for an engineering career, this program requires exposure to graduate-level subjects in each of the Department's five divisions of instruction.

Doctor of Philosophy and Doctor of Science

The general requirements for the doctoral degree are given in Chapter III. The Department's recommendation for the degree requires completion of an approved program of subjects, a minor program, one foreign language (approved by the Graduate Registration Officer or the student's doctoral committee), and a thesis. The contents of each individual program are overseen by the student's own doctoral committee and chaired by the thesis supervisor.

The program involves specialization in depth in a specific field. The thesis must demonstrate an ability to conduct independent and original research of high quality on some aspect of science or engineering of interest to aeronautics or astronautics.

Formal candidacy for the doctoral degree requires demonstrated competence in a qualifying examination which is designed to test the candidate's grasp of the principles of mathematics and physics and their application to simple situations. A later general examination, both written and oral, is administered by the student's committee to examine in depth the candidate's understanding of the specific major field of study.

Interdisciplinary Programs

At the graduate level, several interdisciplinary fields are of special importance for aeronautics and astronautics. Related research effort is actively pursued in Department laboratories and by the Department's faculty.

Instrumentation The doctoral program in Instrumentation involves study in the Departments of Aeronautics and Astronautics, Electrical Engineering, Mechanical Engineering, Mathematics, and Physics; for registration purposes it is administered by Aeronautics and Astronautics. Competence in undertaking the program must first be demonstrated by a qualifying examination designed to test the candidate's grasp of the principles of mathematics, physics, and control theory.

Requirements for the completion of the doctoral degree in Instrumentation include an approved program in one of the interrelated fields of instrumentation — automatic control, navigation and guidance of vehicles, optimum control principles and their applications, information systems, and system components; a foreign language; a general examination including both written and oral parts; and a thesis demonstrating the ability of the student to do original research of high quality on a problem of instrumentation or aerospace systems engineering.

Materials Engineering Programs of study leading to the Materials Engineer and the Doctor of Science or the Doctor of Philosophy have been devised in response to the growing interaction between the fields of materials and flight vehicle development. It may be said that material properties impose limitations on either the performance or efficiency of most flight vehicles and their propulsion systems. Graduates who have backgrounds in the combined fields of aeronautics and astronautics and materials science are required in increasing numbers to deal with these interdisciplinary problems.

Students with undergraduate backgrounds in aeronautics and astronautics may pursue programs leading to the degrees mentioned above. Programs are arranged on an individual basis, depending upon the preparation of the student, however, in general such programs involve a substantial number of subjects in metallurgy, physics, and chemistry, in addition to subjects in the Department.

Biomedical Engineering Students interested in biomedical instrumentation and physiological control systems applying the disciplines involved in aeronautics and astronautics to biology and medicine may pursue an interdepartmental Doctor of Philosophy supervised by the Committee on Biomedical Engineering. Students in this program with a prior engineering background normally pursue a Master of Science in an engineering department and include a broad program in biology and physiology. The program is intended for students with a strong engineering background who wish to make a career commitment to biomedical engineering. For a further description of the program see the section entitled Interdisciplinary Study and Research in Chapter III. Most biomedical engineering activity in the Department of Aeronautics and Astronautics is conducted in the Man-Vehicle Laboratory.

Flight Transportation For students interested in a career in flight transportation, a program exists whereby a broader graduate education in disciplines such as economics, management, law, and operations research can be pursued. There are five areas within flight transportation: Flight Vehicle Design and Operation; Air Traffic Control; Airports; Management and Institutional Factors; and Transportation Systems Analysis and Planning. Graduate research will emphasize one of these areas, with subjects selected appropriately from those available in the Departments of Aeronautics and Astronautics, Civil Engineering, Economics, and the School of Management. A special interdepartmental program may be established for the doctoral student, or participation in the Operations Research Center Interdisciplinary Program may be considered. Flight transportation activity in the Department is carried out primarily in the Flight Transportation Laboratory.

Teaching and Research Assistantships

The Department offers financial assistance for graduate study in aeronautics and astronautics. In addition to several fellowships for full-time study, a research assistantship program provides opportunities to progress toward a graduate degree through combined registration for academic subjects and research leading to the thesis. The research assistant works with a faculty supervisor on a specific research assignment. The experience gained in organizing work, in learning and applying new experimental techniques and analytical tools, and in technical writing, is invaluable in any career in engineering. The Department attempts to place a student in the technical area coinciding with the desired concentration area of study and research in connection with his or her thesis. The Department also offers a limited number of teaching assistantships.

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 School of Management. The primary goals are to develop an atmosphere conducive to inventiveness and to provide the facilities and organization necessary to carry out the development of promising ideas. The complete process of bringing a new concept or device from the idea stage, through development and testing, including marketing and the legal aspects of patents and licensing is undertaken.

Conventional classroom and project laboratory subjects are suggested by the Innovation Education Council to guide students through the early phases of learning the innovation process. The Innovation Co-op is a product development laboratory which provides a professional push in the marketing of products and gives the student clinical exposure to the latter phases of the innovation process. Students are encouraged to develop their ideas into products. The first step is to develop a working model, perform a marketing survey, and prepare a business plan which is presented to the Innovation Co-op. This activity can take place as a laboratory subject, a thesis, or a special project. A product whose business plan is accepted is developed by the Co-op to the stage where it can be marketed as a new venture or presented to industry under a license arrangement. Students are involved in the operation of the Co-op as project coordinators. They transfer knowledge gained during the product development stage and participate in the decision making processes concerning materials, manufacturing, marketing strategy, etc.

Students at any level and from any department may participate.

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.

16.U.R.	Undergraduate Research
16.001	Unified Engineering I
16.002	Unified Engineering II
16.003	Unified Engineering III
16.004	Unified Engineering IV
16.006	Thermodynamics
16.01	Physical Properties of Gases
16.02	Aerodynamics
16.035	Fundamentals of Fluid Mechanics (A)
16.041	Aerodynamics — Viscous Fluids (A)
16.042	Aerodynamic Heating (A)
16.051	Advanced Gas Dynamics (A)
16.052	Real Gas Dynamics (A)
16.06	Molecular Gas Dynamics (A)
16.07	Aerodynamics of Wings and Bodies (A)
16.081J	Principles of Acoustics (A)
16.082J	Flow Noise (A)
16.105	Applied Aerodynamics
16.15	Advanced Flight Vehicle Stability and Control (A)
16.20	Structural Mechanics
16.21	Plates, Stability and Thermoelasticity (A)
16.22	Shell Structures (A)
16.23	Shell Structures (A)
16.24	Plasticity, Viscoelasticity and Creep (A)
16.25	Advanced Topics in Structural Mechanics (A)
16.26J	Structural Mechanics in Nuclear Power Technology (A)
16.27	Finite Element Method (A)
16.28	Advanced Finite Element Method (A)
16.29	Design with Filamentary Composite Materials
16.30	Principles of Automatic Control
16.31	Principles of Instrumentation and Control (A)
16.32	Principles of Instrumentation and Control (A)
16.33	Instrumentation, Guidance and Control Laboratory (A)
16.34	Automatic Control of Flight Vehicles (A)
16.351J	Quantitative Physiology: Sensory and Motor Systems
16.352J	Sensory-Neural Systems (A)
16.353J	Seminar in Sensorimotor Processes (A)
16.36	Principles of Measurement Systems
16.37	Statistical Problems in Automatic Control (A)
16.371	Estimation and Control of Stochastic Processes (A)
16.381	Lasers and Optics for Applications (A)
16.39	Applied Optimal Control (A)
16.40	Principles of Flight Guidance
16.41	Space Dynamics and Gyroscopic Instruments (A)
16.42	Inertial Guidance (A)
16.441J	Dynamical Astronomy
16.46	Astronautical Guidance I (A)
16.47	Astronautical Guidance II (A)
16.48	Elements of Digital Computers (A)
16.481	Digital Computer Controlled Systems (A)
16.491	Selected Topics in Celestial Mechanics (A)
16.492	Selected Topics in Celestial Mechanics (A)
16.52	Introduction to Energy Conversion
16.53	Rocket Propulsion
16.54	Aircraft Engines
16.541	Aircraft Turbine Engines (A)
16.542	Topics in Computational Fluid Physics (A)
16.55	Ionized Gases (A)
16.551	Plasma Propulsion and Power Generation (A)
16.57J	Physics of Fluids
16.58J	Advanced Topics in Plasma Kinetic Theory (A)
16.59	Introduction to Plasma Kinetic Theory
16.60	Advanced Special Project (A)
16.601	Advanced Special Subject (A)
16.605	Special Projects
16.62	Experimental Projects
16.65	Experimental Techniques in Aerodynamics (A)
16.671J	Invention
16.672J	Entrepreneurship
16.675	Invention Development Laboratory
16.676	Internship in New Enterprise Development
16.701	Principles of Systematic Policy Analysis (A)
16.702	Seminar in Systematic Policy Analysis (A)
16.711	Introduction to Probability and Statistics (A)
16.712	Application of Statistical Analysis (A)
16.713	Probability Theory (A)
16.72	Air Traffic Control (A)
16.73	Airline Management Marketing (A)
16.74	Air Transportation Economics (A)
16.751	Flight Transportation (A)
16.752	Flight Transportation Seminar
16.76J	Analysis of Urban Service Systems (A)
16.77	Flight Transportation Operations Analysis (A)
16.781J	Planning and Design of Airport Systems (A)
16.782J	Airport Operations and Management (A)
16.79	Legal and Regulatory Aspects of Transportation (A)
16.80	Industrial Practice
16.801	Aeronautics and Astronautics Seminars
16.81	Aerospace Engineering
16.811J	Introduction to Systems Analysis
16.821	A Management View of Engineering Seminar
16.84	Flight Vehicle Engineering
16.85	Space Systems Engineering
16.86	Advanced Systems Engineering (A)
16.87	Vertical Take-Off Aircraft (A)
16.88	Advanced Vertical Take-Off Aircraft (A)
16.89	Technology, Power, and Values
16.91	Structural Dynamics (A)
16.92	Advanced Aeroelasticity (A)
16.94	Advanced Structural Dynamics (A)
16.99	Seminar

*Full descriptions of all subjects are given in the catalogue entitled **Courses and Degree Programs, 1974–75**, which may be obtained by writing to the Institute Information Services, Room 7-111, M.I.T.

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Oak Ridge

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Assistant Directors and Instructors

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Department of Chemical Engineering

Undergraduate Study

Chemical engineering is the most broadly based of all engineering disciplines. This breadth results from a very deep involvement with chemistry in addition to the applications of physics and mathematics which are common to all engineering disciplines. In its broadest sense, chemical engineering is the creative application of chemistry to the solution of significant problems. Chemical engineering is making unparalleled contributions to the development of clean energy sources, to the provision of adequate food supplies, to the recreation of proper ecological balances, to the advancement of medical/engineering science, and to the economic production of material goods. In order to participate meaningfully in these activities, the engineer requires a thorough grounding in chemistry, mathematics, and physics. At M.I.T., the Department of Chemical Engineering achieves this objective in two undergraduate programs: Chemical Engineering (Course X), leading to the Bachelor of Science in Chemical Engineering; and Chemical Engineering (Course X-C) leading to the Bachelor of Science. The latter 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 wished 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 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 the social sciences, teaching, or management. Students interested in the various areas of graduate study in Chemical Engineering should consult the graduate section which follows Undergraduate Study.

The School of Chemical Engineering Practice, also described in detail in the graduate section, involves one term of work under the direction of Institute faculty 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 and is normally required for the Chemical Engineer.

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. Biology subjects may be used to satisfy some departmental requirements. A suitable program of study may be arranged within regular curricula of Course X or X-C. Interested students should consult with their faculty counselor, as well as with Professor Edward W. Merrill, who is the Department's premedical advisor to undergraduates and graduates.

Bachelor of Science in Chemical Engineering
Course X

	General Institute Requirements		Total units
	Specific science and humanities and social science subjects		132
	The subjects 10.13, 18.03 and 5.41 which are required in the Departmental Program, appear on the list of Science Distribution Subjects and can be used to satisfy the Science Distribution Requirement.		
	Laboratory Requirement		12
	Departmental Program		
	Required Subjects		**99**
5.41	Introduction to Structure, Bonding and Mechanism[1]	5 0 7	
5.62	Physical Chemistry	4 0 8	
10.13	Mass and Energy Processing	4 0 8	
10.14	Chemical Engineering Thermodynamics	2 0 4	
10.26	Chemical Engineering Laboratory	2 8 2	
10.301	Modes of Heat and Mass Transfer	4 0 8	
10.37	Chemical Kinetics and Reactor Design	3 0 6	
18.03	Differential Equations	4 0 8	
	Thesis	12	
	Restricted Electives		
	Chemistry or Biology (in addition to the above required subjects)		**at least 24**
	Chemical Engineering (in addition to the above required subjects)		**at least 30**
	Laboratory work (within the above categories of electives, at least 6 units in addition to the General Institute Laboratory Requirement, 10.26 and Thesis)		
	Unrestricted Electives[2]		**up to 63**
	Total Units Required for the S.B. Degree		**360**

1
Students who take 5.41 to fulfill the General Institute Requirements in Chemistry/Biology must take 12 additional units of Unrestricted Elective.

2
Schedules of students in Course X may always be arranged to leave available 12 units of unrestricted elective in the second year. The Unrestricted Elective must be at least 48 units.

Electives in chemistry are normally selected from the following: 5.42 Organic Chemistry; 5.03 Principles of Inorganic Chemistry I; and relevant laboratory subjects. Electives in chemical engineering normally include most of the following: 10.302 Fluid Mechanics and Transport Processes or 10.311 Continuum Mechanics, and 10.312 Transport Phenomena; 10.21 Structures and Properties of Matter and 10.18 Industrial Chemistry.

Additional opportunity for experimental research, with considerable flexibility in scheduling, is provided in 10.91 Experimental Research Problem, 12 units of which satisfy the General Institute Laboratory Requirement. Students with a strong interest in a professional minor may satisfy this interest by use of the scheduled free elective time.

Freshmen who want an early initial exposure to chemical engineering should take 10.07 Introduction to Polymer Chemistry or 10.10 Process Synthesis which are designed for freshmen. Both may be used to satisfy the restricted electives in Chemical Engineering.

The student who decides early to major in chemical engineering is encouraged to begin taking professional subjects at once. For example, 5.41 Introduction to Structure, Bonding and Mechanism satisfies the Institute requirement in chemistry. It is required in the Departmental Program and may be taken in the freshman year. In the second year, the chemical engineering subjects, 10.13 Mass and Energy Processing and 10.14 Chemical Engineering Thermodynamics; 5.62 Physical Chemistry; and additional mathematics may be taken. The student would then be in an excellent position for professional work in some depth in the third and fourth years.

Some students may wish to defer choice of a major field until the end of two years; or they may decide upon chemical engineering early but still wish, because of strong secondary interest in other engineering or scientific areas, to exercise maximum freedom in the first two years. They have 12 units of elective time in the first year and, if their second year includes two subjects in humanities and a third term of mathematics, 60 units remain to be chosen. If two of the Science Distribution Subjects chosen are in the field of fluid mechanics, thermodynamics, chemistry, biology, or chemical engineering (examples: 2.40 Thermodynamics, 3.00 Thermodynamics of Materials I, 5.41 Introduction to Structure, Bonding and Mechanism, 5.60 Chemical Equilibrium, 7.01 General Biology, 10.07 Introduction to Polymer Chemistry, 10.10 Process Synthesis, or 10.13 Mass and Energy Processing) students can generally complete the requirements for a degree in chemical engineering in two more years. This leaves 36 hours to their own choosing in the second year, but they will have sacrificed some of their elective freedom in the third and fourth years. Students are advised to discuss their proposed program with a Course X faculty counselor as soon as they become interested in a degree in chemical engineering.

Bachelor of Science Course X-C

Students in Course X-C are permitted to plan programs involving basic subjects in chemistry and chemical engineering, but instead of continuing in depth in these areas, can study in other fields, such as other engineering disciplines, biology, biomedical engineering, economics, or management.

Students planning to follow this curriculum should discuss their interests with a member of the faculty of the Department. At the time they decide to enter the Course X-C program, preferably by the first term of their senior year, they should submit to the Department a statement of goals and a program of subjects which will achieve their objectives. Students are assigned a member of the Department faculty as an advisor.

Bachelor of Science Course X-C

	General Institute Requirements	Total units
	Specific science and humanities and social science subjects	132
	The Science Distribution Requirement will be satisfied by 10.13 and 5.41 which are required in the Departmental Program, plus appropriate subjects totaling	12
	Laboratory Requirement	12
	Departmental Program	
	Required Subjects	42
5.41	Introduction to Structure, Bonding and Mechanism[1] 5 0 7	
10.13	Mass and Energy Processing 4 0 8	
10.14	Chemical Engineering Thermodynamics 2 0 4	
10.301	Modes of Heat and Mass Transfer 4 0 8	
	Restricted Electives A coherent program of subjects, with at least 30 units in chemical engineering, in addition to those in the Departmental Program, designed to achieve a specific educational goal. The program is to be planned by the student in consultation with a designated faculty counselor in the Department of Chemical Engineering.	at least 100
	Unrestricted Electives[2]	up to 62
	Total Units Required for the S.B. Degree	360

1
Students who take 5.41 to fulfill the General Institute Requirement in Chemistry/Biology, must take 12 additional units of Unrestricted Elective.

2
The Unrestricted Electives must be at least 36 units.

Five-Year Programs

In addition to offering separate programs leading to the Bachelor of Science and Master of Science in Chemical Engineering, the Department offers a program leading to the simultaneous award of both degrees at the end of five years. A detailed description of this program is available from the Graduate Registration Officer.

For chemical engineering students interested in nuclear applications, the Department of Chemical Engineering and the Department of Nuclear Engineering offer a five-year program leading to the joint Bachelor of Science in Chemical Engineering and Master of Science in Nuclear Engineering. Such Programs are approved on an individual basis between the registration officers of the two departments.

Inquiries

Additional information concerning undergraduate academic and research programs, admissions, financial aid, etc. may be obtained by writing to Professor Raymond F. Baddour, Head, Department of Chemical Engineering, Room 12-135, M.I.T., Cambridge, Massachusetts 02139, (617) 253-4561.

Graduate Study

Fields of Graduate Study

The technology of chemical engineering in the process industries falls loosely into two categories: physical and chemical. While both types are encountered in many industrial problems, graduate subjects of instruction and research are logically grouped in the corresponding fields of engineering operations and applied chemistry. Most graduate students take some work in each field, and in the School of Chemical Engineering Practice the problem assignments involve fundamentals in both areas.

Applied Chemistry The Department offers a diversified program in applied chemistry, designed for students who wish to broaden their competence in the chemical aspects of chemical engineering. This program provides subjects in industrial chemistry and chemical thermodynamics; chemical kinetics and reactor engineering, with emphasis on heterogeneous and catalytic processes; and the physical chemistry of ion-exchange, adsorption, and chromatography. The subjects listed under Materials Science and Engineering also include several on applied chemistry. Much of the Department's research activity falls into these areas, and unique laboratory facilities are provided. Specific subjects offered by the Department include:

10.25	Industrial Chemistry
10.47	Ion Exchange
10.56	Chemical Engineering in Medicine
10.59	Properties of Gases and Liquids
10.60	Catalysis and Catalytic Processes
10.62	Electrochemistry
10.65	Chemical Engineering Kinetics
10.78	Enzyme Technology and Engineering

A well-rounded program in applied chemistry might also include subjects given by other departments in advanced organic, inorganic, or physical chemistry; biochemistry, enzymology, or bacteriology; and physical metallurgy, electrochemistry, corrosion, or ceramics.

Biochemical Engineering The past two decades have witnessed major scientific breakthroughs in the fields of biochemistry and biology. Practical application of these developments is virtually untapped; they represent natural and fertile areas of activity for chemical engineers with strong backgrounds in applied chemistry. Among these are analytical techniques (enzyme-coated electrodes, automated chemical analysis), medical therapy (cancer chemotherapy, artificial kidney) and catalysts for industrial processes. The Department has an active research program focusing upon the use of enzymes in a wide range of applications. Students interested in the field have the opportunity to draw upon a variety of relevant subjects offered by the Department including:

10.25	Industrial Chemistry
10.50	Heat and Mass Transfer
10.56	Chemical Engineering in Medicine
10.58J	Artificial Internal Organs
10.60	Catalysis and Catalytic Processes
10.61	Physics and Chemistry of Surfaces
10.641	Structure and Properties of Polymers
10.65	Chemical Engineering Kinetics
10.78J	Enzyme Technology and Engineering

Well-rounded programs should also include introductory and advanced subjects in biology, biochemistry, bacteriology, biochemical engineering, or microbiology offered in other departments.

Biomedical Engineering The application of chemical engineering to problems in the life sciences and medicine has become an increasingly important and meaningful area of research. The broad backgrounds of chemical engineers, spanning both fundamental and applied aspects of chemistry and physics, makes them uniquely qualified to handle such tasks.

Students interested in this area have the opportunity to draw upon the Department's diverse offering of subjects in the chemical engineering sciences. Relevant subjects offered include:

10.21	Structures and Properties of Matter
10.33	Analytical Treatment of Chemical Engineering Processes
10.40	Chemical Engineering Thermodynamics
10.50	Heat and Mass Transfer
10.51	Macromolecular Hydrodynamics
10.52	Mechanics of Fluids
10.54	Advanced Topics in Mass Transfer
10.56	Chemical Engineering in Medicine
10.58J	Artificial Internal Organs
10.61	Physics and Chemistry of Surfaces
10.62	Electrochemistry
10.641	Structure and Properties of Polymers
10.65	Chemical Engineering Kinetics
10.66	Surface Science and Engineering
10.67	Polymer Science Laboratory
10.681	Physical Chemistry of Polymers
10.78	Enzyme Technology and Engineering

The Department's active graduate research program in biomedically related areas is characterized by an interdisciplinary approach to both fundamental and applied problems. Many projects involve collaboration with physicians, surgeons, and life scientists in other departments and in local hospitals associated with Harvard Medical School. Research topics include the rheology of non-Newtonian biological fluids, mass transfer in blood and in artificial organs, such as the artificial kidney and blood oxygenator, synthesis of blood-compatible synthetic biomaterials, membrane transport phenomena, synthetic replacement of the lung surfactant, physical properties of biopolymers, and ultrafiltration of solutions of biological macromolecules.

Environmental Engineering Most processes which generate pollutants are chemical in nature. A broad chemical engineering background therefore provides an excellent preparation for attacking many aspects of environmental engineering. Problems in air and water pollution control and in solid waste disposal can be analyzed and modified by applying chemical engineering fundamentals. Furthermore, the versatility of the chemical engineer, in terms of an understanding of both chemical and physical aspects of engineering, makes him or her particularly well-qualified to handle the more complex interrelationships which are part of the broader environmental problems.

In addition to graduate subjects in thermodynamics, industrial chemistry, and transport phenomena, students interested in pursuing graduate programs in environmental engineering are encouraged to take some additional subjects in process design, kinetics, catalysis, combustion, and separation processes. Specific subjects in environmental problem areas include:

10.72	Seminar in Air Pollution Control
10.17	Combustion and Air Pollution
10.772	Seminar in Wastewater Treatment Processes

Also recommended are subjects in water resources (Civil Engineering), mesometeorology (Meteorology), microbiology (Biology), and biochemical engineering (Nutrition and Food Science).

Chemical Engineering Systems The Department offers a program for the student who wishes to apply a broad chemical engineering background to the analysis and synthesis of chemical process systems. Increased use of the digital computer for process design and control and the development of improved mathematical and computational methods has made possible the modeling, simulation, and optimization of complex chemical engineering systems, operating in the nonsteady state, with interaction of operating units and components. There are increased opportunities for graduates who have augmented a solid background in chemical engineering fundamentals with an understanding of the tools and language of modern systems analysis.

Relevant subjects offered by the Department include:

10.33	Analytical Treatment of Chemical Engineering Processes
10.34	Numerical Solution of Problems in Chemical Engineering
10.35	Dynamics and Control of Chemical Engineering Process
10.38	Analysis and Simulation of Chemical Processing Systems
10.53	Chemical Engineering Design
10.92	Seminar on Technology Assessment

Well-rounded programs may also include introductory and advanced subjects in applied mathematics, control theory, operations research, and systems analysis offered by other departments.

Graduate research activities in these fields include work on process simulation, modeling, and system optimization, real-time control, computer-aided design and automatic process synthesis. Research is carried out in collaboration with students and faculty in electrical engineering to bring an interdisciplinary approach to the program.

Engineering Operations (Process Engineering) The variety of graduate offerings provides opportunity for programs in heat transfer, fluid mechanics, and the separation processes based on mass transfer — subjects which are basic in process engineering. Opportunities for research of an advanced nature in these areas are available. Relevant subjects offered by the Department include:

10.33	Analytical Treatment of Chemical Engineering Processes
10.35	Dynamics and Control of Chemical Engineering Processes
10.38	Analysis and Simulation of Chemical Processing Systems
10.40	Chemical Engineering Thermodynamics
10.41	Distillation
10.47	Ion Exchange
10.50	Heat and Mass Transfer
10.51	Macromolecular Hydrodynamics
10.52	Mechanics of Fluids
10.53	Chemical Engineering Design
10.54	Advanced Topics in Mass Transfer
10.70	Principles of Combustion

Programs may also include advanced subjects in mathematics, instrumentation, fluid mechanics, metallurgy, and others offered in other departments.

Fuel Engineering Among all the chemical reactions, combustion is the one most widely used — in chemical synthesis, chemical and metallurgical processing, and power production. An integrated program in this field would typically include subjects in heat, momentum and mass transfer, thermodynamics, kinetics, combustion, radiation, a seminar in combustion, and a research problem in fuel processing or combustion. The Department's Fuels Research Laboratory provides excellent facilities for research on a wide range of problems, from small-scale studies of fuel processing or combustion kinetics to research in high-output combustion in rockets, ramjets, and gas turbines requiring use of the Laboratory's 2,00kw compressors to simulate altitudes to 80,000 feet and flight Mach numbers to 2.5. Subjects commonly taken are:

10.39	Energy Technology
10.40	Chemical Engineering Thermodynamics
10.52	Mechanics of Fluids
10.60	Catalysis and Catalytic Processes
10.65	Chemical Engineering Kinetics
10.70	Principles of Combustion
10.72	Seminar in Air Pollution Control
10.74	Radiative Transfer
10.79J	Nuclear Chemical Engineering

Materials Engineering and Polymers The Department maintains an active and diversified graduate research program in surface and colloid chemistry, polymer chemistry, and polymer physics and offers a coordinated instructional program in these areas. Students whose interests lie in the direction of surface phenomena or polymeric materials thus have a rare opportunity to develop specialized skills in these areas in an atmosphere where the focus of attention is on the applied, as well as the basic, scientific aspects. Specific subjects offered are:

10.51	Macromolecular Hydrodynamics
10.641	Structure and Properties of Polymers
10.642	Viscoelasticity of Polymers
10.67	Polymer Science Laboratory
10.681	Physical Chemistry of Polymers
10.682	Statistical Mechanics of Chain Molecules
10.691	Principles of Polymer Synthesis
10.692	Advanced Topics in Polymer Synthesis
10.695	Network Formation in Polymers
10.696	Compounding and Processing of Polymers
10.698	Seminar in Polymer Chemistry

Graduate research activities in these fields include topics such as the rheology of bulk polymers, polymer solutions and particulate dispersions, molecular transport phenomena in polymers, structure and properties of elastomers and microcrystalline thermoplasts, permselective membranes, chemisorption on semiconductors, fluid transport in microporous solids, crystal growth kinetics, and wetting processes. Collaboration between chemical engineering and many other departments in the supervision of these research projects brings an interdisciplinary approach to the entire program.

The following advanced degrees are offered in chemical engineering: Master of Science in Chemical Engineering; Master of Science in Chemical Engineering Practice; Chemical Engineer; Environmental Engineer; Materials Engineer; Doctor of Science or Doctor of Philosophy. Preparation equivalent to 5.62 Physical Chemistry and 5.42 Organic Chemistry is normally essential for any graduate work in chemical engineering.

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

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. The general requirements for a Master's program are given in Chapter III of this Catalogue. To complete the requirements of at least 66 subject units, of which 42 units must be in "A" subjects, together with an acceptable thesis generally takes one academic year.

Master of Science in Chemical Engineering Practice The requirements for the Master of Science in Chemical Engineering Practice (Course X-A) are the same as those for the Master of Science in Chemical Engineering, except that 24 units of practice school experience (10.82,10.83, 10.84, 10.85, 10.86, 10.87, 10.88 or 10.89) may be substituted for the Master's thesis.

Bachelor of Science graduates of this Department ordinarily meet the requirements for the Master of Science in Chemical Engineering Practice (Course X-A) in two terms. Beginning in the September following graduation, students are at the field stations until the end of December, and then return to the Institute to complete the program during the spring term. A similar Practice School field program begins in February and extends to early June.

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. Students are usually not admitted to the Practice School until they have spent at least one term at the Institute.

Field stations are located at the American Cyanamid Company plant in Bound Brook, New Jersey, and the Oak Ridge National Laboratory of the Atomic Energy Commission 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, resuits, and recommendations for action are stressed.

Chemical Engineer The Engineer's degree is offered as an advanced degree in chemical engineering for those students who desire a graduate education in depth but who are not interested primarily in research. The program of advanced study and research normally includes attendance at the Practice School, completion of an approved integrated minor consisting of at least 24 units outside the Department, and a 10.90 Experimental Research Problem (of approximately 10 units) completed under the supervision of a faculty member in the Department of Chemical Engineering. Variations in the program are approved on an individual basis. A detailed description of the Chemical Engineer's program may be obtained from the Graduate Registration Office.

Environmental Engineer The Environmental Engineer goes beyond the Master's program but without the research focus of the doctorate. It 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.

Doctor of Science or Doctor of Philosophy Admission to the doctoral program is granted only after the candidate has passed a general examination consisting of written and oral parts. The general examination is given in January and May. It is usually taken at the end of the second term in residence as a graduate student although students with good preparation may attempt the exam after one term. It is not necessary to complete a Master's in order to obtain a doctorate.

The requirements for the doctoral degree include a program of advanced study, a minor program, and a thesis. The program of advanced study and research is normally carried out in one of the fields of chemical engineering under the supervision of one or more faculty members in the Department of Chemical Engineering. The object of the minor program is to broaden the student's knowledge. The minor consists of completing satisfactorily two or more related subjects, totaling at least 24 credit units, in a field other than chemical engineering and of a more advanced character than would have been required for the student's undergraduate degree. The minor program should be arranged in consultation with and approved by the student's registration officer.

Teaching and Research Assistantships

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 Head of the Department, 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 Raymond F. Baddour, Head, Department of Chemical Engineering, Room 12-135, M.I.T., Cambridge, Massachusetts 02139 (617) 253-4561 or Professor Glenn C. Williams, Graduate Registration Officer, Room 12-175, (617) 253-4587.

Subjects in Chemical 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.

10.U.R.	Undergraduate Research
10.07	Introduction to Polymer Chemistry
10.10	Process Synthesis
10.13	Mass and Energy Processing
10.14	Chemical Engineering Thermodynamics
10.17	Combustion and Air Pollution
10.18	Industrial Chemistry
10.21	Structures and Properties of Matter
10.24	Analytical Chemistry for Chemical Engineers
10.25	Industrial Chemistry (A)
10.26	Chemical Engineering Laboratory
10.301	Modes of Heat and Mass Transfer
10.302	Fluid Mechanics and Transport Processes
10.311	Continuum Mechanics
10.312	Transport Phenomena
10.33	Analytical Treatment of Chemical Engineering Processes (A)
10.34	Numerical Solution of Problems in Chemical Engineering (A)
10.35	Dynamics and Control of Chemical Engineering Process (A)
10.36	Process Design
10.37	Chemical Kinetics and Reactor Design
10.38	Analysis and Simulation of Chemical Processing Systems (A)
10.39	Energy Technology (A)

Engineering Operations

10.40	Chemical Engineering Thermodynamics (A)
10.41	Distillation (A)
10.42	Advanced Thermodynamics (A)
10.47	Ion Exchange (A)
10.50	Heat and Mass Transfer (A)
10.51	Macromolecular Hydrodynamics (A)
10.52	Mechanics of Fluids (A)
10.53	Chemical Engineering Design (A)
10.54	Advanced Topics in Mass Transfer (A)
10.55	Advanced Topics in Heat Transfer (A)
10.56	Chemical Engineering in Medicine (A)
10.58J	Artificial Internal Organs (A)
10.59	Properties of Gases and Liquids (A)

Applied Chemistry

10.60	Catalysis and Catalytic Processes (A)
10.61	Physics and Chemistry of Surfaces (A)
10.62	Electrochemistry (A)
10.631	Surface and Colloid Chemistry
10.641	Structure and Properties of Polymers (A)
10.642	Viscoelasticity of Polymers (A)
10.65	Chemical Engineering Kinetics (A)
10.66	Surface Science and Engineering (A)
10.67	Polymer Science Laboratory (A)
10.681	Physical Chemistry of Polymers (A)
10.682	Statistical Mechanics of Chain Molecules (A)
10.691	Principles of Polymer Synthesis (A)
10.692	Advanced Topics in Polymer Synthesis (A)
10.695	Network Formation in Polymers (A)
10.696	Compounding and Processing of Polymers (A)
10.698	Seminar in Polymer Chemistry (A)
10.699	Seminar in Polymer Chemistry (A)
10.70	Principles of Combustion (A)
10.72	Seminar in Air Pollution Control (A)
10.74	Radiative Transfer (A)
10.76	Oral Technical Presentation
10.77	Commercial Development of New Technology (A)
10.771	Seminar in Wastewater Treatment Processes (A)
10.772	Seminar in Wastewater Treatment Processes (A)
10.78	Enzyme Technology and Engineering (A)
10.79J	Nuclear Chemical Engineering (A)
10.801J	Entrepreneurship
10.802J	Invention

School of Chemical Engineering Practice

10.82	School of Chemical Engineering Practice — Bound Brook Station (A)
10.83	School of Chemical Engineering Practice — Bound Brook Station (A)
10.84	School of Chemical Engineering Practice — Bound Brook Station (A)
10.85	School of Chemical Engineering Practice — Bound Brook Station (A)
10.86	School of Chemical Engineering Practice — Oak Ridge Station (A)
10.87	School of Chemical Engineering Practice — Oak Ridge Station (A)
10.88	School of Chemical Engineering Practice — Oak Ridge Station (A)
10.89	School of Chemical Engineering Practice — Oak Ridge Station (A)

General

10.90	Experimental Research Problem (A)
10.91	Experimental Research Problem
10.92	Seminar on Technology Assessment
10.93	Teaching Experience in Chemical Engineering (A)
10.95	Special Problems in Chemical Engineering (A)
10.96	Selected Topics in Chemical Engineering (A)
10.991	Seminar in Chemical Engineering (A)
10.992	Seminar in Chemical Engineering (A)

*Full descriptions of all subjects are given in the catalogue entitled **Courses and Degree Programs 1974–75**, which may be obtained by writing to the Institute Information Services, Room 7-111, M.I.T.

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Robert Joseph Hansen, Sc.D.
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Donald R. F. Harleman, Sc.D.
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David M. Alschuler, M.C.P.
Robert Coffin Garson, Ph.D.
Bernard Trevor Higonnet, M.S.
John Forbes Mandell, Ph.D.
Thom Louis Neff, Ph.D.
Earl Roger Ruiter, M.S.
Joseph Elias Soussou, Ph.D.
John Howard Suhrbier, S.M.
Ghiath Taleb-Agha, Ph.D.
Anwar Ernest Zaki Wissa, Sc.D.

Professors Emeriti
John Brazer Babcock, III, S.B.
Professor of Railway Engineering, Emeritus

Alexander Jamieson Bone, S.M.
Associate Professor of Civil Engineering, Emeritus

Myle Joseph Holley, Jr., S.M.
Professor of Civil Engineering, Emeritus

Eugene Mirabelli, S.B.
Associate Professor of Civil Engineering, Emeritus

William Edward Stanley, C.E.
Professor of Sanitary Engineering, Emeritus

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

Department of Civil Engineering

Creating the complex systems of constructed facilities required to meet such public and private objectives as economic development, environmental protection, and social well-being is the purpose of civil engineering. Billions of dollars are invested each year by governments and industries throughout the world to meet the rapidly expanding demand for facilities for transportation, communication, energy, defense, water resource utilization, urban development, housing, recreation, manufacturing, etc. Civil engineering has long been the principle instrument for focusing man's scientific and technological skills on these problems and for bringing together the necessary teams of engineering, architectural, and managerial specialists. It has become clear however, that significant progress toward meeting the stated objectives in the face of society's rapidly expanding complexity and changing values requires not only excellent technology but also an awareness and consideration of a whole fabric of social, political, economic, and institutional constraints leading to the identification of a range of feasible alternatives and criteria for their evaluation. This suggests expanded future roles for the civil engineer who will be increasingly responsible for the design and evaluation of entire systems of facilities — systems which in addition to performing their particular function serve the broader interests of society as well.

Reflecting this expanded professional challenge, 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, structures, or materials. Others may study the planning, design, and operations of large-scale systems of facilities in fields such as transportation, water resources, and other public services, including their interaction with the physical and social environment.

Both the educational and research programs are supported by extensive experimental and computational facilities. Access to the facilities of other groups within the Institute further extends this capability. In all such activities, both undergraduate and graduate students participate to the fullest degree, working together with faculty who are widely known for their engineering accomplishments.

Facilities and Special Programs

Educational and research facilities and special programs within the Department are described below.

Laboratories

The **Ralph M. Parsons Laboratory for Water Resources and Hydrodynamics** is a major unit for research in the water environment, containing more than 40,000 square feet of classrooms, laboratories, shops, computer facilities, and offices. A large collection of literature in this field is available for reference. The experimental equipment includes a number of wave tanks and channels for the study of wave deformation and breakwaters and for investigations of the transport of suspended sediment. A 40 ft. by 60 ft. basin is used for the study of waste heat disposal by submerged, multi-port diffusers in estuaries and coastal waters. Water temperature distributions are measured by a 100 probe, automatic scanning system connected to a computer controlled data acquisition facility. Additional specialized equipment and instrumentation is available for the study of turbulence, stratified flows, dispersion in porous media, surface runoff and other phenomena of importance in water resources engineering and water quality control. Equipment for field observations includes drogues for measurement of currents, and recorders of depth, temperature, and salinity.

The **Geotechnical Engineering Research Laboratory** conducts applied and fundamental research on the engineering properties of soil and rock, develops new methods of analysis, and measures and evaluates the field performance of structures during and after construction. The primary objective of the research is evaluation and improvement of methods for predicting the behavior of constructed facilities. The geotechnical laboratory, served by a computer based data acquisition system, includes plane strain and high pressure triaxial apparatus, controlled loading consolidation cells, freezing units, equipment for dynamic testing, and a rock mechanics laboratory.

Undergraduate Program

The **Structures Laboratory** is an educational facility for the study of the behavior of structural elements and structural systems. The laboratory assists the student in relating theoretical predictions to actual response and in visualizing the behavior of complex systems.

The **Materials Research Laboratory** staff includes civil, chemical, and mechanical engineers; metallurgists; and electronics specialists. Its mission is research on materials which are useful to the practice of civil engineering. Among the latter are concrete and cementitious compounds, metallic reinforcements, metals, natural and synthetic polymers, glasses, asphalt and bituminous materials, wood, and various composites containing combinations of these. The research programs are directed toward understanding composition-structure-property relationships, the control of properties for enhanced usefulness, and the experimental measurement of properties to facilitate the best engineering design. As a consequence, considerable and varied equipment for the production, fabrication, and evaluation of materials is available, with new apparatus being continually developed or acquired.

The **Civil Engineering Systems Laboratory** (CESL) is primarily concerned with the analysis and design of large-scale, integrated civil engineering facilities and public services. CESL is founded on the proposition that computers represent a technological change which, by increasing the engineer's ability to manipulate data by several orders of magnitude, will lead to fundamental alterations in the way engineering is carried out. Research and instruction is directed toward the application of the most modern computer based analytic, design, and management techniques to civil engineering systems.

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, economics, political science, and sociology, as well as in mechanical and electrical engineering, ecology, chemistry and geology. Accordingly, departmental research and subject offerings have been developed in many interdisciplinary areas of current and future importance such as environmental engineering, environmental management and control, public service systems, urban engineering, engineering and public policy, project evaluation and management. Undergraduates and graduate students build educational programs in these and other areas, either through use of the liberal elective provisions of the curriculum leading to degrees designated as being in civil engineering, or by formulating a special program leading to a degree without designation. In any case, the subjects chosen may be selected from among the offerings of all the departments of the Institute, including Urban Studies and Planning, Architecture, Management, Mathematics, Economics, Political Science, the life and earth sciences, and the other fields of engineering. 2) Interdisciplinary programs at the graduate level 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, construction management, and the social applications of technology.

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.

The Department of Civil Engineering offers two undergraduate curricula for students seeking a strong base for careers in civil engineering or related fields. The first curriculum, which leads to the Bachelor of Science in Civil Engineering, is designed for students having educational goals which fall substantially within the scope of civil engineering. The second curriculum, which leads to the Bachelor of Science is designed for students having a well-defined educational goal, the attainment of which requires a specially formulated program of study.

Each of these curricula provides sufficient flexibility to permit students to develop their own special interests either by taking subjects offered by the Department of Civil Engineering or by other departments. Undergraduates are encouraged to participate in the research and development activities of the Department and in many cases can obtain degree credit for such work.

Students often find there are academic advantages in planning their programs for the third and fourth years so they will dovetail with possible graduate study. This is readily accomplished for those students who embark on the Departmental Program in their second year. Selected students may be admitted to a special program permitting them to work simultaneously toward undergraduate and graduate degrees.

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 interrelationships of the various disciplines which comprise it. The five-subject core of this curriculum introduces the student first to the issues, problems, and methods of civil engineering, and then acquaints the student with persons successful in this profession, and with their special areas of accomplishment. 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.

Bachelor of Science in Civil Engineering
Course I

	General Institute Requirements		Total units
	Specific science and humanities and social science subjects		132
	The Science Distribution Requirement will be satisfied by 1.11J, which is required in the Departmental Program, plus appropriate subjects totaling[1]		24
	Laboratory Requirement[2]		12
	Departmental Program		
	Required Subjects		60
1.07	Analysis of Uncertainty	3 1 8	
1.11J	Introduction to Systems Analysis	3 3 6	
1.12	Civil Engineering	4 0 8	
1.13	Behavior of Physical Systems	6 0 6	
1.14	Economics for Engineers	3 0 9	

Planned Electives		**at least 33**
Primary Program A coherent selection of three subjects within one of the following areas: Building Systems Engineering Mechanics Environmental Engineering Geotechnical Engineering Materials of Construction Structural Systems Transportation Systems Water Resources Systems		
Secondary Program At least two subjects, chosen from among those offered by the Department of Civil Engineering, which add breadth to the overall program.		**at least 18**
Unrestricted Electives[3]		**up to 81**
Total Units for the S.B.C.E. Degree		**360**

1
This requirement is to be fulfilled by taking, in addition to 1.11J, one mathematics subject such as 18.03 or 18.031, and one physical science subject offered by a department other than Civil Engineering such as 2.403, 3.11, 5.60, 6.01, 8.03, or 13.001.
2
Recommended subjects 1.102, 1.103, 1.104, 1.105, 1.106, 1.107 (Laboratory projects in various areas).
3
Credit for the Unrestricted Electives must total at least 36 units.

Bachelor of Science
Course I

This curriculum is provided for those students whose interests and clearly defined 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 degree Bachelor of Science in Civil Engineering. The core of the program is identical with that required for the Bachelor of Science in Civil Engineering but the planned electives are not constrained to a presently identified subdiscipline of civil engineering. Under this program, students interested in urban affairs, control of the environment, project management, public systems, and the like may develop sequences of planned electives. Subjects taught by other departments may be included.

A student desiring to enter this program must first define his or her educational objectives, and then, through conversations with members of the faculty, find a professor in the department with similar interests who agrees to serve as the program advisor, assisting the student in outlining a curriculum, and endorsing it as a recommendation for departmental approval.

Bachelor of Science
Course I

	General Institute Requirements		Total units
	Specific science and humanities and social science subjects		132
	The Science Distribution Requirement will be satisfied by 1.11J, which is required in the Departmental Program, plus appropriate subjects totaling[1]		24
	Laboratory Requirement[2]		12
	Departmental Program		
	Required Subjects		60
1.07	Analysis of Uncertainty	3 1 8	
1.11J	Introduction to Systems Analysis	3 3 6	
1.12	Civil Engineering	4 0 8	
1.13	Behavior of Physical Systems	6 0 6	
1.14	Economics for Engineers	3 0 9	

Planned Electives		**at least 72**
At least seven subjects, three of which are offered by the Department of Civil Engineering, which will lead to a well-defined educational goal.		
Unrestricted Electives[3]		**up to 60**
Total Units Required for the S.B. Degree		**360**

1
This requirement is to be fulfilled by taking in addition to 1.11J, one mathematics subject such as 18.03 or 18.031, and one physical science subject offered by a department other than Civil Engineering such as 2.403, 3.11, 5.60, 6.01, 8.03, or 13.001.
2
Recommended subjects 1.102, 1.103, 1.104, 1.105, 1.106, 1.107 (Laboratory projects in various areas).
3
Credit for the Unrestricted Electives must total at least 36 units.

Undergraduate Electives

1.00	Information Systems	3	2	7
1.01	Ethics and Technocrats	4	2	6
1.02J	Materials of Construction	3	3	6
1.04	Introduction to Structural Engineering	3	3	6
1.05	Fluid Dynamics	3	3	6
1.06	Soil Mechanics	3	3	6
1.08	Geotechnology	3	3	6
1.09J	Ecology[2]	3	3	6
1.102	Transportation Systems Laboratory Projects[1]	0	3	3
1.103	Geotechnical Engineering Laboratory Projects[1]	0	3	3
1.104	Materials of Construction Laboratory Projects[1]	0	3	3
1.105	Structural Engineering Laboratory Projects[1]	0	3	3
1.106	Water Resources Laboratory Projects[1]	0	3	3
1.107	Water Quality Laboratory Projects[1]	2	6	4
1.121	Civil Engineering	2	0	1
1.200	Introduction to Transportation Systems	3	0	3
1.211	Analysis of Transportation Systems	5	0	7
1.40J	Introduction to Electron Microscopy	1	3	2
1.42	Advanced Construction Materials and Processes	3	0	6
1.44	Materials in the Environment	2	2	5
1.502	Structural Analysis and Design	4	0	8
1.503	Engineering Mechanics	4	0	8
1.60	Introduction to Water Resources	3	0	6
1.82	Environmental Management Processes	3	0	9
1.86	Cycling of Material in the Environment	3	0	9

By the fourth year, students usually have the prerequisites for a variety of graduate subjects offered by the Department. Descriptions of typical sequences of subjects in different areas may be obtained from faculty advisors.

Students wishing to work closely with a faculty member on research may obtain permission to register for thesis or to enroll in 1.999 Special Studies in Civil Engineering.

Students are encouraged to consider appropriate subjects offered by other departments as part of their elective programs.

Graduate Study

The Department of Civil Engineering grants the following advanced degrees: Master of Science; Master of Science in Civil Engineering; Civil Engineer; Environmental Engineer; Materials Engineer; Doctor of Science; and Doctor of Philosophy. For the Institute's general requirements for the various degrees, see Chapter III of this Catalogue. Detailed information regarding the requirements of the department for these degrees, may be obtained from the Civil Engineering Student Information Office, Room 1-281.

Fields of Advanced Study

Integrated programs for advanced study are available in the following areas: civil engineering systems, construction and project management, environmental engineering and management, materials of construction, public systems, geotechnical engineering, structural engineering and mechanics, transportation systems, urban systems engineering, and water resources and hydrodynamics. Major fields available for doctoral theses are included in the civil engineering list in Chapter III. Fields other than those listed must be approved by the Department Graduate Registration Officer and by the Dean of the Graduate School.

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

Civil Engineering Systems Advanced study and research in civil engineering systems focuses on the significant qualitative changes that are taking place in engineering practice. These result from technological advances brought about by computing systems which increase the engineer's ability to manipulate information by several orders of magnitude.

Particular attention is directed to the application of systems analysis techniques to the solution of large-scale civil engineering problems. A broad range of subjects in systems methodology is offered, which covers computer systems, optimization techniques and their use as a means to define areas of desirable design, probabilistic methods ranging from simulation to the analysis of stochastic systems and statistical inference for the development of systems models, and evaluation procedures including multidimensional analyses and decision-theoretic approaches. In the belief that a full understanding of the strengths and limitations of tools and theory comes only from the practice of learning how to mesh them with the structure of specific problems, students are expected to focus their research and academic program on a particular application area such as transportation, water resources, building design, or public systems.

Current research is particularly closely associated with the efforts of the Transportation and Water Resources Divisions. Major projects underway include: simulation of railroad operations for improving the reliability of their operations; mathematical programming for the location and design of water facilities for an entire river basin; computer-aided routing and scheduling for Dial-a-Bus operations; planning and design of airport systems and facilities; and interactive computer graphics for network planning.

Construction and Project Management Forces inside and outside the construction industry are bringing about rapid changes, causing corresponding changes in its organization and management. As construction problems become more complex, the industry must meet, more reliably than ever, the demands for control of time, cost, and performance, cope with new technologies and means of production, and be concerned with increasingly complex human relations. A growing public awareness of the direct influence that constructed facilities have upon the public welfare is forcing close scrutiny and control by public agencies. As a result, there is increasing interdependence between the inception, feasibility determination, design, and production phases of development, with a corresponding need for greater sophistication in organization and management.

The Department has developed a program responsive to this need. It is not limited to the physical construction phase of a facility project. Rather, it encompasses the totality of activities from the initial identification of the need for a facility, through economic and technical feasibility analyses, environmental and social impact analyses, design, construction, and operation.

The academic component of the program, leading to a Master of Science, is designed to promote an understanding of the construction industry and its relevant management and operational disciplines. At the same time, it enables students to concentrate in depth on specific aspects of the industry which are of particular interest. The research component is directed toward improving the knowledge and understanding of interrelationships and interactions of various actors and processes within the industry and toward developing ways to improve both the efficiency and effectiveness of constructed facilities projects. Industry residency opportunities are also available for a limited number of students. Students with residencies participate on a part-time basis in real estate development and construction companies, thus earning while acquiring professional experience, and while progressing academically toward a degree.

Environmental Engineering and Management It is now widely recognized that in the future people must more rationally manage their activities as they relate to the environment and manage natural ecosystems and resources to protect and enhance environmental quality. To respond to these challenges it is necessary to understand the many dimensions and the extent to which science, technology, and social values define problem areas and determine the nature of viable solutions. The education and research efforts in this area are directed toward the identification of some of the major threats, examination of some of the scientific, technological, policy, legal, and economic aspects, and the development of methods of attacking and solving significant environmental problems.

Recent and current research activities include study of ecological impact of oil spills; optimal design of monitoring networks; predictive chemical and biological models for aquatic systems; experiments on the interactions between microbiota and chemical constituents in natural waters; fate of pollutants in receiving waters; technical, legal, and policy aspects of control of toxic substances; curriculum development for environmental management; environmental impact assessment techniques; legal and technical aspects of the siting of constructed facilities; legal framework for offshore mineral extraction; waste heat management; and power plant siting issues.

Materials of Construction Civil engineers are the largest users of materials in any area of technology and the entire field of structural materials is undergoing rapid changes at the present time. These two facts impart unique characteristics to our teaching and research programs related to materials. The origin of properties, in terms of composition and internal structure, must be clearly understood. Equally important is the ability to utilize these properties effectively, economically, and imaginatively, to fulfill engineering needs. The property-composition-internal-structure relationships are treated in a number of fundamental subjects, some of which deal with broad classes or families of materials to illustrate the principles involved. Related to these subjects are research programs employing basic techniques and tools such as optical and electron microscopy X-ray diffraction, single crystal studies, and microstructural examinations; students acquire operational skill with the latter through both their subject work and their research activities.

The application of materials to civil engineering needs, in a rational and quantitative fashion, represents the second main component of our effort. In this area are found subjects and research dealing with structural composites, fracture mechanics, viscoelasticity and rheology, mechanics of materials, and the mechanical behavior of metals. Again, considerable reinforcement between teaching and research takes place and the most modern testing and computational equipment and techniques are employed.

Students are also given opportunity to pursue studies in materials engineering, under interdepartmental supervision, leading to the Materials Engineer or Doctor of Science or Doctor of Philosophy. There is no standard curriculum in this field, and students arrange a program of study and research uniquely suited to their interests and professional goals.

Public Systems Research and education in public systems attempts to define how technology can be harnessed to serve the needs of public facilities. Particular emphasis is directed toward understanding how quantitative techniques can be used in the analysis and subsequent design of large-scale service systems such as mass transit, airports, and post office facilities.

Special attention is directed to the definition of the central issues, technical and ethical, in the application of technology. Subjects are offered in both the critical analysis of the applications of operations research and in the legal and political implications of alternative technological approaches to problems.

Geotechnical Engineering The interaction of soil and rock with constructed facilities and the use of soil and rock as construction material is the domain of the geotechnical engineer. The graduate program in geotechnical engineering leads to an understanding of advanced mechanical and geological principles that control the behavior of soil and rock. The program emphasizes the familiarization of the student with geotechnical analysis and design techniques and with the incorporation of geotechnical aspects in planning of civil engineering projects.

The teaching program offers a comprehensive treatment of theoretical soil mechanics, soil properties, exploration and instrumentation, earth dams and foundations, and advanced subjects in the areas of soil dynamics, reliability, engineering geology and rock mechanics. Thesis research and other studies utilizing the unique laboratory and field facilities of the Department complement the graduate program in geotechnical engineering and offer students excellent opportunities to work closely with the faculty. The major areas of research are: soft ground construction; earthquake engineering; underground construction, especially hard rock tunneling; frost susceptibility of soils; stability of earth dams and natural slopes; negative skin friction on piles; and application of probability and decision theory to geotechnical problems.

Structural Engineering and Mechanics Society, today more than ever, has a great demand for constructed facilities, particularly buildings. In some cases, such as facilities to meet the needs for new energy sources, the challenge is to devise new ways to provide functional and safe structures. Usually, however, the challenge is to reduce both the direct and indirect costs of the facilities. Engineers who are prepared to improve design practice in the face of changing needs and values, and to better integrate structural design into total project planning, will be required to meet these challenges.

The educational program in structural engineering is based upon study of the fundamentals of structural mechanics, analysis of structural systems, dynamic analysis, and structural planning and design. Advanced areas of study include finite element techniques, probability and reliability structural design, and engineering for earthquake and wind loadings.

A cooperative effort within the School of Engineering offers a special opportunity to study in structural mechanics for nuclear power engineering. This effort, while serving a major current need, is also looking forward to the mechanics and materials problems of future energy systems. A joint subject with the Department of Nuclear Engineering introduces the engineering problems. Students studying in this and other aspects of mechanics and materials may take advantage of subject offerings in all departments of the School.

Students wishing to focus upon the overall problems of building design and planning may take advantage of the Department's program in construction and project management. The combination of fundamental subjects in structural engineering, plus subjects from the management program, provides a very strong base for professional work in the building field.

The research program, in which students naturally become involved, currently includes projects in the following areas: wind-induced pressure on buildings and resulting motions; optimum seismic protection of new building construction in Eastern metropolitan areas; seismic risk analysis; statistically-based loading and serviceability criteria for building design; management of nuclear power plant licensing and design; analysis of soil-structure interaction during earthquakes; and non-linear dynamic response to earthquakes.

Transportation Systems The focus of teaching and research in transportation is on systems planning, especially multimode systems. The basic approach is that of rational decision-making about transportation systems, using such techniques of systems analysis as economics, mathematical optimization, and computer models, where each is appropriate. There is also increasing awareness of the political and social factors to be taken into consideration when making transportation decisions. The program builds upon basic knowledge of the properties of transportation systems components, and the ability to analyze interactions among these components and between the transportation system and its environment. Close relation is maintained to that extensive body of research which supports and stimulates the academic program. Subjects of instruction offered include fundamentals of transportation systems, transportation systems analysis, transport systems design, urban transportation systems, flight transportation, traffic flow theory, decision theory, system simulation, mathematical programming, network flow, economic analysis, probabilistic analysis, and substantive applications to highway, air, rail, and sea transport. The Transportation Systems Division actively participates in the work of the Civil Engineering Systems Laboratory, the Urban Systems Laboratory, the Commodity Transportation and Economic Development Laboratory, the Flight Transportation Laboratory, and the Center for Transportation Studies.

Urban Systems Engineering Many civil engineering projects are located in metropolitan areas. Their design must therefore take into consideration not only the physical loads that will be imposed upon them, but also the strong interaction between these facilities and the complex economic and social forces of the urban environment.

Urban systems engineering applies modern computer-aided analytic techniques, tempered by an appreciation for relevant human issues, to the creative solution of urban problems in which the Civil Engineer is involved. The academic program thus integrates three complementary lines of study: methods of systems analysis; an application area such as transportation, construction, or water resources; and the social, economic, and political aspects of the urban context. Research in urban systems engineering is supported by the Interdepartmental Urban Systems Laboratory, the Civil Engineering Systems Laboratory, and the Center for Transportation Studies.

Water Resources and Hydrodynamics The educational and research program is centered on the following areas of engineering in the water environment: theoretical and experimental studies of the physical processes governing the occurrence, distribution, quality and movement of water in the environment; analysis of the hydraulic behavior of individual and interconnected elements in constructed water facilities; mathematical simulation of physical systems to study the behavior, operation, and management of existing or proposed engineering works; water resource planning and management with multiple objectives, multiple alternatives, and chance; ecology and chemistry of the aquatic environment with emphasis on developing control strategies; legal and social aspects pertaining to environmental quality control.

Basic applications of fluid mechanics and of systems engineering are involved in hydraulic engineering, water quality control, coastal and ocean engineering, hydrologic analysis, and the planning of water resource systems.

The educational and research program is designed to accommodate a broad range of interests and backgrounds. For example, the objective may be the development of a mathematical model for the simulation of a physical system; alternatively such a model may be utilized in water resource planning, optimization, and decision making. Students in the area of water resources and environmental problems may have backgrounds in the biochemical or geophysical sciences, mathematics or economics, as well as in civil or other branches of engineering.

Extensive research activities in the Ralph M. Parsons Laboratory for Water Resources and Hydrodynamics are closely coupled with the educational program. Within the hydrodynamics area the major interests center on studies in turbulence and boundary resistance, free surface flow, wave motion, tidal dynamics in estuaries and embayments, flows with density stratification, diffusion and mixing processes, sediment transport, and flow in porous media.

The planning and development of water resources is based on the analysis and synthesis of hydrologic and hydraulic systems and the integration of physical, economic, and social factors. Emphasis is placed on case studies and opportunities are provided for experience in water resource planning studies for various parts of the world.

Within the area of water quality management and control, a major concern is with the development of water quality simulation models for lakes, reservoirs, rivers, aquifers, estuaries, and coastal regions. The objectives are to combine the hydrodynamic aspects of fluid transport processes with the chemical and biological aspects of the ecological system.

In the field of environmental engineering a broad interdisciplinary educational and research program has been developed. The program in water resources and hydrodynamics has been complemented by the addition of faculty members from the professions of ecology, aquatic chemistry, economics, law, and political science.

The research program includes the following topics: evaluation of precipitation measuring systems; optimum linear synthesis of urban runoff; error analysis of mathematical models of surface runoff and streamflow; analysis of uncertainties in the modeling of hydrologic processes, environmental studies in coastal waters; wave scattering by large objects; wave shaling, breaking, stability, mass transport in inshore and foreshore zones; effects of topography on storm or earthquake generated waves; mechanics of water-wave transmission past breakwaters; containment and collection of oil spills on the seas; mechanics of transport of suspended sediment; interaction of turbulent flow with porous boundaries; effects of density stratification on mixing in aquifers; predication and control of temperature distribution due to heated effluents from thermal power stations; thermal stratification and reservoir water quality; dispersion of waste due to tidal motion and salinity intrusion in estuaries; water resource planning for new communities; planning for capacity expansion of water distribution systems; testing of new standards for economic evaluation of water resource projects; design of data collection programs in space and time for hydrologic and hydraulic studies; management aspects of thermal pollution control; mathematical modeling of estuarine water quality; and international environmental control.

Interdepartmental programs in ocean engineering may be arranged through the Department of Civil Engineering.

Entrance Requirements for Graduate Study

Applicants must present evidence of appropriate training for graduate study in the areas of their interest, though this preparation need not have been in civil engineering. Increasing opportunities exist for those having non-traditional backgrounds to continue their education at the graduate level in civil engineering. This has come about partly through a broadening of concerns within the Department and partly through the growth of interdepartmental research and degree programs which are bringing people of diverse background together in search of solutions to the major problems of our society. For example, where decisions on project justification were once made solely on the basis of economic efficiency as determined by benefit-cost analysis, ways are now being sought to incorporate into the decision making the values of the affected community and the impacts of the project upon environmental quality. This creates the need for professionals with training in the social sciences and in the physical sciences, as well as in engineering. Consequently, we are finding it increasingly necessary and desirable to bring into our civil engineering community at M.I.T. graduate students and faculty having prior education and experience in such diverse fields as economics, political science, sociology, architecture, urban and regional planning, management, biology, geology, and oceanography. The primary requirement is for a basic capability and interest in quantitative approaches to real problems. Prerequisites are given in the subject descriptions. Students may make up deficiencies in prerequisites for graduate subjects while pursuing a program of graduate study. In some instances graduate credit may be granted for the work done to make up deficiencies. It is necessary to petition for this, and each case is considered on its own merits.

Teaching and Research 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. In addition to the financial support so gained, such appointments provide valuable educational experience and outstanding thesis opportunities.

Additional Information

The Department of Civil Engineering maintains a Civil Engineering Student Information Office. Detailed information about the policies and programs of the Department may be obtained by writing to that office, Room 1-281, M.I.T., Cambridge, Massachusetts, or by calling (617) 253-7106 or (617) 253-7176.

Subjects in Civil Engineering*

(A) following the name of a subject indicates that it is an approved subject for a graduate degree and is given primarily for graduate students.

1.U.R.	Research in Civil Engineering
	Fundamentals
1.00	Information Systems
1.01	Ethics and Technocrats
1.02J	Materials of Construction
1.04	Introduction to Structural Engineering
1.05	Fluid Dynamics
1.06	Soil Mechanics
1.07	Analysis of Uncertainty
1.08	Geotechnology
1.09J	Ecology
1.102	Transportation Systems Laboratory Projects
1.103	Geotechnical Engineering Laboratory Projects
1.104	Materials of Construction Laboratory Projects
1.105	Structural Engineering Laboratory Projects
1.106	Water Resources Laboratory Projects
1.107	Water Quality Laboratory Projects
1.11J	Introduction to Systems Analysis
1.12	Civil Engineering
1.121	Civil Engineering
1.13	Behavior of Physical Systems
1.14	Economics for Engineers
	Systems Methods
1.143	Mathematical Optimization Techniques (A)
1.146J	Engineering Systems Analysis (A)
1.148	Decision Theories and Social Realities in Engineering Planning (A)
1.154	Simulation Methods (A)
1.157	Simulation Methods (A)
1.16J	Special Studies in Systems Engineering (A)
1.162	Analytic Formulation of Engineering Systems Problems (A)
1.181	Statistical Analysis for Decision Making (A)
1.183	Applications of Multivariate Statistical Analysis (A)
1.184	Applied Random Processes (A)
	Transportation
1.200	Introduction to Transportation Systems
1.201	Transportation Systems Analysis (A)
1.202	Analysis of Transportation Demand (A)
1.203	Transportation Supply Models (A)
1.211	Analysis of Transportation Systems
1.22	Topics in Commodity Distribution (A)
1.231J	Planning and Design of Airport Systems (A)
1.232J	Airport Operation and Management (A)
1.24	Transportation Investment Planning and Programming (A)
1.25	Innovative Urban Transportation Systems (A)
1.262J	Transportation Policy Analysis (A)
1.263J	Transportation and Energy for Greater Boston and New England (A)
1.27	Special Studies in Transportation Engineering (A)
1.271	Research Seminar in Transportation
1.281	Transportation Economics (A)
1.282	Structure and Economic Characteristics of Transportation Services (A)
1.290J	Introduction to Transportation Technology (A)
	Construction
	Geotechnical Engineering
1.311	Theoretical Soil Mechanics (A)
1.321	Soil Behavior (A)
1.331	Soil Dynamics (A)
1.34	Reliability in Geotechnical Engineering (A)
1.361	Advanced Soil Mechanics (A)
1.362	Earth Dams (A)
1.364	Foundation Engineering (A)
1.37	Geotechnical Measurements and Exploration (A)
1.38	Engineering Geology (A)
1.381	Rock Mechanics I (A)
1.382	Rock Mechanics II (A)
1.39	Special Studies in Geotechnical Engineering (A)
	Materials of Construction
1.40J	Introduction to Electron Microscopy
1.401J	Projects in Electron Microscopy (A)
1.41J	Fracture of Structural Materials (A)
1.42	Advanced Construction Materials and Processes
1.44	Materials in the Environment
1.45	Highway Technology (A)
1.46	Construction Materials Systems (A)
1.471J	Mechanical Behavior of Plastics (A)
1.472J	Composite Materials (A)
1.48	Special Studies in Materials of Construction (A)
	Structural Engineering
1.502	Structural Analysis and Design
1.503	Engineering Mechanics
1.531	Special Problems in Structural Engineering (A)
1.532	Mini-subjects in Structural Engineering (A)
1.541	Concrete Design Seminar (A)
1.542	Steel Design Seminar (A)
1.551	Planning and Design of Structural Systems (A)
1.552	Structural Behavior and Design (A)

*Full descriptions for all subjects are given in the catalogue entitled **Courses and Degree Programs, 1974–75**, which may be obtained by writing to the Institute Information Services, Room 7-111, M.I.T.

Continued on next page

1.553	The Practice of Structural Engineering (A)
1.561	Finite Element Methods (A)
1.562	Advanced Structural Mechanics (A)
1.563J	Structural Mechanics in Nuclear Power Technology (A)
1.571	Advanced Structural Analysis I (A)
1.572	Advanced Structural Analysis II (A)
1.582	Structural Reliability (A)
1.586	Structural Dynamics (A)
1.587	Design of Buildings Against Earthquakes (A)

Water Resources and the Water Environment

1.60	Introduction to Water Resources
1.612	Fluid Mechanics (A)
1.613	Fluid Mechanics (A)
1.631	Advanced Hydromechanics I (A)
1.632	Advanced Hydromechanics II (A)
1.65	Free Surface Flow (A)
1.66	Special Problems in Water Resources and Hydromechanics (A)
1.681	Measurement and Modeling of Physical Processes in the Water Environment (A)
1.69	Introduction to Coastal Engineering (A)
1.691	Advanced Wave Hydrodynamics in Coastal Engineering I (A)
1.692	Advanced Wave Hydrodynamics in Coastal Engineering II (A)
1.70	Sediment Transport and Coastal Processes (A)
1.711	Dynamic Hydrology (A)
1.712	Hydrologic Analysis and Synthesis (A)
1.72	Groundwater Hydrology (A)
1.731	Water Resource Systems I (A)
1.732	Water Resource Systems II (A)
1.74	Public Expenditure Theory (A)
1.76	Aquatic Chemistry (A)
1.77	Water Quality Control (A)
1.771	Water Quality Laboratory (A)
1.78	Water Quality Management (A)
1.79	Models of Aquatic Ecosystems (A)

Management of Environment

1.811	Environmental Law: Pollution Control (A)
1.812	Environmental Law: Land and Resource Management (A)
1.82	Environmental Management Processes
1.83	Law and the Social Control of Science and Technology (A)
1.84	Environmental Management: Concepts, Issues, and Processes (A)
1.85J	Coastal Zone Management (A)
1.86	Cycling of Material in the Environment
1.88	Ecological Analysis of Environmental Problems (A)

Project Management

1.90	Introduction to Project Management (A)
1.911	Macro Construction Engineering (A)
1.912J	The Construction of Buildings (A)
1.913J	Transfer and Adaptation of Technology in Developing Countries (A)
1.92	Legal Issues in Construction Project Management (A)
1.93J	Project Organization and Control (A)
1.94	Analysis in Real Estate Development and Construction (A)
1.95J	Human Interactions in Project Management (A)

Special Studies

1.961–1.965	Special Studies in Civil Engineering (A)
1.969	Special Studies in Civil Engineering (A)
1.971	Research in Civil Engineering
1.974	Teaching Civil Engineering
1.991 1.992	Special Undergraduate Studies in Civil Engineering
1.999	Special Undergraduate Studies in Civil Engineering

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Department of Electrical Engineering

Undergraduate Study

Many of the products and services upon which our modern industrial civilization is based are the work of electrical engineers. The large quantities of power which serve both developed and developing societies are provided by electrical 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, psychology, 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 by electrical engineers 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 any field of rapidly changing technology no one can describe the systems and devices of only 15 years hence. What is certain, however, is that their development and understanding will require a firm grounding in the application of mathematics and physics to the design and analysis of "real" systems. "Real" systems include such obvious physical entities as motors, transistors, and lasers and the larger physical systems of which they are components: power systems, communications systems, and computers. Increasingly, the "real" systems with which the engineer must deal also include such abstract entities as algorithms, information structures, and computation schemas. 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 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.

Each of the undergraduate degree programs in Course VI involves three distinct segments: lecture-recitation subjects, laboratory-project subjects, and undergraduate thesis. Classroom subjects provide organized arrangements of important knowledge and an introduction to the application of that knowledge in homework exercises and elementary design problems. Laboratory project work, on the other hand, provides an exposure to the design of experiments — the organization of procedures to achieve specified goals. Also, it provides experience with problems of implementation — the use of the hardware and software tools of the profession. Finally, it requires evaluation of results — the quantitative reconciliation of observations with appropriate conceptual models, or of performance with specified design goals. Because of the importance of this work, all students are expected to complete one Departmental Laboratory subject in addition to the General Institute Laboratory Requirements.

Satisfactory completion of an undergraduate thesis is required in both Programs 1 and 3. The undergraduate thesis is the one part of the curricula in which the total responsibility for success

is on the student's shoulders. He or she is to take the initiative in interviewing members of the staff, discussing possible research or engineering projects, and arranging for supervision. With guidance from the supervisor, students are responsible for determining methods of solving the problem, carrying out the indicated research or design work, and presenting their results both orally and in a formal written report. They are faced with a time limit for the completion of these tasks and are expected to organize their efforts accordingly. Students are encouraged to begin thinking about thesis interests early, since work may begin in the junior year.

Students in Course VI-A not entering the Course VI Master of Science program may substitute work done as part of Industrial Practice for the undergraduate thesis provided the work includes a written proposal, a written report in thesis format, and an oral report either at M.I.T. or at the company. Students in Course VI-A who continue in the Course VI S.B.-S.M. program may submit a single S.M. thesis to satisfy both the undergraduate and graduate thesis requirements.

The electrical engineering programs allow for a number of unrestricted elective subjects without overload. Students may choose these subjects as they see fit. Sequences of electrical engineering electives have been developed to provide an opportunity for specialization in several of the current disciplines in electrical engineering and computer science or for exposure to current research in these areas. Elective sequences are currently available in control, digital systems, electronic materials and devices, and bioengineering. A series of elective subjects has been established to provide an opportunity for undergraduates to develop a close working relationship with an active research group. Participation may extend over several terms and occur in a variety of forms: project work under faculty or staff supervision, independent study of relevant literature, assisting graduate students in thesis research, or individual research or design work. Students should consult their faculty counselors about the choice of appropriate electives.

All undergraduates are encouraged to acquire industrial experience during their program at M.I.T. Many aspects of engineering education can be more effectively accomplished on the job than in a classroom. Further, most students gain a great deal of pleasure from discovering that the knowledge they have gained at M.I.T., which may have seemed rather abstract, does in fact help to solve real and important engineering problems. This experience may be acquired either through participation in Course VI-A or through appropriate summer jobs.

Bachelor of Science in Electrical Engineering
Course VI
Program 1: Electrical Science and Engineering

Program 1 leads to the Bachelor of Science in Electrical Engineering, preparing students for careers in industry, research, or the academic world. Through a proper selection of elective subjects students may get a good start on an industrial career in one of the specialized branches of electrical engineering or prepare themselves for the graduate study needed for an academic or research career in engineering or such related fields as physics, mathematics, management, or the social sciences. Program 1 requires at least one term of mathematics including differential equations and linear algebra, and one term of quantum physics or thermodynamics beyond the General Institute Requirements. This background forms the basis for the core of the curriculum: seven subjects in network theory, electronics, electromagnetic fields, electrodynamics, signals and systems, computer languages, and computation structures. The presentation of this material is based upon lectures and demonstrations, small recitation sections, carefully developed homework assignments, and individual weekly conferences between students and teaching assistants. An additional set of restricted electives allows the student to choose from the fields of statistical physics, probability, or advanced mathematics, including complex variables, modern algebra, or analysis, depending on interest.

The **Bioelectrical Engineering Option** is a variant of Program 1 that prepares students for a variety of careers in biomedical engineering and medicine. The curriculum differs from the normal Program 1 curriculum primarily in that three subjects in quantitative physiology replace several advanced subjects in mathematics and physical science. In addition students in the Bioelectrical Engineering Option are free to make other substitutions that may be more appropriate to their career objectives, and are particularly encouraged to study more deeply the life sciences and chemistry through electives.

The curriculum requirements for Program 1 are given here. Since this program satisfies both the Science Distribution and Laboratory components of the General Institute Requirements, a total of 60 units (36 units in the Bioelectrical Engineering Option) of elective time are available in each student's program. The requirements listed are not rigid. Some variations are routinely permitted, while others are considered on an individual basis. Well-motivated substitutions of substantially equivalent subjects are routinely approved. Departmental approval of requests for substantial changes will generally be granted only to well-prepared students whose proposed programs are comparable to the curricula listed in breadth, depth, and integrated approach to a well-defined educational objective.

The curricula for both versions of Program 1 are given on the following page.

Bachelor of Science in Electrical Engineering
Course VI
Program 1: Electrical Science and Engineering

	General Institute Requirements	Total units
	Specific science and humanities and social science subjects.	132
	The subjects 6.011, 8.211 or 5.60 or 2.40, 18.03 or 18.031, and 6.041 or 18.303, which are required in the Departmental Program, appear on the list of Science Distribution Subjects and can be used to satisfy the Science Distribution Requirement[5].	
	Laboratory Requirement	12
	Departmental Program	
	Required Subjects[1]	96
6.011	Introductory Network Theory 4 0 8	
6.012	Electronic Devices and Circuits 4 0 8	
6.013	Electromagnetic Fields and Energy 4 0 8	
6.014	Electrodynamics 4 0 8	
6.015	Signals and Systems 4 0 8	
6.031	Structure and Interpretation of Computer Languages 4 2 6	
6.032	Computation Structures 4 0 8	
	Thesis[2] 12	
	Restricted Electives	60
	1. Either	
18.03	Differential Equations 4 0 8	
	or	
18.031	Introduction to Linear Algebra and Differential Equations 4 0 8	
	2. Either	
2.40	Thermodynamics 4 0 8	
	or	
5.60	Chemical Equilibrium 4 0 8	
	or	
8.211	Introduction to Quantum Physics 4 0 8	
	3. One subject from each of two of the following groups:	
	A. Statistical Physics	
6.018	Statistical Mechanics and Thermodynamics 4 0 8	
	B. Probability Theory	
6.041	Probabilistic Systems Analysis 4 0 8	
	or	
18.303	Probability and Random Variables 3 0 9	
	or	
18.313	Probability 3 0 9	
	C. Advanced Mathematics	
18.04	Complex Variables with Applications 12	
	or	
6.043	Introduction to Modern Algebra 4 0 8	
	or	
18.100	Analysis I 3 0 9	
	4. Departmental Laboratory: Subjects selected from the list below (in addition to the General Institute Laboratory Requirement) 12	
6.100	Electrical Engineering Laboratory[3] Arr.	
6.101	Introductory Electronics Laboratory 3 8 1	
6.111	Introductory Digital Systems Laboratory 3 7 2	
6.112	Digital Systems Project Laboratory 2 8 2	
6.113	Advanced Digital Systems Project Laboratory 2 8 2	
6.121	Bioelectronics Project Laboratory 2 8 2	
6.122	Advanced Bioelectronics Project Laboratory 2 8 2	
6.131	Control Systems Project Laboratory 2 8 2	
6.132	Feedback Control Laboratory[3] Arr.	
6.141	Power Systems Project Laboratory 2 8 2	
6.151	Semiconductor Devices Project Laboratory 2 8 2	
6.161	Modern Optics Project Laboratory 2 8 2	
6.162	Image Transmission Systems Project Laboratory 0 12 0	
6.163	Strobe Project Laboratory 2 8 2	
6.171	Artificial Intelligence Project Laboratory 2 8 2	
6.175	Control Robotics Laboratory 1 10 1	
6.176	Computer Performance Measurement Laboratory 2 6 4	
6.181	Audio Frequency Communications Project Laboratory 2 8 2	
6.182	Psychoacoustics Project Laboratory 3 4 5	
	Unrestricted Electives[4]	60
	Total Units Required for the S.B. Degree	360

1
Under special circumstances, substitution of subjects of similar content may be permitted by petition to the Department.
2
A thesis of at least 12 units is required. Up to 18 additional units of thesis may be used as elective.
3
Registration in 6.100 or 6.132 must consist of at least 6 units in order to satisfy a part of the Departmental Laboratory Elective Requirement.
4
Schedules of students in Course VI, Program 1, may always be arranged to leave available 12 units of unrestricted elective in the second year.
5
Either 6.011 or 6.041 but not both may be used to satisfy the Science Distribution Requirement.

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

	General Institute Requirements	Total Units
	Specific science and humanities and social science subjects	132
	The subjects 6.011, 5.60, 18.03 or 18.031, and 6.041 or 18.303, which are required in the Departmental Program, appear on the list of Science Distribution Subjects and can be used to satisfy the Science Distribution Requirement[6].	
	Laboratory Requirement	12
	Departmental Program	
	Required Subjects[1]	144
6.011	Introductory Network Theory 4 0 8	
6.012	Electronic Devices and Circuits 4 0 8	
6.013	Electromagnetic Fields and Energy[2] 4 0 8	
6.014	Electrodynamics[2] 4 0 8	
6.015	Signals and Systems 4 0 8	
6.021J	Quantitative Physiology: Cells and Tissues 4 0 8	
6.022J	Quantitative Physiology: Organ Transport Systems 4 0 8	
6.023J	Quantitative Physiology: Sensory and Motor Systems 4 0 8	
6.031	Structure and Interpretation of Computer Languages 4 2 6	
6.032	Computation Structures 4 0 8	
5.60	Chemical Equilibrium[2] 4 0 8	
	Thesis[3] 1 2	
	Restricted Electives	36
	1. Either	
18.03	Differential Equations 4 0 8	
	or	
18.031	Introduction to Linear Algebra and Differential Equations 4 0 8	
	2. Either	
6.041	Probabilistic System Analysis 4 0 8	
	or	
18.303	Probability and Random Variables 3 0 9	
	or	
18.313	Probability 3 0 9	
	3. Departmental Laboratory: Subjects selected from the list of laboratory subjects given under Course VI, Program 1 (in addition to the General Institute Laboratory Requirement) 12	
	Unrestricted Electives[4,5]	36
	Total Units Required for the S.B. Degree	360

1
Substitutions of subjects of similar content may be permitted by petition to the Department.
2
An alternative program of 36 units that provides both an introduction to thermodynamics and an illustration of the application of partial differential equations to some field of physical science (such as fluid mechanics or acoustics) will generally be approved in substitution for 6.013, 6.014 and 5.60. In particular, the substitution of 8.033, 8.043 and 12 units of Unrestricted Elective will always be approved for students who take 8.023 as part of the General Institute Requirements.
3
A thesis of at least 12 units is required. Up to 18 additional units of thesis may be used as elective.
4
Many students will wish to include advanced chemistry and biology subjects in their programs. Note that, although 5.41 Introduction to Structure, Bonding, and Mechanism, and 7.01 General Biology are not specifically required in the Departmental Program, these subjects are prerequisites for many advanced chemistry and biology subjects. Only those students with a good high school preparation in chemistry and biology should elect not to take 5.41 and 7.01. Students who may be interested in applying for admission to medical school will probably want to elect additional chemistry and biology subjects, such as 5.31 Introduction to Chemical Experimentation, 5.42 Organic Chemistry, and 7.011 Introduction to Experimental Biology.
5
Schedules of students in the Bioelectrical Engineering option may always be arranged to leave available 24 units of unrestricted elective in the second year.
6
Either 6.011 or 6.041 but not both may be used to satisfy the Science Distribution Requirement.

Bachelor of Science in Electrical Engineering
Course VI
Program 3: Computer Science and Engineering

Program 3 is designed to give students a background in the computer sciences 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 the computer sciences. Although this program is not intended for students whose sole interest lies in the techniques or mechanics of programming or computer design, a selection of subjects from the curriculum may provide a good introduction to these areas for students in other programs.

The Program 3 curriculum has three major components. The first deals with the design and use of computer languages and systems, and with the role of computers in problem solving. It includes the study of algorithms and information structures, the organization of programs and information processing systems, and the methods of artificial intelligence. The second component broadens the student's experience by providing an introduction to the description and analysis of linear systems. The concepts involved in this component underlie a wide range of computer applications and are prerequisite to the successful integration of computers with a variety of physical systems and processes. The third component, which consists of subjects in linear algebra, probability, and modern algebra, introduces the student to certain fundamental areas of mathematics that support and supplement the first two components.

For some students, particularly those whose interests are centered on the hardware aspects of computation, a program of studies involving a combination of subjects from the Program 1 and 3 curricula may be appropriate. Such programs should be arranged through the student's department faculty counselor.

The curriculum requirements are listed below. Although they are intended to meet the needs of most students whose major interest lies in computers and computation, these requirements are not rigid. Well motivated substitutions of essentially equivalent subjects are normally approved. Substantial changes may also be approved provided they result in a program of comparable breadth and depth and serve a well-defined educational objective.

Bachelor of Science in Electrical Engineering
Course VI
Program 3: Computer Science and Engineering

	General Institute Requirements		Total units
	Specific science and humanities and social science subjects		132
	The Science Distribution Requirement will be satisfied by 6.011, 6.034, and 18.031, which are required in the Department Program, plus appropriate subjects totaling 4		12
	Laboratory Requirement		12
	Departmental Program		
	Required Subjects[1]		120
6.011	Introductory Network Theory	4 0 8	
6.015	Signals and Systems	4 0 8	
6.031	Structure and Interpretation of Computer Languages	4 2 6	
6.032	Computation Structures	4 0 8	
6.034	Introduction to Artificial Intelligence	4 0 8	
6.035	Translation and Execution of Programs	3 0 9	
6.041	Probabilistic Systems Analysis	4 0 8	
6.043	Introduction to Modern Algebra	4 0 8	
18.031	Introduction to Linear Algebra and Differential Equations	3 0 9	
	Thesis[2]	12	
	Restricted Electives		36
	1. One subject from each of two of the following groups:		
	Group A:		
6.033	Information Systems	4 0 8	
	Group B:		
6.036J	Problem Solving Paradigms	3 3 6	
	Group C:		
6.044	Computability, Formal Systems, and Logic	4 0 8	
6.045	Theoretical Models for Computation	3 0 9	
	Group D:		
6.046	Introduction to Algorithms	3 0 9	
6.073	Computational Methods	3 2 7	
	2. Department Laboratory	12	
	Subjects totaling 12 units selected from the list of laboratory subjects given under Course VI, Program 1 (in addition to the General Institute Laboratory Requirement)		
	Unrestricted Electives[3]		48
	Total Units Required for the S.B. Degree		360

1
Under appropriate circumstances, substitution of subjects of similar content may be arranged.
2
A thesis of at least 12 units is required. Up to 18 additional units of thesis may be used as elective.
3
Schedules of students in Course VI, Program 3 may always be arranged to leave available 12 units of unrestricted elective in the second year.
4
Either 6.011 or 6.034, but not both, may be used to satisfy the Science Distribution Requirement.

Bachelor of Science in Electrical Engineering
Course VI-A

The Course VI-A Program is a program which provides industrial and research experience concurrently with academic work through a series of organized cooperative work assignments interwoven with regular study at M.I.T. Since the Course VI-A Program ensures a continuing liaison between each participating company and the professorial staff of the Department, students are likely to receive work assignments more professionally rewarding than from the typical summer job. In addition, they can earn part of their educational expenses on the job, receive academic credit for the Industrial Practice subjects, and take other subjects for credit while on work assignment.

Second year students in good standing in any of the regular programs of Course VI may apply for admission to the VI-A Cooperative Program. Application should be made at the Course VI-A Office, Room 38-476, early in the second term. The Department cannot guarantee the acceptance of a student into the Program, however, since it is the cooperating companies which make the final selections.

The curriculum of the Course VI-A Program permits completion of the Bachelor's degree requirements in the normal four years, including a minimum of two, but occasionally three, work assignments. When participation warrants, the Department may arrange for special evening sections of selected regular M.I.T. subjects, or tutoring for advanced standing examinations, to be offered at the participating companies. Some students register for subjects offered by other universities in the evening and arrange for transfer credit at M.I.T. Students often work on thesis projects as part of their work assignments. Course VI-A students stopping at the S.B. degree may substitute work done as part of Industrial Practice for the undergraduate thesis provided the work includes a written proposal, a written report in thesis format, and an oral report either at M.I.T. or at the company.

Students in Course VI-A who are admitted to the combined Course VI S.B.-S.M. program are expected to complete four work assignments with their cooperating company. Formal application must be made to the M.I.T. Graduate School for participation in this combined program. Since the third and fourth contiguous work assignments generally involve projects of appropriate calibre, they are often developed into Master's theses to satisfy both the undergraduate and graduate thesis requirements. Such Course VI-A students usually receive the S.B. and S.M. degrees simultaneously at the end of the fifth year.

The companies and laboratories participating in the Course VI-A Program provide a wide spectrum of work assignments in the various fields of electrical science and engineering and computer science and engineering. Although students are individually associated with only one company while in the Program, work assignments are arranged to provide a broad exposure to the kinds of activities in which engineers are currently engaged. Further, the technical sophistication and responsibility involved in the assignments progresses with the developing technical competence, academic achievement, and maturity of the participating students.

Companies or laboratories currently cooperating with M.I.T. in the Course VI-A Cooperative Program include AVCO-Everett Research Laboratory, Bell Laboratories, Comsat Laboratories, Digital Equipment Corporation, Fairchild Camera and Instrument Corp., General Electric Company, General Radio Company, Hewlett-Packard Company, Honeywell, Inc., I.B.M. Corporation, Naval Ordnance Laboratory, Naval Underwater Systems Center, Raytheon Company, R.C.A., and Texas Instruments, Inc.

While on work assignments, students are subject to the usual company regulations and receive regular financial compensation for their work. In all cases, Course VI-A students must remain with the company with which they start the program. At the conclusion of the Program, students are not obligated to accept employment with their company, nor is the company obligated to offer such employment.

Bachelor of Science in Electrical Engineering
Course VI-A
Program 1: Electrical Science and Engineering

	General Institute Requirements				Total units
	Specific Science and humanities and social science subjects				132
	The subjects 6.011, 8.211 or 5.60 or 2.40, 18.03 or 18.031, and 6.041 or 18.303, which are required in the Departmental Program, appear on the list of Science Distribution Subjects and can be used to satisfy the Science Distribution Requirement[5].				
	Laboratory Requirement				12
	Departmental Program				
	Required Subjects[1]				120
6.011	Introductory Network Theory	4	0	8	
6.012	Electronic Devices and Circuits	4	0	8	
6.013	Electromagnetic Fields and Energy	4	0	8	
6.014	Electrodynamics	4	0	8	
6.015	Signals and Systems	4	0	8	
6.031	Structure and Interpretation of Computer Languages	4	2	6	
6.032	Computation Structures	4	0	8	
	Thesis[2]		12		
	Industrial Practice[3]		24		
	Restricted Electives[1]				60
	1. Either				
18.03	Differential Equations	4	0	8	
	or				
18.031	Introduction to Linear Algebra and Differential Equations	4	0	8	
	2. Either				
2.40	Thermodynamics	4	0	8	
	or				
5.60	Chemical Equilibrium	4	0	8	
	or				
8.211	Introduction to Quantum Physics	5	0	7	
	3. One subject from each of two of the following groups:				
	A. Statistical Physics				
6.018	Statistical Mechanics and Thermodynamics	4	0	8	
	B. Probability Theory				
6.041	Probabilistic Systems Analysis	4	0	8	
	or				
18.303	Probability and Random Variables	3	0	9	
	or				
18.313	Probability	3	0	9	
	C. Advanced Mathematics				
6.043	Introduction to Modern Algebra	4	0	8	
	or				
18.04	Complex Variables with Applications		12		
	or				
18.100	Analysis	3	0	9	
	Restricted Electives (continued)				
	4. Departmental Laboratory: Subjects selected from the list below (in addition to the General Institute Laboratory Requirement)		12		
6.100	Electrical Engineering Laboratory		Arr.		
6.101	Introductory Electronics Laboratory	3	8	1	
6.111	Introductory Digital Systems Laboratory	3	7	2	
6.112	Digital Systems Project Laboratory	2	8	2	
6.113	Advanced Digital Systems Project Laboratory	2	8	2	
6.121	Bioelectronics Project Laboratory	2	8	2	
6.122	Advanced Bioelectronics Project Laboratory	2	8	2	
6.131	Control Systems Project Laboratory	2	8	2	
6.132	Feedback Control Laboratory[3]		Arr.		
6.141	Power Systems Project Laboratory	2	8	2	
6.151	Semiconductor Devices Project Laboratory	2	8	2	
6.161	Modern Optics Project Laboratory	2	8	2	
6.162	Image Transmission Systems Project Laboratory	0	12	0	
6.163	Strobe Project Laboratory	2	8	2	
6.171	Artificial Intelligence Project Laboratory	2	8	2	
6.175	Control Robotics Laboratory	1	10	1	
6.176	Computer Performance Measurement Laboratory	2	6	4	
6.181	Audio Frequency Communications Project Laboratory	2	8	2	
6.182	Psychoacoustics Project Laboratory	3	4	5	
	Unrestricted Electives[4]				36
	Total Units Required for the S.B. Degree				360

1
Under special circumstances, substitution of subjects of similar content may be permitted by petition to the Department.
2
A thesis of at least 12 units is required. Up to 18 additional units of thesis may be used as elective. Students who continue studies for the S.B. degrees simultaneously may substitute 12 units of additional elective for the undergraduate thesis.
3
Credit for Industrial Practice subjects is limited to a maximum of 36 units and a minimum of 24 units.
4
Schedules of students in Course VI-A, Program 1, may always be arranged to leave available 12 units of unrestricted elective in the second year.
5
Either 6.011 or 6.041 but not both may be used to satisfy the Science Distribution Requirement.

Bachelor of Science in Electrical Engineering
Course VI-A
Program 3: Computer Science and Engineering

	General Institute Requirements				Total units
	Specific science and humanities and social science subjects				132
	The Science Distribution Requirement will be satisfied by 6.011, 6.034, and 18.031, which are required in the Department Program, plus appropriate subjects.[4]				12
	Laboratory Requirement				12
	Departmental Program				
	Required Subjects[1]				144
6.011	Introductory Network Theory	4	0	8	
6.015	Signals and Systems	4	0	8	
6.031	Structure and Interpretation of Computer Languages	4	2	6	
6.032	Computation Structures	4	0	8	
6.034	Introduction to Artificial Intelligence	4	0	8	
6.035	Translation and Execution of Programs	3	0	9	
6.041	Probabilistic Systems Analysis	4	0	8	
6.043	Introduction to Modern Algebra	4	0	8	
18.031	Introduction to Linear Algebra and Differential Equations	4	0	8	
	Thesis[2]		12		
	Industrial Practice[3]		24		
	Restricted Electives[1] Same as listed for Course VI, Program 3				36
	Unrestricted Electives[5]				36
	Total Units Required for the S.B. Degree				372

1
Under appropriate circumstances, substitution of subjects of similar content may be arranged.
2
A thesis of at least 12 units is required. Up to 18 additional units of thesis may be used as elective. Students who continue studies for the S.M. degree and receive the S.M. and S.B. simultaneously may substitute 12 units of additional elective for the undergraduate thesis.
3
Credit for Industrial Practice subjects is limited to a maximum of 36 units and a minimum of 24 units.
4
Either 6.011 or 6.034, but not both, may be used to satisfy the Science Distribution Requirement.
5
Schedules of students in Course VI-A, Program 3 may always be arranged to leave available 12 units of unrestricted elective in the second year.

Graduate Study

The program of graduate education in the Department of Electrical Engineering has three aspects. First, a variety of classroom subjects in physics, mathematics, and fundamental fields of electrical engineering is offered to permit students to develop strong theoretical backgrounds. Second, more specialized classroom and laboratory subjects and a wide variety of colloquia and seminars introduce the student to the problems of current interest in many fields of research, and to the techniques which may be useful in attacking them. Third, each candidate for any advanced degree conducts research under the direct supervision of a member of the faculty and reports the results in a thesis.

Three advanced degree programs are offered. A well-prepared student can 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 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 towards 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 science and control engineering; 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.

In addition to graduate subjects in electrical engineering, many students find it profitable to study subjects in other departments such as Biology, Economics, Foreign Literatures and Linguistics, Management, Mathematics, Physics and Psychology.

The informal seminar is an important mechanism for knitting together members of the various research groups. There are about 16 that meet every week. In these, graduate students, faculty, and visitors report their research in an atmosphere of free discussion and criticism. For the new graduate student, these open seminars are excellent places to learn about the various research activities in the Department.

Research activities in electrical engineering are carried on by students and faculty in laboratories of extraordinary range and strength, including the Electronic Systems Laboratory, the Research Laboratory of Electronics, Project MAC, 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, the High Voltage Research Laboratory, the Francis Bitter National Magnet Laboratory, the Laboratory for Insulation Research, and the Stroboscopic Light and Pulsed Sonar Laboratory. Full descriptions of these laboratories, including a list of current projects, may be found in Chapter III, under Interdisciplinary Research Facilities.

Requirements for Graduate Study

Because the undergraduate backgrounds of applicants in electrical engineering are so varied (electrical engineering, physics, mathematics, computer science, biomedical engineering, for example), no specific admissions requirements can be listed. The backgrounds of all applicants are studied carefully to assure that they meet the principal prerequisites necessary for probable graduate programs. Applicants with non-electrical engineering backgrounds are encouraged to communicate directly with faculty members in their proposed area of study for advice. In any case, superior achievement in undergraduate mathematics and physics is considered particularly important.

All regular graduate students in electrical engineering 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

The general requirements for the Master of Science are given in Chapter III. The Department requires that the program include at least four formal graduate-level classroom and 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 Electrical Engineering. The program of study must be well balanced, emphasizing one or more of the theoretical or experimental aspects of electrical engineering. A thesis is required. All four undergraduate programs, previously described, may lead to the Bachelor of Science and Master of Science in Electrical Engineering, awarded simultaneously at the end of the graduate year.

Inquiries

Electrical Engineer

Able students who desire more extensive training than is possible within the Master of Science program are encouraged to study for the degree of Electrical Engineer. The course of studies for this degree is elective, and a thesis is required. The program ordinarily requires at least four terms of graduate study beyond the Bachelor of Science level. The general requirements for the Engineer's degree are given in Chapter III. The Department also requires that the program include at least eight approved graduate "A" subjects.

Doctor of Philosophy and Doctor of Science

The general requirements for the degree of Doctor of Philosophy or Doctor of Science are given in Chapter III. Only students who have shown promise of performing truly creative work in either engineering or engineering science 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 of Electrical Engineer; the quality of the thesis submitted for these degrees is a major component in the decision to admit a student to the doctoral program. The General Examination 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. When the doctoral thesis research is completed, a thesis examination is held.

Each candidate for the doctorate in electrical engineering must demonstrate intermediate competence in speaking and reading one modern foreign language. A Minor Program is required by the Department and must have departmental approval.

Fellowships and Research and Teaching Assistantships

Studies toward an advanced degree can be supported by personal funds, by an award such as the National Science Foundation Fellowship which the student brings with him 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 spent 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 at M.I.T.*, describing research and teaching opportunities in detail, may be obtained from the Department.

Additional information concerning 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.

Subjects in Electrical 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.

	Basic Undergraduate Subjects
6.011	Introductory Network Theory
6.012	Electronic Devices and Circuits
6.013	Electromagnetic Fields and Energy
6.014	Electrodynamics
6.015	Signals and Systems
6.018	Statistical Mechanics and Thermodynamics
6.021J	Quantitative Physiology: Cells and Tissues
6.022J	Quantitative Physiology: Organ Transport Systems
6.023J	Quantitative Physiology: Sensory and Motor Systems
6.030	Introduction to Computation
6.031	Structure and Interpretation of Computer Languages
6.032	Computation Structures
6.033	Information Systems
6.034	Introduction to Artificial Intelligence
6.035	Translation and Execution of Programs
6.036J	Problem Solving Paradigms
6.041	Probabilistic Systems Analysis
6.043	Introduction to Modern Algebra
6.044	Computability, Formal Systems, and Logic
6.045	Theoretical Models for Computation
6.046	Introduction to Algorithms

*Full descriptions of all subjects are given in the catalogue entitled **Courses and Degree Programs, 1974–75**, which may be obtained by writing to the Institute Information Services, Room 7-111, M.I.T.

	Basic Undergraduate Electives
6.071	Introduction to Electronics
6.072	Systems, Networks, and Computation
6.073	Computational Methods
6.074	Introduction to Telecommunications Systems
6.081	Problem Solving
6.082	Switching Circuit, Logic and Digital System Design
6.083	Programming of Small Scale Computers
6.086	Seminar in Current Computer Science

	Undergraduate Laboratory Subjects
6.100	Electrical Engineering Laboratory
6.101	Introductory Electronics Laboratory
6.111	Introductory Digital Systems Laboratory
6.112	Digital Systems Project Laboratory
6.113	Advanced Digital Systems Project Laboratory
6.121	Bioelectronics Project Laboratory
6.122	Advanced Bioelectronics Project Laboratory
6.131	Control Systems Project Laboratory
6.132	Feedback Control Laboratory
6.141	Power Systems Project Laboratory
6.151	Semiconductor Devices Project Laboratory
6.161	Modern Optics Project Laboratory
6.162	Image Transmission Systems Project Laboratory
6.163	Strobe Project Laboratory
6.171	Artificial Intelligence Project Laboratory
6.175	Control Robotics Laboratory
6.176	Computer Performance Measurement Laboratory
6.181	Audio Frequency Communications Project Laboratory
6.182	Psychoacoustics Project Laboratory

Advanced Undergraduate Subjects and Graduate Subjects by Area

	Systems Science and Control Engineering
6.201	Dynamic Systems, Control and Optimization
6.202	Dynamic Systems, Control and Optimization
6.212J	Quantitative Models and Public Policy
6.231	Dynamical Systems and Control I (A)
6.232	Dynamical Systems and Control II (A)
6.241	Control System Theory (A)
6.242	Industrial Control
6.251J	Theory of Mathematical Programming and Discrete Time Optimal Control (A)
6.252J	Optimization in Finite and Infinite Dimensions (A)
6.253	Algebraic System Theory (A)
6.254	Qualitative Theory of Dynamical Systems (A)
6.255	Advanced Optimal Control Theory (A)
6.261	Modeling, Estimation and Identification (A)
6.262J	Advanced Markov Models and their Applications (A)
6.271J	Introduction to Operations Research (A)
6.272J	Introduction to Operations Research (A)
6.281J	Analysis of Urban Service Systems (A)
6.291	Seminar in Control Research (A)
6.293	Special Problems in Control (A)
6.295J	Special Studies in Systems Engineering (A)

	Electronics, Computers, and Systems
6.301	Solid State Circuits I
6.302	Solid State Circuits II
6.311	Telephony
6.312	Acoustics
6.313	Image Transmission Systems
6.331	Advanced Circuit Techniques (A)
6.332	Electronic Instrumentation and Control (A)
6.333	Electronic Circuits (A)
6.341	Digital Processing of Signals (A)
6.342	Advanced Topics in Digital Signal Processing (A)
6.351	Topics in Advanced Instrumentation (A)
6.352	Topics in Advanced Instrumentation (A)
6.361	Image Processing (A)
6.362	Pattern Recognition (A)
6.363	Pattern Recognition (A)

	Probabilistic Systems
6.431	Applied Probability (A)
6.432	Random Processes (A)
6.441	Transmission of Information (A)
6.451	Principles of Communication (A)
6.452	Detection, Estimation, and Modulation Theory (A)
6.453	Optical Communication Systems (A)
6.454	Advanced Topics in Optical Communication Research (A)
6.455J	Marine Data Systems (A)

	Bioelectrical Engineering
6.501	Sound, Speech, and Hearing
6.502J	Musical Acoustics
6.503	Animal Communication Systems
6.521	Electrocardiography
6.522	Radiation Therapy
6.532J	Sensory-Neural Systems (A)
6.541J	Speech Communication (A)
6.542J	Laboratory on the Physiology, Acoustics, and Perception of Speech (A)
6.543	Natural Language Processing (A)
6.551	Signal Processing by the Auditory System: Physiology (A)
6.552	Signal Processing by the Auditory System: Perception (A)
6.591	Communication Sciences Seminar (A)
6.592	Communications Sciences Seminar (A)

	Electrodynamics
6.601	Fields, Forces, and Motion
6.611	Lasers and Applications
6.632	Advanced Electromagnetic Theory (A)
6.633	Electrodynamics of Waves, Media, and Interactions (A)
6.635	Advanced Topics in Continuum Electrodynamics (A)
6.641	Microwave Circuits (A)
6.642	Antennas (A)
6.651J	Introduction to Plasma Physics (A)
6.652	Special Topics in Plasma Research (A)
6.661	Detection and Measurement of Radio Astronomical Signals (A)
6.662J	Fundamentals of Radio Astronomy (A)
6.663J	Techniques of Radar Astronomy (A)
6.664J	Radio Interferometry (A)
6.666	Principles of Environmental Sensing (A)
6.671	Continuum Electromechanics I (A)
6.672	Continuum Electromechanics II (A)
6.681	Power System Engineering I (A)
6.682	Power System Engineering II (A)
6.683	Planning and Operation of Power Systems (A)
6.684	Special Topics in Power System Engineering (A)
6.685	Dynamics of Electric Machines (A)
6.686	Advanced Electrical Energy Processing Laboratory (A)

Continued on next page

	Solid State Materials and Devices
6.720	Semiconductor Devices
6.731J	Physics of Solids I (A)
6.732J	Physics of Solids II (A)
6.734J	Application of Group Theory to the Physics of Solids (A)
6.741J	Theory of Solids I (A)
6.742J	Theory of Solids II (A)
6.743	Conduction Processes in Solids (A)
6.751	Quantum Electronics (A)
6.752	Quantum Theory of Magnetism (A)
6.753	Microwave Magnetics (A)
6.754	Signal Processing with Coherent Wave States in Crystals (A)
6.761J	Electronic Materials (A)
6.762	Dielectric, Optical and Magnetic Materials and Devices (A)
6.771	Semiconductor Electronics (A)
6.772	Semiconductor Devices and Processes: Micro- and Opto-electronics (A)
6.773	Topics in Semiconductor Device Research (A)
6.774	Semiconductor Microwave Devices and Circuits (A)
6.791	Special Topics in the Solid State and Its Application (A)
6.792	Special Topics in the Solid State and Its Application (A)

	Computer Science
6.831	Programming Language Processors (A)
6.841	Semantic Theory for Computer Systems (A)
6.845	Topics in Computer Systems Research (A)
6.851	Algorithms (A)
6.852	Algebraic Manipulation (A)
6.853	Computation by Automata (A)
6.861J	Artificial Intelligence and Heuristic Programming (A)
6.862	Topics in Artificial Intelligence (A)
6.863	Problems of Natural Language in Artificial Intelligence Research (A)
6.871	Knowledge Based Applications Systems (A)
6.891–6.899	Special Topics in the Computer Sciences (A)

	Special Subjects
6.901	Inventions and Patents
6.910	Special Studies in Electrical Engineering and Computer Science
6.911–6.919	Special Subjects in Electrical Engineering
6.921	Industrial Practice
6.922	Advanced Industrial Practice
6.929	Undergraduate Thesis Presentation
6.930	Innovation, Research and Development Seminar
6.931	Development of Inventions and Creative Ideas (A)
6.932J	The Nuclear Arms Race and Arms Control — Technology, and Government Policy (A)
6.935J	Invention
6.936J	Entrepreneurship
6.951	Graduate Industrial Practice
6.961	Introduction to Electrical Engineering Research
6.962, 6.963	Special Studies in Electrical Engineering
6.971–6.979	Special Subjects in Electrical Engineering (A)
6.980	Teaching Electrical Engineering
6.989	Teaching Electrical
6.981–	Engineering
6.991–6.999	Research in Electrical Engineering
6.U.R.	Undergraduate Research in Electrical Engineering
6.ThU	Undergraduate Thesis
6.ThG	Graduate Thesis (A)

Department of Mechanical Engineering

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Professor of Mechanical Engineering
Head of the Department

Professors

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Professor of Mechanical Engineering (Absent)

Ali Suphi Argon, Sc.D.
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Stanley Backer, Sc.D.
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Ralph Frederick Goldman, Ph.D.
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Department of Mechanical Engineering

Broader than all other engineering fields, the profession of mechanical engineering deals with many types of systems and many types of devices. The diverse aspects of modern technology involved make it a most interesting and useful profession. Individuals may choose from among many different activities in their professional careers as mechanical engineers, and they may shift their activities as their interests change.

Engineering is always concerned with change as it combines 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 vital services such as energy, health care, transportation, and communication. Many mechanical engineers a decade from now will be working in fields which do not exist today but which will be even more exciting and challenging than those of current interest.

The educational program in mechanical engineering aims at preparation for careers in an era of rapidly evolving technology. It combines a broad base in the engineering sciences (mechanics and materials, fluid and thermal sciences, and system dynamics and control) with project based laboratory and design experience. It is formulated to prepare students to become professionals in the highest sense — independent individuals with a continued capability for growth and leadership.

Since mechanical engineering is involved in nearly all of the physical devices and systems which technology has produced, a simple description of the field is difficult. Rather, several broad fields of professional concentration are described here which offer exciting career opportunities for mechanical engineering graduates in the years ahead. These include Power and Energy; Environmental Engineering; Manufacturing and Materials Processing; Biomedical Engineering; Transportation; and Computers and Control.

Power and Energy That part of mechanical engineering described under the heading of power and energy includes the technology associated with the design, construction, and operation of equipment for energy conversion. Mechanical engineers are particularly concerned with the conversion of thermal, chemical, mechanical, and electrical energy. The devices which are used to accomplish these conversions include not only the traditional turbines, generators, boilers, and internal combustion engines, but also newer devices such as fuel cells, thermionic converters, solar heating systems, and nuclear power plants.

With both short- and long-term energy shortages ahead, as well as increasing pollution problems, this field is entering a new and exciting phase. Mechanical engineering provides a broad background for a career in almost all aspects of the power and energy industries.

Environmental Engineering Concern about environmental degradation has led engineers to consider ways to reduce air, water, and land pollution caused by the products or processes of industrialization. Mechanical engineers are especially involved in reducing air pollution from automobiles, aircraft, power plants, and incinerators; in purifying water; in cleaning up the liquid effluent from factories; in collecting and processing of solid waste; and in reducing or eliminating noise. Mechanical engineers who wish to work on environmental problems must understand both the nature of the processes giving rise to pollution, as well as the principal characteristics of the air, water and land ecosystems which are affected by pollution.

Manufacturing and Materials Processing Mechanical engineers have a traditional interest in the production of equipment, components, and materials. Manufacturing industries comprise a major element of the economy and their productivity strongly influences domestic living standards and competitive positions in international trade.

Industrial production encompasses a range of subject areas from pure research to technical management, including physics of manufacturing processes; design and control of manufacturing processes and machinery; design, implementation and operation of complex manufacturing systems; and optimization of processes and products relative to people, cost, and function. This field is now being extended to computer controlled automation of complete manufacturing systems.

Biomedical Engineering There is a growing recognition of the enormous potential of science and engineering toward the advancement of human health. This includes deeper understandings of physiology, improved and new methods of medical diagnosis and therapy, more effective and economical health care systems, and the development and production of devices concerned with all the foregoing.

An undergraduate foundation in engineering can be directed either toward a career as a biomedical engineer, or toward medical school and practice and research in medicine. The Department of Mechanical Engineering, by reason of its offerings in the engineering sciences and in biomedical engineering, together with its project orientation and extensive research programs in medically related topics, provides an excellent undergraduate base for either of these directions. Many faculty members are involved in medically oriented research. Thus ample opportunity exists, through project laboratories and thesis, for engineering based medical research and/or clinical experience.

Transportation The transportation of people and goods vitally affects the economy and the quality of life. Transportation accounts for about 20 percent of the gross national product and is both a resource for unprecedented mobility and diversification and a major source of air pollution and noise, death and injury, and urban disruption. The growing need for better transportation service coupled with increasing emphasis on safety, environmental protection and energy conservation will create many new and exciting 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. The core program provides a sound background for entering almost any transportation related field, but particularly those related to ground transportation.

Computers and Control The area of computers and automatic control includes both 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. Computation and control methods will be central in such developing fields as automated manufacturing, materials processing, power generation from atomic and fossil fuels, public transportation, pollution abatement, and biomedical engineering.

Mechanical engineering provides a broad base in the engineering sciences combined with design and laboratory experience which is excellent background for working in this field. Educational opportunities are enhanced by a small but very complete facility which allows student "hands on" experience in digital, analog and hybrid computers along with graphical display terminals, light pens, and plotters.

Another way to illustrate the wide range of the mechanical engineer is to list the areas in which active research at the forefront of technological problems is currently conducted in the Department. Some of these research areas are listed below in the three divisions in which the Department is organized.

Mechanics and Materials
Continuum mechanics: elasticity, plasticity, rheology
Physics and mechanics of deformation and fracture in materials
Mechanical behavior and processing of polymeric materials
Dynamics, vibrations, acoustics
Surface physics, wear, lubrication, friction
Manufacturing processes, machines, materials and systems
Fibers, polymers, textiles
Biomechanics
Biomaterials
Noise and Vibration Control

Thermal and Fluid Sciences
Thermodynamics, kinetic theory, statistical mechanics
Heat transfer, mass transfer
Gas-surface interactions
Fluid mechanics
Combustion and fire spread
Re-entry physics
Cryogenics
Power generation and transmission
Internal combustion engines
Biomedical fluid mechanics and heat transfer
Air and water pollution control
Water desalination and purification

Systems and Design
Modeling, analysis, synthesis and management of systems
Control system theory and design
Man-machine systems
Instrumentation and measurement systems
Electromechanics
Biomechanics
Neural surgery
Sensory aids and prostheses
Societal systems design: transportation, underdeveloped technologies, urban problems
Fluidics and fluid power control
Computer-aided engineering: computer graphics, information storage and retrieval
Power and propulsion systems
Transportation system dynamics

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 must acquire adequate proficiency in the engineering sciences: dynamics, mechanics, and properties of materials; fluid dynamics; heat and mass transport; thermodynamics; systems analysis; and controls. Further, students must 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 creative nature, is the primary object of subjects in laboratory and design. Laboratory experience, which takes many forms, is intended to help students achieve an understanding of how experimental methods may be used to help solve engineering problems. Design experience includes devising means to perform certain specified tasks, such as the design of a device or the synthesis of a system made up of many parts, and involves consideration of economic, social, legal, and political factors.

Undergraduate Study

Bachelor of Science in Mechanical Engineering
Course II

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.

The curriculum for the Bachelor of Science in Mechanical Engineering has been designed to provide alternatives — through the Restricted Electives and Unrestricted Electives — for students who have quite different career goals. In particular, 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 in mechanical engineering 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.

The Department also provides many opportunities for undergraduates to establish a close relationship with faculty members and their research groups in the Department. Students interested in doing project work should consult their faculty counselors.

The requirements for the Bachelor of Science in Mechanical Engineering have been selected to provide a balanced background in mechanical engineering while allowing students who defer entering the Department until the end of the second year to graduate in the normal four-year period. Students with a satisfactory academic record who have averaged 45 units per term, who have met the General Institute Requirements in chemistry, mathematics, and physics, and who have also taken 18.03 Differential Equations can graduate in four years.

Bachelor of Science in Mechanical Engineering
Course II

	General Institute Requirements	Total Units
	Specific science and humanities and social science subjects	132
	The Science Distribution Requirement[1] will be satisfied by 2.02 and 18.03 which are required in the Departmental Program, plus appropriate subjects totalling	12
	Subjects 2.671 and 2.672 which are Departmental Requirements satisfy the Institute Laboratory Requirement.	

	Departmental Program[1]		
	Required Subjects		**135**
2.01	Mechanics of Solids	4 0 8	
2.02	Engineering Modeling & Analysis	4 0 8	
2.03	Dynamics	4 0 8	
2.20	Fluid Mechanics	4 0 8	
2.30	Mechanical Behavior of Solids	3 2 7	
2.40	Thermodynamics	4 0 8	
2.671	Measurement and Instrumentation	2 3 4	
2.672	Project Laboratory	1 3 2	
2.70	Introduction to Design	2 3 4	
2.73	Design Projects	2 3 4	
2.86	Manufacturing Projects Laboratory	3 3 3	
18.03	Differential Equations	4 0 8	
	Thesis[3]	9	
	Restricted Electives		**24**
	(Two subjects chosen from the following, at least one from Group A)		
	Group A		
2.06	Vibration and Sound	4 0 8	
2.14	Control System Principles	3 1 8	
2.34	Structures and Materials: Engineering Case Studies	4 0 8	
2.41J	Thermodynamics of Power Systems	3 0 9	
2.51	Heat and Mass Transfer	3 0 9	
	Group B		
1.14	Economics for Engineers	3 0 9	
2.19J	Introduction to Systems Analysis	3 0 9	
2.74	Advanced Mechanical Design	3 0 9	
2.96	Management in Engineering	3 0 9	
15.001	Managerial Economics	4 0 8	
	Unrestricted Electives[4]		**57**
	The Department recommends that all students elect an introductory digital computing course such as 2.10, 2.11 or 1.00 as early as possible in their programs.		
	Total Units Required for the S.B. Degree		**360**

1
The Department recommends that 6.071 Introduction to Electronics be elected by all students to complete the Science Distribution Requirement.
2
Substitution of subjects of similar content may be permitted by petition.
3
To foster substantial research and design achievement, the Department permits up to 6 units of additional thesis credit, subject to approval of the student's Faculty Counselor.
4
Schedules of the students in Course II may always be arranged to leave available 24 units of unrestricted electives in the second year.

Recommended Elective Subjects

Students are urged to consult the Department as soon as they have decided to enter Mechanical Engineering so that faculty counselors may be assigned. Students and their faculty counselors together plan a program that best utilizes the 24 units of Restricted Electives and the 69 units of Unrestricted Electives available in this degree program. Although the selection of elective subjects is an individual decision, the faculty of the Department has developed several areas of professional concentration. Students wishing to follow one of these undergraduate concentrations will find below recommended guidelines for selection of elective subjects. The fields described are not all inclusive; students interested in other professional programs—including interdisciplinary programs—should consult their faculty counselors or the Department Head.

Power and Energy If one wishes to work in this field three areas in the core curriculum are particularly important: controls, materials, and thermal-fluid sciences. For study in these areas the following mechanical engineering undergraduate electives are especially appropriate:

2.14	Control System Principles
2.34	Structures and Materials; Engineering Case Studies
2.41J	Thermodynamics of Power Systems
2.404	Introduction to Molecular Thermodynamics
2.51	Heat and Mass Transfer

Mechanical engineering also provides an excellent undergraduate training for those who intend to work in the nuclear power industry. The following two undergraduate subjects are suggested:

22.02	Physics of Nuclear Energy
22.03	Engineering of Nuclear Power Reactor Systems

Other suitable areas for choosing undergraduate electives for this area are management and economics.

A number of subjects in the graduate school in the power and energy areas are appropriate for seniors with adequate background. The subjects are listed below.

2.301	Advanced Mechanical Behavior of Materials (A)
2.601J	Thermal Power Systems (A)
2.615	Advanced Internal Combustion Engines (A)
2.621	Gas Turbine Design (A)
2.649	Low Temperature Refrigeration (A)
3.38	Behavior of Metals at Elevated Temperatures (A)
6.685	Dynamics of Electric Machines (A)
10.39	Energy Technology (A)
22.211	Nuclear Reactor Physics I (A)
22.312	Engineering of Nuclear Reactors (A)

Environmental Engineering Beyond the Institute requirements and the core subjects in Mechanical Engineering, the following undergraduate electives are recommended as good preparation for environmental engineering:

2.06	Vibration and Sound
2.404	Introduction to Molecular Thermodynamics
2.41J	Thermodynamics of Power Systems
2.51	Heat and Mass Transfer

The following recommended undergraduate subjects cover a range of physical, engineering and social aspects of environmental pollution, and are not generally dependent upon professional prerequisites:

1.60	Introduction to Water Resources
2.23	Environmental Pollution Seminar
12.003 12.004	Environmental Ecology
14.42	Economics of Pollution
17.41	Science, Technology and Politics
19.02	Descriptive Meteorology
19.83	Physical Oceanography

Among the humanities subjects, the following would be of interest to a mechanical engineer concerned with controlling environmental pollution:

21.423	History of the Automobile
21.963	Technology, Values and Social Choice

For seniors who have taken the appropriate prerequisites, the following graduate subjects permit a more intense study of the mechanical engineering aspects of the environment:

2.066	Noise and Vibration in Transportation Systems (A)
2.283	Fluid Physics of Pollution (A)
2.284	Water Purification (A)

Manufacturing and Materials Processing Specialization in manufacturing is dependent on a good foundation in engineering science, which warrants the taking of appropriate advanced subjects in mechanics, in materials and in heat transfer. The following are recommended:

2.06	Vibration and Sound
2.14	Control System Principles
2.34	Structures and Materials; Engineering Case Studies
2.51	Heat and Mass Transfer
2.863	The Manufacturing Environment
2.916	Industrial Technology
3.18	Materials Processing
6.071	Introduction to Electronics

To do effective professional work in this area, one must understand its technical facets and also its economic, human and legal aspects. For this reason, we recommend that interested students select an economics sequence in satisfying part of their humanities–social science Institute requirements, e.g.:

14.01	Economic Principles I
14.02	Economic Principles II
14.03	Applied Microeconomics
14.63	Labor in Industrial Society

For those wishing to study manufacturing processes in greater depth, the following graduate subjects are available:

2.158	Advanced Automation Systems (A)
2.865	Theory of Material Interface Phenomena (A)
2.866	Manufacturing Systems, Materials, Tools, and Processes
2.867	Thermo-Mechanical Processing of Polymers
2.921	Polymer Deformation and Fracture (A)
2.922	Mechanics of Fiber Processing (A)

Finally, we recommend that students seek experience on the manufacturing scene, either independently or by participation in the departmental programs, 2.951 and/or 2.952 Industrial Practice.

Biomedical Engineering Students planning a medically related engineering program are encouraged to take the physics sequence providing biological examples: 8.013 Physics I, 8.023 Physics II, and 8.033 Physics III.

Although Course II has sufficient flexibility to incorporate all the pre-medical requirements, some students will find the additional freedom of Course II-A more adaptable to their goals. For such it is recommended that their restricted electives include:

2.01	Mechanics of Solids
2.02	Engineering Modeling and Analysis
2.20	Fluid Mechanics
2.40	Thermodynamics

Whether in Course II or Course II-A, medically oriented students are advised to take the following:

2.791J	Quantitative Physiology: Cells and Tissues
2.792J	Quantitative Physiology: Organ Transport Systems
2.793J	Quantitative Physiology: Sensory and Motor Systems
5.41	Introduction to Structure, Bonding and Mechanism
7.01	General Biology

Additional subjects recommended include:

2.14	Control System Principles
2.51	Heat and Mass Transfer
2.900J	Biomedical Materials

For undergraduates with sufficient grounding and interest, the Department offers the following graduate subjects:

2.277	Biomedical Fluid Mechanics (A)
2.75	Biomechanics (A)
2.76J	Biological Effects and Medical Applications of Ultrasound and other Non-Ionizing Radiations (A)
2.78	Biomedical and Rehabilitation Engineering Research Seminar (A)
2.907J	Science and Engineering of Biological Membranes and Structural Tissue (A)

Transportation The following three undergraduate electives are recommended for all students interested in transportation:

1.200	Introduction to Transportation Systems
2.14	Control System Principles
2.19J	Introduction to Systems Analysis

Other undergraduate electives which are particularly appropriate include:

2.06	Vibration and Sound
2.96	Management in Engineering
2.41J	Thermodynamics of Power Systems
15.001	Managerial Economics

A large selection of subjects relating to transportation are available in the graduate school to seniors with adequate background; see the description of the Center for Transportation Studies in Chapter III. The following basic subjects are especially recommended:

1.201	Transportation Systems Analysis (A)
1.281	Transportation Economics (A)
2.120J	Introduction to Transportation Technology (A)

Interdisciplinary programs which combine a basic mechanical engineering background with a strong emphasis on the social, economic, planning and institutional aspects of transportation may be arranged through Course II-A.

Computers and Control For students primarily interested in the application of computers to analysis and design the following undergraduate electives are suggested:

2.10 or 2.11	Elementary Programming and Machine Computation
2.101	Computer Models of Physical and Engineering Systems
2.19J	Introduction to Systems Analysis
6.073	Computational Methods

Concentration in at least one engineering science, such as mechanics and materials, thermodynamics, heat transfer, fluid mechanics or dynamics beyond the core requirements is recommended; the subjects in Restricted Elective Group A are especially suitable. The following are especially recommended.

2.092	Methods of Engineering Analysis
2.157	Computer-Aided Design (A)
1.561	Finite Element Methods (A) or
16.27	Finite Element Method (A)

For students wishing to concentrate in automatic control, the following undergraduate electives are recommended:

2.10 2.11	Elementary Programming and Machine Computation
2.14	Control System Principles
2.19J	Introduction to Systems Analysis
6.071	Introduction to Electronics

An extensive selection of graduate subjects is offered which are suitable for seniors with adequate background. The following are especially recommended:

2.151	Advanced System Dynamics and Control (A)
2.152	Modern Control Theory and Applications (A)
2.161	Computer Controlled Experimentation (A)
2.171	Fluid Power Controls and Fluidics (A)
2.173	Instruments for Measurement and Control (A)
2.18	Man-Machine Systems (A)

Bachelor of Science Course II-A

Many students have a defined goal which can best be met by organizing a curriculum specifically tailored to that goal. Such a curriculum may be significantly different from that required for the Bachelor of Science in Mechanical Engineering or, for that matter, different from that required for a degree in any specified field at M.I.T.

To meet such needs, the Department offers the Bachelor of Science, with a significant part of the curriculum made up of Planned Electives. These are chosen by agreement between the student and a departmental officer so that the complete curriculum is coherent and in pursuit of a clear objective.

For instance, some students may wish to penetrate more deeply into some field of mechanical engineering by choosing additional subjects in one of the professional fields of concentration already mentioned, as well as introductory graduate subjects from among the related engineering sciences. Others interested in electromechanical devices might combine advanced subjects in dynamics, systems analysis, and vibrations with subjects in electric circuits and electromagnetic field theory. Students interested in air pollution, fires, internal combustion engines, and related fields involving chemical reaction might make up a package involving work in fluid mechanics, heat transfer, physical chemistry, reaction kinetics, and statistical mechanics. Some combine subjects in mechanical engineering with subjects in economics and management. Students interested either in going to medical school or in a career in biomedical engineering may get strong backgrounds in biology, biochemistry or physiology. These are suggestive examples; many other combinations are possible.

Students who wish to study for this degree must advise the Department by the beginning of their junior year in order that there be adequate opportunity for planning the complete curriculum. Registration for this degree program requires approval in writing from the Registration Officer in charge of Course II-A.

Bachelor of Science Course II-A

	General Institute Requirements	Total Units
	Specific science and humanities and social science subjects.	132
	The Science Distribution Requirement will be partially satisfied by 2.01 and 18.03 which appear on the list of Restricted Electives.	
	The Institute Laboratory Requirement may be satisfied by any two of the following subjects which are among the restricted electives: 2.671, 2.672, 2.86.	
	Departmental Program	
	Required Subjects	
	Thesis[1]	9
	Restricted Electives	**at least 78**
2.01	Mechanics of Solids	4 0 8
2.02	Engineering Modeling and Analysis	4 0 8
2.03	Dynamics	4 0 8
2.06	Vibration and Sound	4 0 8
2.14	Control System Principles	3 1 8
2.20	Fluid Mechanics	4 0 8
2.30	Mechanical Behavior of Solids	3 2 7
2.34	Structures and Materials — Engineering Case Studies	4 0 8
2.40	Thermodynamics	4 0 8
2.41J	Thermodynamics of Power Systems	3 0 9
2.51	Heat and Mass Transfer	3 0 9
2.671	Measurement and Instrumentation	2 3 4
2.672	Project Laboratory	1 3 2
2.70	Introduction to Design	2 3 4
2.73	Design Projects	2 3 4
2.74	Advanced Mechanical Design	3 0 9
2.86	Manufacturing Projects Laboratory	3 3 3
18.03	Differential Equations	4 0 8
	Planned Electives A coherent selection of subjects which, together with the remaining portions of the student's program is aimed at a well-defined educational goal. The planned electives are to be agreed upon between the student and a designated Faculty Counselor of the Department of Mechanical Engineering.	**at least 72**
	Unrestricted Electives[2]	**up to 69**
	Total Units Required for the S.B. Degree	**360**

1
To foster substantial research and design achievement, the Department permits up to 6 units of additional thesis credit, subject to approval of the student's faculty counselor.

2
Schedules of students may always be arranged to leave 12 units of unrestricted electives in the second year. The Unrestricted Electives must be at least 18 units.

Bachelor of Science in Mechanical Engineering: Cooperative Program Course II-B

Students who wish to gain industrial experience during their four-year undergraduate program may do so by electing to enroll in Course II-B. Experience in a wide variety of industries is available in a great many geographical locations.

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 cooperative companies. Students in Course II-A may make similar arrangements. The plant work is considered as equivalent to an 18-unit elective subject: 2.951–2.952 Industrial Practice. Alternatively, the Department tries to find suitable summer positions at the end of the sophomore and junior years that carry credit in these two subjects.

Program for the Bachelor's and Master's Degrees

The Department offers a program of study leading to the simultaneous award of the Bachelor of Science and the Master of Science. The program normally requires five years of study; only a single thesis is required, of size comparable to a Bachelor's plus Master's thesis. The Master's study may be in the Department or in a cooperating department such as Nuclear Engineering. Students interested in this combination should consult the chairman of the departmental graduate committee early in the senior year.

Undergraduate Honors Course

Towards the end of the junior year a limited number of students of superior ability may join an Honors Course group which provides coordinated study through the senior and a graduate year. The Honors Course leads to the Bachelor of Science and Master of Science in Mechanical Engineering, awarded simultaneously at the end of the fifth year of study. The program must satisfy all the requirements for both degrees, but only a single thesis is required.

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, electrical 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.

Fields of Graduate Study

The fields of advanced study and research are those briefly listed in Chapter III. Well-equipped facilities are available in the following laboratories: Acoustics and Vibrations Laboratory; Automotive Laboratory; Biomechanics Laboratory; Combustion and Propulsion Laboratory; Computer Facility; Controls Laboratory; Cryogenic Engineering Laboratory; Fibers and Polymers Laboratory; Fluid Mechanics Laboratory; Fluid Power Control Laboratory; Gas Turbine Laboratory; Heat Transfer Laboratory; Man-Machine Systems Laboratory; Materials Laboratory; Materials Processing Laboratory; Power Systems Engineering Laboratory; Sensory Aids Center; Shock Tube Laboratory; Surfaces Laboratory; and Thermodynamics and Kinetics Laboratory.

As a guide to graduate students, the various avenues for forming a program are described below.

Engineering Science Some students elect to concentrate their studies in one or more of the various engineering sciences. Subjects in the engineering science areas, in which a student may direct his or her studies, are grouped according to the following series of numbers:

2.0–Applied Mechanics, including Solid Mechanics, Dynamics, and Acoustics
2.1–System Dynamics and Controls
2.2–Fluid Mechanics and Combustion
2.3–Materials Science
2.4–Thermodynamics, Statistical Mechanics, and Quantum Mechanics
2.5–Heat and Mass Transfer
2.9–Polymer and Fiber Materials Science

Professional Areas The six fields listed below represent professional areas of concentration in graduate study in mechanical engineering. They are described more fully in the introduction to this Department, as well as under Undergraduate Study. Listed under the latter are some of the graduate subjects offered in each area by the Department of Mechanical Engineering. Additional subjects in each area are offered by various other departments and may also be taken by graduate students.

Power and Energy — problems of energy conversion, including cyrogenics applications

Environmental Engineering — problems of air, water and land pollution

Biomedical Engineering — the application of engineering techniques to the advancement of human health, including diagnosis, therapy, health care systems, and development and production of devices used in the medical field

Manufacturing and Materials Processing — manufacturing processes, design and control of process machinery, process optimization, and computer controlled automation

Transportation — transportation methods and systems including structures, power and propulsion, automation and control

Computers and Control — the application of computers to problem solving and the use of automatic controls for many processes and devices

Mechanical Processing of Polymers
The Department offers a graduate program of teaching and research on mechanical processing of polymers with a strong industrial orientation and direct engineering utility, based on a fundamental background ranging from applied mechanics of polymer deformation to the physics of the structure-mechanical behavior relationship. Qualified students registered in the department may either incorporate the program into their studies leading to the regular Master's degree, Materials Engineer degree or the doctorate awarded by the Department, or make it part of a broader doctoral program on polymeric materials described in Chapter III under Interdisciplinary Programs, and administered by the Dean of the Graduate School through a special committee. For a brochure describing the program in greater detail students should write to Professor Ali S. Argon.

Master of Science in Mechanical Engineering and Master of Science

The general requirements for the degrees are given in Chapter III with the provision that the 66 required units must be taken during the two regular terms or during the summer term (not including the January Independent Activities Period).

To qualify for the Master of Science in Mechanical Engineering a student must have had two terms of advanced mathematics and must take one subject in each of two areas of engineering science. Students not satisfying this requirement are awarded the Master of Science.

The student working for the Master of Science (**not** the Master of Science in Mechanical Engineering) elects a program which is not necessarily restricted to those subjects given by the Department of Mechanical Engineering. The selection of individual subjects should place some emphasis on a foundation in engineering science and mathematics. The program must appear substantial and logical in the judgment of the faculty advisor. As a well balanced program, it should emphasize one or more of the analytical, economic, design, or experimental aspects of the field.

A description of the requirements for these degrees may be procured from the Graduate Registration Office.

Master of Science in Textile Technology

Candidates for the Master of Science in Textile Technology should have the training offered by the Institute (or equivalent training from another institution) in the fields of either chemical engineering, chemistry, mechanical engineering, business and engineering administration, or industrial physics. The program for the degree lasts from one to two years, depending upon preparation. Students who have graduated with high standing from technical or textile schools which offer less extensive preparation in science and engineering may be accepted for study but should expect to spend at least two years fulfilling degree requirements.

Mechanical Engineer

For those who desire preparation for engineering practice at a professional level beyond the Master of Science, the Mechanical Engineer is offered. The degree requires approximately one year of study beyond the Master of Science. The program is centered around the application of engineering principles to advanced development problems and includes an applications oriented thesis. The general requirements for the degree are given in Chapter III, 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 III.

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.

Doctor of Philosophy and Doctor of Science

Admission to the doctoral program is granted only after the candidate has passed a qualifying examination, which should be taken as soon as possible after completing the Master's program. The requirements for the doctoral degree include a program of advanced study, a minor program, a thesis in the field of mechanical engineering or in the field of materials engineering, and the language requirement specified for the doctorates.

The program of advanced study and research may be selected in any field of science or engineering approved by the Department Committee on Graduate Studies. While no fixed number of units is prescribed, the usual program includes a substantial number of subjects in the student's area of principal interest, in addition to those taken to satisfy the requirements for the Master's degree; these, with the minor program, usually require an additional two terms of work beyond the Master's degree. The minor program must be approved by the student's doctoral committee. The qualifying examination must be completed before the program of doctoral research is undertaken. The language requirement should be fulfilled as early as possible in the program, so that the student is capable of reading foreign scientific literature on the proposed thesis subject before beginning research.

For the thesis, each candidate undertakes a program of research which will contribute significantly to the major field of interest. This contribution may be analytical, experimental, or design knowledge. The program of advanced study and the thesis are under the supervision of a doctoral committee selected by the student and the thesis supervisor. The doctoral committee makes an annual evaluation of the candidate's progress and conducts a final examination based on the thesis. While no fixed number of units is prescribed, research usually requires at least one year of registration.

Candidates who enter this doctoral program following award of the Master of Science in Textile Technology must meet the foregoing requirements but with a thesis based on research in the field of fibrous materials.

Doctor of Philosophy in Biomedical Engineering

The Department has an extensive program of research and teaching in biomedical engineering. In addition to pursuing programs for the regular Master's degree and doctorate awarded by the Department, with a focus in biomedical engineering, qualified students registered in the Department may alternatively elect an interdepartmental doctoral program in biomedical engineering (administered by the Committee on Biomedical Engineering) which is described in Chapter III.

Fellowships and Assistantships

A large number of fellowships and research assistantships and a few teaching assistantships are available to incoming students. These appointments and awards provide adequate financial support for both tuition and living expenses. In practically all cases the thesis research is done as an integral part of the work associated with the research assistantship or fellowship. Application for these appointments and awards is made by checking the appropriate boxes on the application form for admission. Information about these appointments and other financial assistance may be obtained by writing the Head of the Department or 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 Stanley Backer, Undergraduate Officer, Room 3-158, M.I.T., Cambridge, Massachusetts 02139, (617) 253-2258; and Professor Warren M. Rohsenow, Graduate Officer, Room 3-264, (617) 253-2208.

Subjects in Mechanical Engineering*

(A) following the name of a subject indicates that it is an approved subject for a graduate degree and is given primarily for graduate students.

2.U.R.	Undergraduate Research in Mechanical Engineering
2.01	Mechanics of Solids
2.015	Mechanics of Solids
2.02	Engineering Modeling and Analysis
2.023	Dynamic Systems
2.03	Dynamics
2.032	Advanced Mechanics (A)
2.06	Vibration and Sound
2.060J	Principles of Acoustics (A)
2.061	Random Vibration (A)
2.062	Wave Propagation (A)
2.063	Theory and Applications of Statistical Energy Analysis (A)
2.065J	Flow Noise (A)
2.066	Noise and Vibration in Transportation Systems (A)
2.071	Advanced Mechanics of Solids
2.072	Mechanics of Continuous Media
2.073	Solid Mechanics — Plasticity and Anelastic Deformation (A)
2.083	Applied Elasticity (A)
2.084J	Structural Mechanics in Nuclear Power Technology (A)
2.092	Methods of Engineering Analysis (A)
2.095	Special Problems in Applied Mechanics (A)
2.10	Elementary Programming and Machine Computation
2.101	Computer Models of Physical and Engineering Systems I
2.11	Elementary Programming and Machine Computation
2.120J	Introduction to Transportation Technology (A)
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)
2.154	Dynamics and Control of Rotating Machine Systems (A)
2.155	Dynamics and Control of Thermofluid Processes and Systems (A)
2.157	Computer-Aided Design (A)
2.158	Advanced Automation Systems (A)
2.161	Computer Controlled Experimentation (A)
2.171	Fluid Power Controls and Fluidics (A)
2.173	Instruments for Measurement and Control (A)
2.18	Man-Machine Systems (A)
2.19J	Introduction to Systems Analysis
2.190J	Modelling and Analysis of Systems Pertaining to National Development (A)
2.192J	Engineering Systems Analysis
2.20	Fluid Mechanics
2.203	Applications in Fluid Mechanics
2.23	Environmental Pollution Seminar
2.25	Advanced Fluid Mechanics (A)
2.271	Compressible Fluid Mechanics (A)
2.272	Viscous and Turbulent Flows (A)
2.275	Turbomachinery Design (A)
2.277	Biomedical Fluid Mechanics (A)
2.281	Reacting Gas Dynamics (A)
2.282	Combustion (A)
2.283	Fluid Physics of Pollution (A)
2.284	Water Purification (A)
2.29	Advanced Topics in Fluid Mechanics and Combustion (A)
2.30	Mechanical Behavior of Solids
2.301	Advanced Mechanical Behavior of Materials (A)
2.302J	Introduction to Electron Microscopy
2.303J	Projects in Electron Microscopy (A)
2.332J	Physics of Deformation and Fracture of Solids I (A)
2.333J	Physics of Deformation and Fracture of Solids II (A)
2.34	Structures and Materials; Engineering Case Studies
2.398	Research in Materials
2.399	Research in Materials (A)
2.40	Thermodynamics
2.402	Thermodynamics
2.404	Introduction to Molecular Thermodynamics
2.41J	Thermodynamics of Power Systems
2.451	Intermediate Thermodynamics (A)
2.452	Advanced Thermodynamics (A)
2.453	Advanced Projects in Heat and Thermodynamics (A)
2.461	Equilibrium Statistical Mechanics (A)
2.462	Nonequilibrium Statistical Mechanics of Gasses (A)
2.47J	Quantum Foundations of Mechanics and Thermodynamics (A)
2.51	Heat and Mass Transfer
2.53	Problems in Heat
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)
2.58	Radiation Heat Transfer (A)
2.601J	Thermal Power Systems (A)
2.615	Advanced Internal Combustion Engines (A)
2.618	Automotive Vehicles
2.621	Gas-Turbine Design (A)
2.632	Research in Lubrication (A)
2.649	Low Temperature Refrigeration (A)
2.66J	Transportation and Energy for Greater Boston and New England (A)

*Full descriptions of all subjects are given in the catalogue entitled **Courses and Degree Programs, 1974–75**, which may be obtained by writing to the Institute Information Services, Room 7-111, M.I.T.

2.671	Measurement and Instrumentation
2.672	Project Laboratory
2.673	Projects in Mechanical Engineering
2.70	Introduction to Design
2.73	Design Projects
2.733	Special Problems in Systems and Design
2.734	Advanced Projects in Systems and Design (A)
2.737	Kinematic Synthesis of Mechanisms (A)
2.74	Advanced Mechanical Design
2.75	Biomechanics (A)
2.76J	Biological Effects and Medical Applications of Ultrasound and other Non-Ionizing Radiations (A)
2.77	Research in Biological Effects and Applications of Ultrasound and other Non-Ionizing Radiations (A)
2.78	Biomedical and Rehabilitation Engineering Research Seminar (A)
2.791J	Quantitative Physiology: Cells and Tissues
2.792J	Quantitative Physiology: Organ Transport Systems
2.793J	Quantitative Physiology: Sensory and Motor Systems
2.86	Manufacturing Projects Laboratory
2.863	The Manufacturing Environment
2.865	Theory of Material Interface Phenomena (A)
2.866	Manufacturing Systems, Materials, Tools, and Processes (A)
2.867	Thermo-Mechanical Processing of Polymers
2.869	Research in the Mechanical Processing of Materials (A)
2.900J	Biomedical Materials
2.901	Polymer Materials Science
2.903	Elements of Textile Materials and Processes
2.905	Polymer Viscoelasticity (A)
2.906	Physical Chemistry of Macromolecular Systems (A)
2.907J	Science and Engineering of Biological Membranes and Structural Tissue (A)
2.914	Fibers and Polymers Seminar (A)
2.915	Clothing: Design and Comfort
2.916	Industrial Technology
2.921	Polymer Deformation and Fracture (A)
2.922	Mechanics of Fiber Processing (A)
2.923	Mechanical Behavior of Fibers (A)
2.941J	Invention
2.942J	Entrepreneurship
2.951	Industrial Practice
2.952	Industrial Practice
2.96	Management in Engineering
2.97	Independent Activities
2.999	Engineer's Degree Thesis Proposal Preparation (A)

Department of Metallurgy and Materials Science

Walter Shepherd Owen, Ph.D., D.Eng.
Professor of Materials Science and Engineering
Head of the Department

Professors

Benjamin Lewis Averbach, Sc.D.
Professor of Metallurgy

Walter Alan Backofen, Sc.D.
Professor of Metallurgy

Arden Lee Bement, Ph.D.
Professor of Nuclear Materials

Michael Berliner Bever, Dr.Jur., Sc.D.
Professor of Metallurgy

John Werner Cahn, Ph.D.
Professor of Metallurgy

Robert Louis Coble, Sc.D.
Professor of Ceramics

Morris Cohen, Sc.D.
Ford Professor of Materials Science and Engineering

John Frank Elliott, Sc.D.
Professor of Metallurgy

Merton Corson Flemings, Sc.D.
ABEX Professor of Metallurgy
Assistant Director, Center for Materials Science and Engineering

Harry Constantine Gatos, Ph.D.
Professor of Electronic Materials
Professor of Molecular Engineering

Nicholas John Grant, Sc.D.
Professor of Metallurgy
Director, Center for Materials Science and Engineering

Roy Kaplow, Sc.D.
Professor of Metallurgy

Thomas Burness King, Ph.D.
Professor of Metallurgy

William David Kingery, Sc.D.
Professor of Ceramics

Koichi Masubuchi, D. Eng.
Professor of Ocean Engineering
Professor of Materials Science

Frederick Jerome McGarry, S.M.
Professor of Materials Engineering
Professor of Civil Engineering
Secretary of the Faculty

Robert Edward Ogilvie, Sc.D.
Professor of Metallurgy

Robert Michael Rose, Sc.D.
Professor of Metallurgy

August Ferdinand Witt, Ph.D.
Professor of Metallurgy

Bernhardt John Wuensch, Ph.D.
Professor of Ceramics

Associate Professors

Harvey Kent Bowen, Sc.D.
Associate Professor of Ceramics

Keith Huber Johnson, Ph.D.
Associate Professor of Metallurgy

Ronald Michael Latanision, Ph.D.
Associate Professor of Materials Science and Engineering

Heather Nan Lechtman, M.A.
Associate Professor of Archaeology and Ancient Technology

Regis Marc Noel Pelloux, Sc.D.
Associate Professor of Metallurgy

Kenneth Calvin Russell, Ph.D.
Associate Professor of Metallurgy

Donald Robert Uhlmann, Ph.D.
Associate Professor of Polymers and Ceramics

Assistant Professors

Robert William Hopper, Ph.D.
Assistant Professor of Polymeric Materials

Robert Mehrabian, Sc.D.
Assistant Professor of Metallurgy

John Bruce Vander Sande, Ph.D.
Assistant Professor of Metallurgy

Senior Lecturer

Herbert Henry Uhlig, Ph.D.

Lecturers

Joseph Tibor Blucher, Sc.D.
(Visiting)
Pamela Bowren Vandiver, M.A.

Technical Instructors

Arthur Jeremiah Gregor
Paul Frederick Hughes (Absent)
Robert Victor Huston
Anthony Joseph Zona

Administrative Officer

Kathleen Ann Gallery, B.A.

Research Associates

Noboru Matsumoto, Ph.D.
Richard John Salzbrenner, Ph.D.
Kenneth Peter Young, Ph.D.

Professors Emeriti

John Chipman, Ph.D., Sc.D.
Professor of Metallurgy, Emeritus

Carl Frederick Floe, Sc.D.
Professor of Metallurgy, Emeritus

Antoine Marc Gaudin, Sc.D.
Richards Professor of Mineral Engineering, Emeritus

Frederick Harwood Norton, Sc.D.
Professor of Ceramics, Emeritus

John Torrey Norton, Sc.D.
Professor of the Physics of Metals, Emeritus

Cyril Stanley Smith, Sc.D.
Institute Professor, Emeritus
Professor of Metallurgy, Emeritus
Professor of the History of Science and Technology, Emeritus

Herbert Henry Uhlig, Ph.D.
Professor of Metallurgy, Emeritus
Senior Lecturer

John Wulff, D.Sc.
Professor of Metallurgy, Emeritus

Department of Metallurgy and Materials Science

The Department of Metallurgy and Materials Science is concerned with the 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 is materials science, 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 designing materials for specific applications the modern materials engineer must have a proper concern for economic, social and environmental factors. Materials technology is only one, although an essential component of a total materials system. Students wishing to specialize in materials engineering are provided with many opportunities to obtain an understanding of the economic and societal components of materials systems in association with the technological aspects of materials design.

The links between materials engineering and materials science are very strong, and the two activities are interwoven in the Department of Metallurgy and Materials Science. 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 leading to an emphasis on engineering, science, or perhaps a judicious mixture of the two.

Materials science and materials engineering disciplines seek to identify and understand the principles, phenomena, and ideas which are basic to all materials. For example, there are, important differences in details in the fracture of ceramic, metallic, and polymeric materials but the basic physics of fracture is the same in each case. Extruding a polymeric fiber and a metal wire may, at first sight, appear to be unrelated processes but careful study reveals many interesting similarities. Many large industries today manufacture products containing a large variety of different materials. Their materials engineers must acquire a working understanding of the basic behavior of all of them. However, there are also many large industries in which a single class of material (for example, steel, polymers, glasses, etc.) is manufactured and processed. In these circumstances, the materials expert must have a knowledge of various aspects of the science and engineering of one class of material. It is for this reason that programs are provided in the Department which enable a student to specialize in the science and engineering of ceramics, metals, or polymers.

Materials engineers and materials scientists, whether generalists or specialists in a particular class of material, are of vital importance to modern industry. The design and operation of propulsion units such as gas turbines and rocket motors, energy producers such as nuclear reactors, energy converters such as magnetohydrodynamic generators, semiconductor or superconductor devices and machines, laser communication systems, or any one of dozens of other developments of modern engineering are critically dependent upon the availability of materials with the requisite blend of properties. Scientists and engineers with the knowledge and skills to carry out imaginative research on new materials or to design 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.

Undergraduate Study

Bachelor of Science in Metallurgy and Materials Science Course III

The undergraduate program caters to the diverse needs of students who intend to pursue graduate work, to those who are more inclined toward engineering application, and to those who prefer solid-state science. The decision to concentrate on either the science or the engineering of materials may be reached by students as late as the sophomore year or even during the junior year.

For these reasons, the curriculum is flexible. Understanding of materials is developed from a foundation of physical and engineering science and a core of subjects in mechanics, thermodynamics, crystal structure, and structure-property relations. These essential subjects are taught within the Department so that meaningful examples can be used to illustrate the material. However, appropriate substitutions of subjects taken in other departments are permitted and, indeed, encouraged when a student has somewhat different educational objectives.

The elective program is chosen, with the help of an advisor, to give depth in one or more technical areas such as the preparation and purification of materials, including chemical process technology, the processing and fabrication of materials by deformation, heat treatment, and phase change, the study and control of structure-property relations in ceramic, metallic, and polymeric materials, and the physics of solid materials in general. Many graduate subjects are open to undergraduates with the necessary preparation.

Other choices under the elective program are, of course, possible. A student may concentrate elective time on modern production or research management techniques in the materials industry, or on the technology appropriate to a specific industry, or the student may choose a program which provides a sound basis in materials science and engineering from which an effective graduate program can be developed.

Participation in laboratory work by undergraduates is an integral part of both an engineering and a research experience. Laboratories are not associated with particular subjects, and, especially in thesis work, the undergraduate student has access to the extensive facilities for research in materials.

The teaching facilities, some of which are located in the Center for Materials Science and Engineering, include an electron-optics laboratory with x-ray and electron diffraction equipment; electron microscopes and microanalyzers; laboratories for microscopic studies, heat treatment, and physical testing of materials; and complete test apparatus for the study of mechanical, thermal, electrical, and magnetic properties. In the ceramics laboratories most types of refractory, as well as electrical ceramics and glasses, can be prepared and their properties studied. Facilities for the growth and characterization of metallic and nonmetallic crystals are available in several laboratories. The chemical metallurgy laboratories contain equipment for the study of heat and mass flow and for thermodynamic and kinetic investigations at high temperatures. The materials processing laboratories are equipped for work on deformation, solidification, joining, and vapor deposition as processing techniques. Laboratories in polymer structure and properties, surface chemistry, and corrosion are also open to undergraduates. Other services include a complete analytical laboratory and computation facilities with a remote console.

Bachelor of Science in Metallurgy and Materials Science Course III

	General Institute Requirements		**Total Units**
	Specific science and humanities and social science subjects. Economic Principles I (14.01) is recommended in the humanities, arts, and social science program		132
	The Science Distribution Requirement may be satisfied by 3.00, 3.10, or 3.11 which are required in the Departmental Program, plus appropriate subjects totaling		24
	The subject 3.081, which is required in the Departmental Program, may be used to satisfy the Laboratory Requirement.		
	Departmental Program		
	Required Subjects		100
3.00	Thermodynamics of Materials I	4 0 8	
3.01	Thermodynamics of Materials II	3 0 5	
3.02	Kinetics of Reactions in Materials	3 0 5	
3.081	Materials Laboratory I	1 6 5	
3.082	Materials Laboratory II	1 6 5	
3.10	Chemical Physics of Materials	3 0 5	
3.11	Mechanics of Materials I	4 0 8	
3.12	Mechanics of Materials II	3 0 5	
3.13	Crystallography	3 0 5	
	Thesis	12	
	Restricted Electives		
	Four subjects chosen from the following:		at least 32
3.03	Chemical Metallurgy	3 0 5	
3.06	Polymers and Glasses	3 0 5	
3.07	Introduction to Ceramics	4 0 8	
3.14	Physical Metallurgy	3 0 5	
3.15	Physical Properties of Materials	3 0 5	
3.18	Materials Processing	3 0 5	
	Unrestricted Electives		up to 76
	Total Units Required for S.B. Degree		360

Students who decide during the first year at M.I.T. to study materials science and engineering can facilitate their later progress by ensuring that their second-year subjects include additional mathematics and physics, as well as 3.00 Thermodynamics of Materials I and 3.11 Mechanics of Materials I, or their equivalents. The third and fourth years may then be devoted to study, in some depth and with adequate preparation, of areas such as ceramics, metallurgy, or polymerics through appropriate use of upper-class elective time.

Some students, on the other hand, do not wish to make a Course choice until their junior year or may wish to use their elective time to the fullest possible extent in the second year rather than in later years. Generally, it will be possible to complete the Departmental Program and Institute Requirements in two more years, especially if one of the second-year Science Distribution subjects is in mechanics of solids; however, some elective freedom, particularly in the fourth year, will have been sacrificed.

Bachelor of Science Course III-A

Many desirable educational goals exceed the bounds of a departmental program, particularly in an interdisciplinary field such as materials science. The student may wish, for instance, to combine biology with materials science to satisfy an interest in biomaterials, or may have a strong interest in the role of materials in the humanities, ocean engineering and deep sea submergence, space exploration, transportation and communication, electronic devices and digital computers, energy conversion, environmental systems, and other fields. Some students may wish to emphasize such important areas as concretes, cements, or soils, or they may be interested in the problems and control of industrial pollution.

Generally, a curriculum may be set up to attain such goals. For this purpose the Department offers the Bachelor of Science. If the student informs the Department of his or her intentions at the beginning of the junior year, there is usually enough time for the student and a faculty advisor to plan a coherent program with a list of planned electives and to submit it to the Department for approval. Such a program can be much more effective if the student's aims are discussed, as early as possible, with the appropriate faculty members. The program should, in all cases, be presented no later than the beginning of the spring term of the junior year.

The curriculum requirements are intended as a guide to students. A program involving more project work and fewer formal subjects may also be undertaken.

Bachelor of Science Course III-A

	General Institute Requirements	Total Units
	Specific science and humanities and social science subjects	132
	Economic Principles I (14.01) is recommended in the humanities, arts, and social science program	
	Science Distribution Requirement	36
	The subjects 3.00, 3.10, or 3.11, which are among the restricted electives, may be used to satisfy part of the Science Distribution Requirement.	
	Laboratory Requirement	12
	The subject 3.081, which is among the restricted electives, appears on the list of Laboratory Subjects and may be used to satisfy the Laboratory Requirement.	

	Departmental Program		
	Restricted Electives		
	A. Four of the following subjects:		32 to 40
3.00	Thermodynamics of Materials I	4 0 8	
3.01	Thermodynamics of Materials II	3 0 5	
3.02	Kinetics of Reactions of Materials	3 0 5	
3.10	Chemical Physics of Materials	3 0 5	
3.11	Mechanics of Materials I	4 0 8	
3.12	Mechanics of Materials II	3 0 5	
3.13	Crystallography	3 0 5	
	B. Two of the following subjects:		16 to 20
3.03	Chemical Metallurgy	3 0 5	
3.06	Polymers and Glasses	3 0 5	
3.07	Introduction to Ceramics	4 0 8	
3.14	Physical Metallurgy	3 0 5	
3.15	Physical Properties of Materials	3 0 5	
3.18	Materials Processing	3 0 5	
	C. One of the following subjects:		12
3.081	Materials Laboratory I	1 6 5	
3.082	Materials Laboratory II	1 6 5	
	Planned Electives		at least 72
	At least six subjects which are selected by the student and faculty advisor; together with the restricted electives these should make up a program intended to attain the goal defined by the student.		
	Unrestricted Electives		36 to 72
	Total Units Required for S.B. Degree		360

Graduate Study

The Department offers the following graduate degrees: Master of Science in Ceramics; Master of Science in Metallurgy; Master of Science in Polymerics; Master of Science in Materials Engineering; Master of Science in Materials Science; Metallurgical Engineer; Materials Engineer; Doctor of Science; and Doctor of Philosophy.

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.

Polymerics Polymeric materials have taken their place alongside ceramics and metals as working substances of modern technology and have become an essential component of materials science and engineering. The program covers the processing and applications of polymers, the structure-property relationships, and the improvement of properties by the modification and control of structure.

	Core Subjects
2.906	Physical Chemistry of Macromolecular Systems
3.20	Thermodynamics of Materials
3.21	Kinetic Processes in Materials
3.44	X-ray and Crystal Physics
3.60	Physical Ceramics II
3.66	Materials Science of Polymers
0.641	Structure and Properties of Polymers
0.681	Physical Chemistry of Polymers

	Recommended Subjects
3.06	Polymers and Glasses
3.07	Introduction to Ceramics
3.20	Thermodynamics of Materials
3.21	Kinetic Processes in Materials
3.22	Solid State Surfaces and Defects
3.25J	Physics of Deformation and Fracture of Solids I
3.60	Physical Ceramics II
3.61	Physical Ceramics III: Glass Structure and Properties
3.62	Electrical and Optical Properties of Ceramics

	Elective Subjects
1.40J	Introduction to Electron Microscopy
3.91J	Mechanical Behavior of Plastics
3.92J	Composite Materials
2.301	Advanced Mechanical Behavior of Materials
2.867	Thermo-mechanical Processing of Polymers
2.905	Polymer Viscoelasticity
2.921	Polymer Deformation and Fracture
2.922	Mechanics of Fiber Processing
2.923	Mechanical Behavior of Fibers
3.26J	Physics of Deformation and Fracture of Solids II
3.30	Electron Microscopy: Image Interpretation
3.67	Polymer Processing
3.68	Electrical and Optical Properties of Polymers
10.642	Viscoelasticity of Polymers
10.67	Polymer Science Laboratory
10.682	Statistical Mechanics of Chain Molecules
10.691	Principles of Polymer Synthesis
10.692	Advanced Topics in Polymer Synthesis
10.696	Compounding and Processing of Polymers

Materials Science The field of materials science has evolved as an independent discipline only in the last two decades. It is the science concerned with the discovery, analysis, and understanding of the nature of materials. The objectives are to provide coherent descriptions or models of the structure of materials and to explain how this structure relates to composition, properties, and behavior.

	Core Subjects
3.20	Thermodynamics of Materials
3.21	Kinetic Processes in Materials
3.22	Solid-State Surfaces and Defects
3.41	Physics and Chemistry of Materials

	Elective Subjects
2.301	Advanced Mechanical Behavior of Materials
3.24	Structure and Properties of Materials
3.25J	Physics of Deformation and Fracture of Solids I
3.26J	Physics of Deformation and Fracture of Solids II
3.30	Electron Microscopy: Image Interpretation
3.31	Phase Transformations
3.32	Introduction to Electron Optics and Electron Microscopy
3.35	Solidification Processing
3.39	Fracture Mechanisms in Metals
3.42J	Physics of Solids I
3.43J	Physics of Solids II
3.44	X-ray and Crystal Physics
3.54	Corrosion
3.62	Electrical and Optical Properties of Ceramics
3.76J	Electronic Materials
6.741J 8.511J	Theory of Solids
6.742J 8.512J	Theory of Solids
6.743	Conduction Processes in Solids

Materials Engineering The essence of materials engineering is the synthesis and use of fundamental and empirical knowledge to develop, produce, modify, and apply materials to meet specific needs. It is concerned with innovation, cost, quality, and reliability in materials production and utilization, and with accompanying social and environmental costs and benefits.

	Core Subjects
1.146J 2.192J 13.62J	Engineering Systems Analysis
3.20	Thermodynamics of Materials
3.21	Kinetic Processes in Materials
10.50	Heat and Mass Transfer

	Elective Subjects
1.154	Simulation Methods
1.181	Statistical Analysis for Decision Making
1.41J 3.90J 13.16J	Fracture of Structural Materials
1.471J 3.91J	Mechanical Behavior of Plastics
1.472J 3.92J	Composite Materials
2.301	Advanced Mechanical Behavior of Materials
2.905	Polymer Viscoelasticity
2.921	Polymer Deformation and Fracture
2.922	Mechanics of Fiber Processing
3.08	Economics of Engineering Materials
3.24	Structure and Properties of Materials
3.26J 2.333J	Physics of Deformation and Fracture of Solids II
3.35	Solidification Processing
3.36J	Welding Engineering
3.37	Deformation Processing
3.38	Behavior of Metals at Elevated Temperatures
3.39	Fracture Mechanisms in Metals
3.50	Thermodynamics in Process Metallurgy
3.52	Dynamic Behavior of Metallurgical Systems
3.54	Corrosion
3.66	Materials Science of Polymers
3.67	Polymer Processing
3.76	Electronic Materials
10.35	Dynamics and Control of Chemical Engineering Process
10.38	Analysis and Simulation of Chemical Processing Systems
10.62	Electrochemistry
14.121	Microeconomic Theory I
14.122	Microeconomic Theory II
15.012	Microeconomics for Management
15.081	Mathematical Programming
15.761	Operations Management
15.762	Management Planning and Control
15.852	Principles of Dynamics Systems I

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.

	Core Subjects
3.20	Thermodynamics of Materials
3.21	Kinetic Processes in Materials
3.37	Deformation Processing
3.50	Thermodynamics in Process Metallurgy

	Elective Subjects
2.55	Advanced Heat Transfer
3.22	Solid State Surfaces and Defects
3.24	Structure and Properties of Materials
3.25J	Physics of Deformation and Fracture of Solids I
3.26J	Physics of Deformation and Fracture of Solids II
3.31	Phase Transformations
3.35	Solidification Processing
3.38	Behavior of Metals at Elevated Temperatures
3.39	Fracture Mechanisms in Metals
3.52	Dynamic Behavior of Metallurgical Systems
3.54	Corrosion
10.50	Heat and Mass Transfer
10.62	Electrochemistry

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. Nor are the graduate fields isolated from other activities in materials at the Institute. Faculty from other departments participate in the work of the departmental graduate fields. Subjects offered by other departments are, whenever appropriate, included in the recommended electives, and many students registered in one of the fields participate in multidisciplinary research projects with students and faculty from various parts of the Institute.

Students are expected to learn the fundamentals of their chosen field and to develop a deep understanding of one or more significant aspects of it. The general examinations are designed accordingly. A full range of advanced-level subjects is offered in each graduate field. In addition, arrangements can be made for private study of any topic by directed reading, individual programs, or participation in informal seminars. Students are not required to take any specified subjects. It is strongly recommended that they take appropriate core subjects unless they have taken equivalent subjects earlier in their careers. The selection of subjects from the list of electives and decisions about combinations of subjects which constitute a minor are matters which usually require much thought by the student. Faculty advisors offer experienced help with these selection problems.

A large and active research program on the structure and properties, preparation, and processing of materials, with emphasis on ceramics, metals, polymers, and electronic materials, is conducted by faculty and students in the Department. Graduate research is an important part of the educational process and much emphasis is placed on the preparation, presentation, and defense of a research thesis. Students choose research projects from many alternative opportunities which exist within the Department. All students work closely with an individual faculty member throughout the time the research is under way. In addition to providing the contents of a thesis, the results of the research are usually of sufficient significance to warrant publication in the scientific literature. There are a large number of well-equipped research laboratories in the Department, and there is much interaction between them. There are many formal and informal arrangements for sharing experimental facilities and equipment. Most members of the Department are also members of the Center for Materials Science and Engineering, which provides and maintains many excellent central facilities as well as a machine and instrument shop. The Center promotes interdisciplinary research in materials, in which faculty and students from the different departments of the Institute participate.

Requirements for Completion of Graduate Degrees

The general requirements for completion of graduate degrees are described in Chapter III. The Department requires that candidates for the doctoral degrees go through a qualifying procedure before continuing with their programs of study and research, and that they satisfy a minor requirement. Information on this examination and on the areas covered by the general examination is available from the Chairman of the Departmental Committee on Graduate Students.

Entrance Requirements for Graduate Study

The general admissions requirements are given in Chapter III. Usually, there are no departmental requirements which are more restrictive than the general Institute requirements. Programs are arranged on an individual basis depending upon the preparation and interests of the student. Those who have not studied some thermodynamics and kinetics at the undergraduate level are advised to take 3.01 Thermodynamics of Materials II and 3.02 Kinetics of Reactions in Materials. Students wishing to do graduate work in ceramics are asked to take 3.07 Introduction to Ceramics unless they have had a similar subject in their undergraduate programs.

Teaching and Research Assistantships

The Department offers assistantships and fellowships for graduate study. Research and teaching assistantships are available in the fields in which the Department is active. Further information may be obtained from the Chairman of the Departmental Committee on Graduate Students.

Inquiries

Additional information regarding graduate programs, admissions, financial aid, etc. may be obtained by writing to Professor R. L. Coble, Chairman of the Departmental Committee on Graduate Students, Room 8-211, M.I.T., Cambridge, Massachusetts 02139, (617) 253-3328.

Subjects in Metallurgy and Materials Science*

(A) following the name of the subject indicates that is an approved subject for a graduate degree and is given primarily for graduate students.

3.U.R.	Undergraduate Research
3.00	Thermodynamics of Materials I
3.01	Thermodynamics of Materials II
3.02	Kinetics of Reactions in Materials
3.03	Chemical Metallurgy
3.05	Modeling of Materials Systems
3.06	Polymers and Glasses
3.07	Introduction to Ceramics
3.08	Economics of Engineering Materials
3.081	Materials Laboratory I
3.082	Materials Laboratory II
3.091	Introduction to Solid-State Chemistry
3.092	Perspectives in Materials Science
3.095	Materials Processing; An Engineering and Historical Approach
3.10	Chemical Physics of Materials
3.101J	Biomedical Materials
3.11	Mechanics of Materials I
3.12	Mechanics of Materials II
3.13	Crystallography
3.14	Physical Metallurgy
3.141	Engineering Materials Laboratory
3.142J	Introduction to Electron Microscopy
3.143J	Materials of Construction
3.15	Physical Properties of Materials
3.17	Understanding the Discovery Process — An Historical Approach
3.172	Critical Experiments in Materials Science
3.18	Materials Processing
3.19	Techniques of Metal Sculpture
3.20	Thermodynamics of Materials (A)
3.21	Kinetic Processes in Materials
3.22	Solid State Surfaces and Defects (A)
3.24	Structure and Properties of Materials (A)
3.25J	Physics of Deformation and Fracture of Solids I (A)
3.26J	Physics of Deformation and Fracture of Solids II (A)
3.30	Electron Microscopy: Image Interpretation
3.31	Phase Transformations (A)
3.32	Introduction to Electron Optics and Electron Microscopy (A)
3.35	Solidification Processing (A)
3.36J	Welding Engineering (A)
3.37	Deformation Processing (A)
3.38	Behavior of Metals at Elevated Temperatures (A)
3.39	Fracture Mechanisms in Metals (A)
3.41	Physics and Chemistry of Materials
3.42J	Physics of Solids I (A)
3.43J	Physics of Solids II (A)
3.44	X-ray and Crystal Physics (A)
3.50	Thermodynamics in Process Metallurgy (A)
3.51	Process Metallurgy (A)
3.52	Dynamic Behavior of Metallurgical Systems (A)
3.54	Corrosion (A)
3.59	Research Proposals — Planning for Discovery (A)
3.60	Physical Ceramics II (A)
3.61	Physical Ceramics III: Glass Structure and Properties (A)
3.62	Electrical and Optical Properties of Ceramics (A)
3.63	Ceramic Processes (A)
3.64	Special Problems in Ceramics (A)
3.65	Ceramics Seminar (A)
3.66	Materials Science of Polymers (A)
3.67	Polymer Processing (A)
3.68	Electrical and Optical Properties of Polymers (A)
3.69	Special Problems in Polymer Science and Engineering (A)
3.691–3.699	Teaching Metallurgy and Materials Science
3.70	Special Problems in Metallurgy (A)
3.701J	Materials for Ocean Engineering
3.71J	Physical Metallurgy Principles for Engineers (A)
3.72J	Nuclear Fuels (A)
3.721J	Radiation Effects in Crystalline Solids (A)
3.73	Applications of Digital Computers (A)
3.75J	Radiation Effects to Reactor Structural Materials (A)
3.76J	Electronic Materials (A)
3.77	Laboratory Measurement and Control
3.80J	Comparative Ancient Technologies
3.81J	Art, Materials, and Culture
3.82J	Structural Mechanics in Nuclear Power Technology (A)
3.90J	Fracture of Structural Materials (A)
3.91J	Mechanical Behavior of Plastics (A)
3.92J	Composite Materials (A)

*Full descriptions of all subjects are given in the catalogue entitled **Courses and Degree Programs, 1974–75**, which may be obtained by writing to the Institute Information Services, Room 7-111, M.I.T.

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Professor of Nuclear Engineering
Head of the Department

Kent Forrest Hansen, Sc.D.
Professor of Nuclear Engineering
Executive Officer of the Department

Professors

Arden Lee Bement, Jr., Ph.D.
Professor of Nuclear Materials

Manson Benedict, Ph.D.
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Elias Panayiotis Gyftopoulos, Sc.D.
Ford Professor of Engineering
Chairman of the Faculty

Allan Francis Henry, Ph.D.
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Department of Nuclear Engineering

The Department of Nuclear Engineering provides advanced technical 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. Although the technological problems of energy generation by neutron induced fission of heavy elements in nuclear reactors and fusion of light particles in thermonuclear plasmas receive primary emphasis in the Department, the totality of its interests is best described as the engineering physics of low-energy charged particles, neutrons and radiation. Included is a strong involvement in the broader problems of providing energy in socially acceptable ways and of energy policy alternatives in general.

Fission reactors are used to produce heat and electricity, to propel submarines and ships, and to transmute elements and to produce radioisotopes. The 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 U.S. electric utility industry is less than ten years. The supply and utilization of these increasing amounts of energy with minimal environmental impact has become one of society's major technological problems.

World resources of fossil fuels are limited and in uncertain supply. The need for alternative methods of energy production is becoming more critical with each year. Energy from nuclear fission is expected to provide about 50 percent of all new electrical generation capacity. The safe and economic development, design, construction, and operation of nuclear power plants and their related nuclear fuel processing facilities has become a major new field of engineering.

Nuclear power is already economically competitive with power from coal, oil, or gas in many regions of the United States and in many foreign countries. One challenging task facing today's nuclear engineers is reducing the capital cost of nuclear power stations and extending the life of nuclear fuels so that nuclear plants will become the most economic way of generating electricity in ever-widening regions of the world. These cost reductions can be realized by improving the performance of today's reactors, by development of better methods for designing tomorrow's reactors, and by conceiving types of reactors better than any now in use.

Another challenge to nuclear engineers is the development of economic nuclear power systems that regenerate or yield a net increase in their essential fuel. Foremost are breeder reactors which use regenerated plutonium or uranium-233 to make available all the latent fission energy of abundant uranium-238 or thorium instead of the relatively scarce isotope uranium-235, which is the principle fissionable material in presently operating reactors. Breeder reactors will provide an energy resource capable of supplying the needs of the world for millions of years.

Fission reactors find widespread use in research on the interaction of radiation and matter and in the production of radioisotopes and the transmutation of elements. Also, the large amount of energy obtainable per unit mass of fissile fuel and the fact that air is not needed to sustain the fission reaction make fission reactors especially valuable in submarine and space applications.

Another potential source of nuclear energy and neutrons is controlled fusion of light elements. Energy from such thermonuclear reactions would provide another practically inexhaustible supply of energy. These fusion reactions must be carried out in a fully ionized plasma heated to a temperature of many million degrees and confined under stable conditions by strong magnetic fields. Recent progress in confining plasmas increases the likelihood that controlled fusion will become a practical source of energy within the lifetime of today's engineering students. The use of fusion reactions for an economic supply of neutrons could be achieved even sooner. Attainment of a practical fusion energy source requires improved behavior of plasmas in electric and magnetic fields, development of materials capable of withstanding high stresses and exposure to intense radiation and great engineering ingenuity in combining fusion power components into a practical and economic system. The Department is active in these three fields: the fundamentals of plasma behavior, materials for intense radiation fields, and the engineering of fusion systems.

Study of the fundamentals of plasma behavior leads to improved understanding of astrophysical and ionospheric phenomena, magnetohydrodynamic energy conversion, ion propulsion, direct-conversion thermionic diodes, and high-power gas lasers. The latter two topics are applications of particular present interest in the Department. Students in the Department concentrating on applied plasma physics therefore are trained not only to advance knowledge of controlled fusion and of the plasma field as a whole, but also to apply the fundamental science in other contexts of more immediate practical significance. In these plasma activities, the Department is an active participant in M.I.T.'s broad, interdepartmental program of research and instruction in plasma physics and its varied applications.

The Department's involvement with reactors and sources of radiation has led to an applied radiation physics program concerned with the radiations these sources emit and with uses to be made of radiation. This program deals in a unified manner with neutrons, charged particles, gamma rays, and light and other electromagnetic radiations. It is concerned with the production of neutrons and gamma rays by fission reactors, the production of alpha, beta and gamma rays to radioisotopes, the production of electrons, positive ions, neutrons and gamma rays in particle accelerators, and the production of coherent electromagnetic radiation by lasers. Topics treated include the detection and measurement of radiation, the interaction of radiation with matter, the use of radiation in processing materials, the design of irradiators, biological effects of radiation and the use of scattering experiments with neutrons and coherent light to determine the structure and molecular dynamics of solids, liquids, and dense gases.

To achieve the full potential of nuclear energy from either fission or fusion reactors, it will be necessary to develop materials capable of withstanding intense radiation for long periods of time. Nuclear reaction systems require novel materials processed in special ways. The Department's nuclear materials engineering program is concerned with effects of radiation on materials and development of improved radiation-resistant materials. Also of major importance are the chemical and metallurgical engineering aspects of the production and fabrication of enriched uranium, thorium, and plutonium to serve as fuel for fission reactors, and the processes for recovering these materials from the highly radioactive spent fuel discharged from reactors. Processing and enrichment of lithium and hydrogen-isotopes for fusion reactor fuels are also treated.

In these programs, attention is focused on the technology of the fission reaction and plasma phenomena and on aspects of applied mathematics, physical science, and engineering which contribute importantly to the efficient development of these fields — for example, low-energy nuclear physics, plasma physics, nuclear materials, numerical methods and high-flux heat transfer. The Department follows a broad interdisciplinary approach, making use of important segments of physics, chemistry, applied mathematics, and metallurgy and drawing on the techniques of chemical, civil, electrical, and mechanical engineering where relevant to the solution of nuclear engineering problems. The programs in nuclear engineering at M.I.T. are open to students with undergraduate training in these and related fields. They aim to teach the basic principles of nuclear technology and applied plasma and radiation physics and to show students how their fields of undergraduate specialization may be applied to problems in these fields.

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.

Advanced undergraduates and graduate students 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. A new 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

The Department of Nuclear Engineering does not offer an undergraduate degree, but it does offer options of interest to undergraduates who wish to prepare for employment in the nuclear industry or for graduate work in nuclear engineering. A series of elective subjects at the freshman through senior level is offered so that students can study nuclear engineering as a minor program to complement their major engineering or science course of study. In addition, the Department offers several subjects of broad interest which deal with technical problems on a global scale and are suitable for undergraduate students. Juniors and seniors with adequate prerequisite preparation may also elect one or more graduate subjects in nuclear engineering. A more comprehensive course of study is provided by the five-year programs which are offered jointly with a number of M.I.T. departments and lead to joint Bachelor of Science and Master of Science degrees. The M.I.T. departments currently participating in these programs are the Departments of Chemical Engineering, Civil Engineering, Electrical Engineering, Mechanical Engineering, and Physics.

Five-Year Degree Programs

The five-year programs leading to a joint Bachelor of Science in chemical engineering, civil engineering, electrical engineering, mechanical 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

An undergraduate degree in physics, engineering physics, chemistry, mathematics, metallurgy, or chemical, civil, electrical, mechanical, or nuclear engineering furnishes suitable preparation for graduate study in nuclear engineering. Optimum undergraduate preparation would include the following material:

Physics At least two years, including mechanics, heat, light, electricity, and magnetism, and an introduction to wave mechanics and modern physics, equivalent to M.I.T. subjects 8.01, 8.02, 8.03, and 8.04 or 8.211. Students planning to follow the Department's program of graduate study in applied plasma physics or applied radiation physics should have more advanced preparation in theoretical physics, electricity, and magnetism, equivalent to M.I.T. subjects 8.06 and 8.07.

Mathematics At least two and one-half years, including ordinary and partial differential equations, vector analysis, matrix algebra, orthogonal functions, Bessel and Legendre functions, Fourier and Laplace transforms, and an introduction to functions of a complex variable, equivalent to M.I.T. subjects 18.01, 18.02, 18.03, 18.075, and 18.076.

Chemistry At least one term of general, inorganic, and physical chemistry, including the periodic table, valence, oxidation-reduction potentials, equilibrium constants, and heterogeneous equilibrium.

Engineering Fundamentals Mechanical properties of materials, fluid flow, heat transfer, and engineering thermodynamics, equivalent to M.I.T. subjects 2.01 or 10.302, 10.301 or 10.13. Students without such undergraduate engineering preparation may obtain background in engineering fundamentals by taking 22.311 Engineering Principles for Nuclear Engineers.

Prospective graduate students should make every effort to complete undergraduate preparation before starting graduate study. Students whose preparation is incomplete may make up their deficiencies after admission to graduate study, but they will need more time to complete the graduate program.

Students who expect to apply for admission to the graduate course in Nuclear Engineering should discuss their undergraduate programs with the Department's Registration Officer, preferably before the end of their junior year. Applicants for admission are advised, but not required, to take the Graduate Record Examination.

Master of Science in Nuclear Engineering
Course XXII

The object of the Master's program is to give the student as good a general knowledge of aspects of nuclear engineering as can be gained in one year of full-time graduate study. This will provide a good foundation either for productive work in the nuclear field or for more advanced graduate study. The general requirements for this degree are listed in Chapter III. Subjects recommended for all Master degree candidates include:

22.111	Nuclear Physics for Engineers I
22.112	Nuclear Physics for Engineers II
22.211	Nuclear Reactor Physics I

Other subjects may be selected in accordance with the student's particular field of interest. Most Master's candidates specialize in one of four alternative fields: fission reactor technology, applied plasma physics, applied radiation physics, or nuclear materials engineering. For students specializing in **fission reactor technology**, additional subjects recommended are:

22.212	Nuclear Reactor Physics II
22.29	Nuclear Reactor Measurements Laboratory
22.312	Engineering of Nuclear Reactors

Other subjects of interest to Master of Science candidates specializing in fission reactor technology include:

22.313	Advanced Engineering of Nuclear Reactors
22.314	Structural Mechanics in Nuclear Power Technology
22.33	Nuclear Reactor Design
22.34	Economics of Nuclear Power
22.35	Nuclear Fuel Management
22.37	Environmental Impact of Power Production
22.39	Nuclear Reactor Operations and Safety
22.42	Numerical Methods of Reactor Analysis
22.534	Radiation Engineering and Shielding
22.611	Plasmas and Controlled Fusion I
22.72J	Nuclear Fuels
22.76J	Nuclear Chemical Engineering

For students specializing in **applied plasma physics,** subjects recommended in addition to 22.111, 22.112, and 22.211 are:

22.611	Plasmas and Controlled Fusion I
22.612	Plasmas and Controlled Fusion II
22.63	Engineering Physics of Plasma and Particle Devices
22.69	Plasma Laboratory

Students specializing in **applied radiation physics** should select subjects in addition to 22.111, 22.112, and 22.211 from:

3.42J	Physics of Solids I
22.29	Nuclear Reactor Measurements Laboratory
22.312	Engineering of Nuclear Reactors
22.534	Radiation Engineering and Shielding
22.73J	Radiation Effects in Crystalline Solids

Students specializing in **nuclear materials engineering** should select subjects in addition to 22.111, 22.112, and 22.211 from those listed immediately above and:

22.71J	Physical Metallurgy Principles for Engineers
22.72J	Nuclear Fuels
22.75J	Radiation Effects to Reactor Structural Materials
22.76J	Nuclear Chemical Engineering

Students with adequate undergraduate preparation normally need one full year to complete the requirements for the Master of Science. Additional information concerning the requirements for the Master of Science in Nuclear Engineering are given in an information circular obtainable from the Department of Nuclear Engineering.

Nuclear Engineer

The two-year program of study leading to the Nuclear Engineer provides deeper knowledge of nuclear engineering than is possible in the Master's program and is intended to train students for creative professional careers in engineering application or design.

General requirements for this degree, described in Chapter III, include 162 units of subject credit plus a thesis. The Department requires that each student plan an individually selected program of study, to be approved in advance by the faculty adviser, and that he or she complete, and orally defend, a substantial project of significant engineering value.

The principal areas of study are: nuclear reactor physics, nuclear reactor engineering, nuclear materials engineering, nuclear fuel management, applied radiation physics and applied plasma physics. The objectives of the study program are to provide the candidate with a broad knowledge of the profession and to develop competence in engineering applications or design. The emphasis in the program is more applied and less research oriented than the doctoral program.

The engineering project required of all candidates for the Nuclear Engineer is generally the subject of an Engineer's thesis. A student with full undergraduate preparation normally needs two years to obtain the Nuclear Engineer. A student who satisfies the requirements for the Engineer's degree is simultaneously approved for the S.M. 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.

Doctor of Philosophy and Doctor of Science

The program of study leading to these degrees aims to give a comprehensive knowledge of nuclear engineering, to develop competence in advanced engineering research, and to develop perspective in assessing the role of nuclear science and technology in our society.

General requirements for the doctorate are given in Chapter III and in the *Graduate School Manual*. The specific requirements of the Department of Nuclear Engineering are presented here. The four principal parts of the doctoral program are the major program leading to the General Examination, the minor program, the language requirement and the doctoral thesis. Upon a satisfactory completion of this program, the student ordinarily receives the Doctor of Science unless he or she requests the Doctor of Philosophy. The requirements for both degrees are the same.

The object of the **major program** is to give students good general knowledge of nuclear engineering, together with detailed familiarity with the specific field in which they intend to undertake research. To this end, before students may start their doctoral research, they are required to pass a general examination demonstrating adequate undergraduate preparation in physics, chemistry, mathematics, and engineering fundamentals and comprehensive knowledge at the graduate level of their chosen field in nuclear engineering.

The alternative fields in which doctoral candidates may elect to study and 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. Details of the doctoral examination in each of these fields are given in an information circular for doctoral candidates obtainable from the Department of Nuclear 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 nuclear engineering and of a more advanced character than would have been required for the student's undergraduate degree. The minor program should be arranged in consultation with the student's registration officer, and should have his approval. Graduate level subjects taken at other schools may be used to satisfy the minor requirement if the registration officer judges them to be substantially equivalent to M.I.T. graduate subjects.

The object of the **language requirement** is to ensure that the student has familiarity with some language other than English. Students whose native language is not English are presumed to have satisfied this requirement. Other students may satisfy it by successful completion of a one-year college-level sequence of foreign language subjects while undergraduates in the M.I.T. Department of Foreign Literatures and Linguistics, or at Harvard University or Wellesley College.

Doctoral research may be undertaken either in the Department of Nuclear Engineering or in a nuclear related field in another department. Appropriate areas of research include the following: in fission reactor physics — physics of thermal reactors, physics of fast reactors, reactor dynamics, neutron transport theory, numerical methods of reactor analysis; in fission reactor engineering — high-flux heat transfer, two-phase flow in boiling systems, liquid-metal heat transfer, nuclear reactor safety, structural design of reactor components; in nuclear fuel management — in-core and out-of-core fuel cycle analysis, economics of energy production, power system modeling and planning; in applied plasma physics — plasma production and confinement, plasma kinetic theory, plasma diagnostics, charged particle transport theory, fusion power systems, thermionic energy conversion, gas laser technology; in applied radiation physics — chemical or biological effects of radiation, radiation processing of materials, neutron diffraction studies, neutron cross section correlations, studies of molecular dynamics by scattering of light or neutrons, shielding of gamma rays or neutrons; in nuclear materials engineering — properties of nuclear fuels, effect of radiation on reactor materials, solvent extraction of metals, isotope separation, nuclear fuel reprocessing, treatment of radioactive wastes.

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. Research Reactor

The M.I.T. Research Reactor operates at a power of 5,000 kw. It is fueled with U-235 and cooled and moderated by heavy water. Completed late in the spring of 1958, it is one of the finest university research reactors in the world. It provides first-hand experience in the design, performance, and operation of nuclear reactors and serves as a source of radiations for use in laboratory instruction on radiation detection and measurement methods. The reactor is being modified in 1974 to increase the useful neutron intensity and its versatility as a research tool even more. A variety of research projects make use of the intense sources of neutrons and gamma rays produced by the reactor. Areas of research in which the reactor is being used include: neutron physics, cross-section measurements, reactor physics, neutron scattering by gases and liquids, solid-state studies based on neutron diffraction, radiochemistry, physics of neutron-capture processes, activation analysis, research with short-lived radioisotopes, radiation catalyzed chemical reactions, radiation induced biological effects, radiation therapy, and studies of radiation effect on materials.

Experimental Plasma Facilities

The Department utilizes extensive experimental facilities for production and confinement of large volumes of highly ionized plasmas and for studies of plasma turbulence, particle motions, and other phenomena. High-power lasers and other equipment are available both for plasma diagnostics and for study of basic physical interactions. Experimental apparatus for thermionic conversion studies is also available. The Department has facilities to support a unique program of controlled fusion engineering studies and has its own well-equipped graduate laboratory for instruction on plasma laboratory techniques.

The Department has played a major role in the design and operation of the new high field Tokamak fusion device ALCATOR, a joint project of the Research Laboratory of Electronics and the National Magnet Laboratory. ALCATOR is expected to produce a dense, hot plasma approaching the regime of fusion interest. ALCATOR is a major plasma physics installation and is expected to function for many years as the plasma equivalent of the M.I.T. Research Reactor as an educational and research facility.

Most of the research on plasmas and controlled fusion is done in M.I.T.'s Research Laboratory of Electronics. This Laboratory is an association of faculty and graduate students from many departments, and it includes groups active in all aspects of plasma research.

Other Research Facilities

The Department has a well-equipped nuclear instrumentation laboratory, a 14 MeV neutron source, and two subcritical natural-uranium reactors, one moderated by water and the other by graphite. Laboratory space and shop facilities are available for research in all areas of nuclear engineering. M.I.T.'s IBM Type 370/165 digital computer is used extensively in research and graduate instruction. In addition the Department has its own PDP-8 digital computer. The Department has its own liquid helium refrigeration unit.

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.

Subjects in Nuclear 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.

	Undergraduate Subjects
22.U.R.	Undergraduate Research Opportunities Program
22.02	Physics of Nuclear Energy
22.03	Engineering of Nuclear Power Reactor Systems
22.04	Radiation Effects and Uses
22.06	Nuclear Engineering in Society
22.08J	Energy

	Nuclear Physics
22.111	Nuclear Physics for Engineers I (A)
22.112	Nuclear Physics for Engineers II (A)

	Nuclear Reactor Physics
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 Kinetics (A)
22.29	Nuclear Measurements Laboratory (A)

	Nuclear Reactor Engineering
22.311	Engineering Principles for Nuclear Engineers
22.312	Engineering of Nuclear Reactors (A)
22.313	Advanced Engineering of Nuclear Reactors (A)
22.314	Structural Mechanics in Nuclear Power Technology (A)
22.315J	Structural Mechanics in Nuclear Power Technology (A)
22.32	Nuclear Power Reactors (A)
22.33	Nuclear Reactor Design (A)
22.34	Economics of Nuclear Power (A)
22.35	Nuclear Fuel Management (A)
22.36J	Two-Phase Flow and Boiling Heat Transfer (A)
22.37	Environmental Impact of Power Production (A)
22.38	Current Developments in Nuclear Energy (A)
22.39	Nuclear Reactor Operations and Safety (A)

	Numerical and Mathematical Methods
22.41	Mathematical Methods of Reactor Analysis (A)
22.42	Numerical Methods of Reactor Analysis (A)
22.43	Advanced Methods of Reactor Analysis (A)

	Applied Radiation Physics
22.51	Interaction of Radiations with Matter (A)
22.52	Neutron Physics and Applications (A)
22.534	Radiation Engineering and Shielding (A)
22.55	Nuclear Radiation in Biology and Medicine (A)
22.58J	Quantum Foundations of Mechanics and Thermodynamics (A)

	Plasmas and Controlled Fusion
22.611J	Plasmas and Controlled Fusion I (A)
22.612	Plasmas and Controlled Fusion II (A)
22.62	Thermonuclear Reactor Design (A)
22.63	Engineering Physics of Plasma and Particle Devices (A)
22.64J	Plasma Kinetic Theory (A)
22.65J	Advanced Topics in Plasma Kinetic Theory (A)
22.69	Plasma Laboratory (A)

	Nuclear Materials
22.71J	Physical Metallurgy Principles for Engineers (A)
22.72J	Nuclear Fuels (A)
22.73J	Radiation Effects in Crystalline Solids (A)
22.75J	Radiation Effects to Reactor Structural Materials (A)
22.76J	Nuclear Chemical Engineering (A)

	General
22.80	National Socio-Technological Problems and Responses (A)
22.82	History of Nuclear Engineering: A Case Study in the Interaction between Technology and Society
22.83	Reliability Analysis Methods
22.89	Basic Electronic Instrumentation Laboratory
22.90	Special Problems in Nuclear Engineering (A)
22.911	Seminar in Nuclear Engineering (A)
22.912	Seminar in Nuclear Engineering (A)

*Full descriptions of all subjects are given in the catalogue entitled **Courses and Degree Programs, 1974–75**, which may be obtained by writing to the Institute Information Services, Room 7-111, M.I.T.

Department of Ocean Engineering

Ira Dyer, Ph.D.
Professor of Ocean Engineering
Head of the Department

Professors

Martin Aaron Abkowitz, Ph.D.
Professor of Ocean Engineering

Alexander Douglas Carmichael, Ph.D.
Professor of Power Engineering

John Harvey Evans, B.Eng.
Professor of Naval Architecture

Ernst Gabriel Frankel, Mar.Mech.E.
Professor of Marine Systems

Alfred Adolf Heinrich Keil, Dr. Rer. Nat.
Professor of Ocean Engineering
Dean of the School of Engineering

Justin Elliot Kerwin, Ph.D.
Professor of Naval Architecture

Patrick Leehey, Ph.D.
Professor of Naval Architecture
Professor of Applied Mechanics

Philip Mandel, B.S.
Professor of Naval Architecture

Koichi Masubuchi, D.Eng.
Professor of Ocean Engineering
Professor of Materials Science

John Nicholas Newman, Sc.D.
Professor of Naval Architecture

Kevin James O'Toole, Nav.E.
Professor of Naval Architecture
Professor of Naval Science (Visiting)
Director, Office of Naval Science

Shannon Curtis Powell, Dott.Ing.
Professor of Marine Engineering (Absent)

Associate Professors

Arthur Bernard Baggeroer, Sc.D.
Associate Professor of Ocean Engineering
Associate Professor of Electrical Engineering

Chryssostomos Chrysostomidis, Ph.D.
Associate Professor of Naval Architecture

John William Devanney, III, Ph.D.
Associate Professor of Marine Systems

Clark Graham, Ph.D.
Associate Professor of Marine Systems

Wesley Leroy Harris, Sr., Ph.D.
Associate Professor of Ocean Engineering
Associate Professor of Aeronautics and Astronautics

Norman Jones, Ph.D.
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Alaa El-'Din Mansour, Ph.D.
Associate Professor of Ocean Engineering

Jerome H. Milgram, Ph.D.
Associate Professor of Naval Architecture (Absent)

J. Daniel Nyhart, J.D.
Associate Professor of Management
Special Assistant to the Chancellor

Assistant Professors

Judith Tegger Kildow, Ph.D.
Assistant Professor of Ocean Policy

Joseph Baker Lassiter, III, Ph.D.
Assistant Professor of Ocean Engineering

Henry Stuart Marcus, D.B.A.
Assistant Professor of Marine Systems

Senior Lecturers

Harry A. Jackson, B.S. (Visiting)
Miguel Chapero Junger, Sc.D. (Visiting)
William S. Pellini, B.S. (Visiting)
Willard Franklin Searle, Jr., Nav.E. (Visiting)

Lecturers

William Avery Baker, S.B.
Robert Clayton Blumberg, J.D. (Visiting)
Damon Ellis Cummings, Ph.D.
Pierre Paul Dogan, Ph.D.
Franz A. P. Frisch, M.S. (Visiting)
James W. Mavor, Jr., S.M. (Visiting)
David A. Ross, Ph.D. (Visiting)

Instructor

Robert Joseph Stewart, S.M.

Administrative Officer

Keatinge Keays, Nav.E.

Research Associates

Kwang June Bai, Ph.D.
Albert M. Bradley, Ph.D.
Edward Clarence Kern, Ph.D.
Muneharu Kutsuna, Ph.D.
Howard S. Lahman, M.S.
Toyohiko Muraki, D.Eng.
Ronald W. Yeung, Ph.D.

Visiting Engineers

Isao Sugimoto
Yoshitsugu Toshioka

Professors Emeriti

Evers Burtner, S.B.
Associate Professor of Naval Architecture and Marine Engineering, Emeritus

Frank Mendell Lewis
Professor of Marine Engineering, Emeritus

Norman Judson Padelford, Ph.D., LL.D.
Professor of Political Science, 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.

The education of an ocean engineer revolves around two central components. The first essential is a firm foundation in such basic engineering disciplines as mathematics, hydrodynamics, structural mechanics, vibratory phenomena, energy conversion, materials, and electronics. Second, the engineer needs broad exposure and practical experience in marine systems analysis as a means of synthesizing and integrating engineering knowledge. The Department's undergraduate and graduate programs combine these two aspects in a balanced way to provide an educational base upon which to build a satisfying career in ocean engineering.

Opportunities in Ocean Engineering

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 to sophisticated ocean research vessels. For more than 80 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. The task is complex and demanding, especially as drilling moves farther off the continental shelf and into deeper parts of the ocean. Another task of central importance in recent years is the development of new methods to protect marine wildlife and coastal regions against the undesirable side effects of offshore oil production.

Mining of seafloor minerals is certain to assume greater importance as land based mineral resources are depleted or withheld from free international trade. To the ocean engineer 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. Just as technology transformed modern agriculture, so ocean engineering has significant contributions to make to aquaculture. Using technology to cultivate our seafood may prove to be the only alternative to the continued or expanded consumption of such favored species as lobster, shrimp, and haddock.

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 persons to cope with technologies relevant to modern naval systems, including ship design alternatives, seafloor habitats, hydrophone arrays, and underwater navigation and communication.

In addition to career opportunities in the areas outlined above, the Department offers programs to prepare graduate students for academic and research careers in ocean related disciplines such as those sampled below.

Disciplines represented in the Department and a sample of related subjects
Many subjects entail more than one discipline; the principal identification is indicated here.

	Ship, Rig, and Platform Design
13.36	Ocean Engineering Structural Design
13.405	Introductory Ocean Engineering Design*
13.43	Naval Ship-System Design I
13.64J	Water, Air and Interface Vehicles*
	Systems Engineering and Probabilistic Modeling
13.61	Network Scheduling, Routing and Planning
13.62J	Engineering Systems Analysis
13.63	Reliability, Availability, and Maintainability of Systems
13.67	Marine Decision Making Under Uncertainty
	Economics, Public Policy and Law
13.66	Marine Transportation Economics
13.92	Public Policy and Use of the Sea
13.94J	Engineering and Law Seminar
13.96	Marine Resource Economics*
	Production and Management
13.65	Ship Production Analysis
13.68	Management of Marine Systems
13.69	International Shipping
13.98J	Coastal Zone Management
	Propulsion and Power
13.21	Ship Power and Propulsion
13.22	Naval Ship Propulsion
13.25J	Thermodynamics of Power Systems*
13.27	Ocean Engineering Power Systems
	Materials and Fabrication
13.15J	Materials for Ocean Engineering
13.17J	Welding Engineering
13.39	Analysis of Techniques for Fabricating Structures
13.993	Deterioration of Materials in the Ocean
	Instruments, Sensors, Measurement Systems, and Gear
13.74J	Marine Data Systems
13.90	Ocean Engineering Laboratory*
13.994	Buoy Engineering
13.995	Oceanographic Deep Submergence Engineering
	Hydrodynamics
13.001	Introduction to Marine Applied Mechanics*
13.02	Marine Hydrodynamics
13.03	Advanced Hydromechanics of Ship Design
13.04	Hydrofoils and Propellers
	Structural Mechanics and Dynamics
13.002	Marine Applied Mechanics*
13.10	Introduction to Structural Mechanics*
13.11	Theory of Plates and Shells
13.12	Marine Structures
	Acoustics, Vibration and Shock
13.80	Mechanical Vibration and Noise for Ship Designers
13.84J	Flow Noise
13.85	Fundamentals of Underwater Sound Applications
13.86	Sound Transmission in the Ocean

*Indicates undergraduate subjects.

The Department's educational programs lead to broad engineering and scientific competence. Once a student has attained the fundamental engineering skills, individualized study programs to meet particular interests are strongly encouraged. The Department's faculty consists of women and men with 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 library studies and laboratory experience. The Department participates in several of the M.I.T. interdepartmental efforts and research facilities, such as the Power Engineering Program, the Energy Laboratory, the Center for Transportation Studies, the Environmental Studies Program, the Acoustics Program, and the Center for Policy Alternatives. This combination of a flexible curriculum, a strong Department faculty with extensive research facilities, an unusually close student-faculty relationship, and a sharing of Institute-wide programs forms the basis of a sound and effective education.

The sections that follow describe the Department's undergraduate and graduate programs. Special requirements for the Graduate School and opportunities for financial aid are summarized in the section on graduate study.

Undergraduate Study

Bachelor of Science in Ocean Engineering, in Naval Architecture and Marine Engineering, or without designation
Course XIII

Course XIII is the basic program offered by the Department. For undergraduates, the four-year program relates to students interested in engineering aspects of ocean sciences, ocean exploration, and the utilization of the oceans for transportation, defense, and resources. The program leads to the Bachelor of Science in Ocean Engineering, in Naval Architecture and Marine Engineering, or without designation of field. A curriculum without designation of field permits pursuit of broader marine related interests. Graduates are prepared for work in industry or government, or for further study in graduate school.

All Course XIII undergraduates take the same required subjects in mathematics, science, and engineering fundamentals, along with subjects fulfilling the general Institute requirements in humanities and laboratory work. Some departmentally prescribed subjects may be replaced by other subjects if such substitutions enhance student objectives. The elective program consists of two parts: planned electives, which are designed to meet the student's Course objective, and unrestricted electives, which permit further study in specialized areas or a broadening of the student's overall educational experience.

The Department offers counseling to students wishing to use some combination of planned and unrestricted electives for environmental studies. Such a course of study is similar to the other four-year M.I.T. programs, supplemented with elective studies, that prepare students for environmentally related work.

Bachelor of Science in Ocean Engineering, in Naval Architecture and Marine Engineering, or without designation
Course XIII

	General Institute Requirements				Total units
	Specific science and humanities and social science subjects.				132
	Economic Principles I (14.01) is required in the humanities, arts, and social science program if another subject in the field of economics is not included in the elective program.				
	The subjects 2.40, 13.001, and 18.03, which are required in the Departmental Program, appear on the list of Science Distribution Subjects and can be used to satisfy the Science Distribution Requirement.				
	Laboratory Requirement.				12
	Departmental Program				
	Required Subjects[1] [2]				75
2.40	Thermodynamics	4	0	8	
13.001	Introduction to Marine Applied Mechanics	4	0	8	
13.002	Marine Applied Mechanics	4	0	8	
13.73	A Survey of Ocean Engineering	1	1	1	
13.79	Applied Ocean Engineering	3	3	6	
18.03	Differential Equations	4	0	8	
18.075	Advanced Calculus for Engineers	3	0	9	
	Planned Electives[3] [4] At least seven subjects which are selected by the student and his Faculty Counselor, chosen to attain the educational objective of preparation for a career in Ocean Engineering, in Naval Architecture and Marine Engineering, or an educational objective defined by the student.				at least 71
	Unrestricted Electives[2] [5]				70
	Total Units Required for the S.B. Degree				360

1
The Department allows substitution of subjects of similar content after consultation with the Faculty Counselor.
2
For the degree without designation of field delete 13.79 Applied Ocean Engineering (3-3-6) from the list of required subjects and increase the unrestricted elective units by 12.
3
For the degree in Ocean Engineering at least one planned elective subject must be selected in four of the following seven areas: Acoustics and Vibration, Design Hydrodynamics, Instrumentation, Materials and Fabrication, Ocean Environment, Power and Propulsion, Probability and Structures. No undergraduate thesis is required, but a suitable Special Problem (of at least 9 units), 13.700-13.709 Special Problems in Ocean Engineering must be included.
4
For the degree in Naval Architecture and Marine Engineering, at least one suitable planned elective subject must be selected in each of the following areas: Design, Hydrodynamics, Materials and Fabrication, Power and Propulsion, and Structures. A suitable Special Problem (of at least 9 units), 13.700-13.709 Special Problems in Ocean Engineering, must also be included.
5
Schedules of students in Course XIII may always be arranged to leave available 12 units of unrestricted elective in the second year.

Bachelor of Science in 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. All the requirements of the undergraduate curriculum in naval architecture and marine engineering must be satisfied, with the following exceptions:

1
13.700 — 13.709 Special Problems in Ocean Engineering (9 units) is omitted, allowing 9 units of additional professional subjects; and
2
the concentration in Economics and Labor in Industrial Society of the humanities program is not permitted.

Although students are not formally admitted to the program until the beginning of the fourth year, the elective program in earlier years should be arranged with this course objective in view.

Graduate Study

Bachelor of Science Course XIII-C

Course XIII-C is a cooperative work-study program that enables students to combine professional experience with their academic work, while at the same time providing for part of their educational expenses. This four-year program leads to the Bachelor of Science. Students in the cooperative program may also 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. undergraduate students in good standing can apply for entrance to the program. Preference is given to second-year students. 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 work-study 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, technical planning, and administration.

Bachelor of Science Course XIII-C

	General Institute Requirements		Total Units
	Specific science and humanities[1] and social science subjects.		132
	The subjects 2.40, 13.001, and 18.03 which are required in the Departmental Program, appear on the list of Science Distribution Subjects and can be used to satisfy the Science Distribution Requirement.		
13.90	Ocean Engineering Laboratory (Laboratory Requirement)[2]		12
	Departmental Program		
	Required Subjects[2]		108
2.40	Thermodynamics	4 0 8	
13.001	Introduction to Marine Applied Mechanics	4 0 8	
13.002	Marine Applied Mechanics	4 0 8	
	Required Subjects (continued)		
13.501	Introduction to Computer Application to Marine Problems	2 2 5	
13.73	A Survey of Ocean Engineering	1 1 1	
13.79	Applied Ocean Engineering	3 3 6	
18.03	Differential Equations	4 0 8	
18.075	Advanced Calculus for Engineers	3 0 9	
	Industrial Practice in Ocean Engineering[4]	24	
	Planned Electives[5, 6] At least six subjects which are selected by the student and his Faculty Counselor, chosen to attain the educational objective of preparation for a career in Ocean Engineering, in Naval Architecture and Marine Engineering, or an educational objective defined by the student.		at least 60
	Unrestricted Electives[3, 7]		48
	Total Units Required for the S.B. Degree		360

1
Economic Principles I (14.01) is required in the humanities, arts, and social science program if another subject in the field of economics is not included in the program.

2
The Department allows substitution of subjects of similar content after consultation with and concurrence of the Faculty Counselor.

3
For the degree without designation of field delete 13.79 Applied Ocean Engineering (3-3-6) from the list of required subjects and increase the unrestricted elective units by 12.

4
Credit toward the Bachelor of Science for Industrial Practice in Ocean Engineering is limited to a maximum of 36 units and a minimum of 24 units.

5
For the degree in Ocean Engineering at least one planned elective subject must be selected in four of the following nine areas: Acoustics and Vibration, Design, Hydrodynamics, Instrumentation, Materials and Fabrication, Ocean Environment, Power and Propulsion, Probability, and Structures. A suitable Special Problem (of at least 9 units), 13.700 — 13.709 Special Problems in Ocean Engineering, must be included.

6
For the degree in Naval Architecture and Marine Engineering, at least one suitable planned elective subject must be selected in each of the following areas: Design, Hydrodynamics, Materials and Fabrication, Power and Propulsion, and Structures. A suitable Special Problem (of at least 9 units), 13.700 — 13.709 Special Problems in Ocean Engineering, must also be included.

7
Schedules of students in Course XIII-C may always be arranged to leave available 12 units of unrestricted electives in the second year.

Graduate study 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 graduate program of subjects plus an acceptable thesis leading to the Master of Science in Ocean Engineering, in Naval Architecture and Marine Engineering, or without specification of field, usually requires about one calendar year, if the undergraduate preparation is adequate. For some students up to two academic years is needed.

The Ocean Engineer degree requires at least two years, including a substantial thesis.

Obtaining the Doctor of Science or Doctor of Philosophy with a specification in an ocean related field usually requires more than three years following a Bachelor of Science.

In most cases, students working together with their program advisors can tailor their programs of graduate study to suit individual interests and career objectives. Detailed Departmental requirements are available from the Departmental Student Information and Records Office.

Subjects in various areas appropriate to the programs of graduate students in the Department are suggested in the list of disciplines and career opportunities outlined under Opportunities in Ocean Engineering.

Also offered within the basic Course XIII curriculum are several specialized programs designed to meet certain individualized interests.

The Department offers a program in **marine systems.** An entering student should have background in economics and probabilistic systems in addition to the Department's usual requirements, or should plan to acquire this background early in the graduate program. Central to this curriculum are two Departmental subjects that introduce the student to marine applications of systems analysis. Two additional subjects introduce the student to the economics of marine transportation and natural resource systems, and techniques for making operational and investment decisions with respect to these systems. These subjects are supplemented by other offerings of the student's choice. Such a program usually leads to the Master of Science without specification of field. Also, students whose main interest is in the development and application of operations research techniques to marine systems may pursue the doctoral program administered by the Operations Research Center, which is described in Chapter III, while registered in the Department of Ocean Engineering.

Curricula are available which lead to graduate degrees in ocean engineering with a focus on **coastal zone development.** The curricula combine ocean engineering studies with subjects in other fields such as urban and regional planning, estuarine and coastal engineering, economics, law, and political science. To integrate this knowledge, the Department offers an advanced seminar in coastal zone problems, concentrating on analysis of actual issues. The methodologies employed are relevant not only to the coastal zone but also to a wide range of societal and technological issues.

A joint program in conjunction with the Harvard Law School and members of other M.I.T. departments offers opportunities for the study of **ocean engineering and law of the seas.** To integrate the relationship between engineering and law, the Department offers an advanced seminar, under guidance of the joint faculties, which focuses on contemporary issues.

Students entering the Department may also opt for a School of Engineering program leading to the degree of **Environmental Engineer.** During the student's first year in the Department, he or she prepares a firm technical base in engineering fundamentals. During the second year, the student, together with the Department's representative to the Environmental Engineer Committee of the School of Engineering, plans a coherent program which prepares the student for a thesis that incorporates both the technical and the policy aspects of environmental engineering. The thesis and the formal course work must be approved by the School of Engineering Committee responsible for environmental engineering.

A cooperative effort within the School of Engineering offers a special opportunity to study in **structural mechanics for nuclear power engineering.** This effort, while serving a major current need, also looks toward the mechanics and materials problems of future energy systems. A joint subject with the Department of Nuclear Engineering introduces the engineering problems. Students who study this and other aspects of mechanics and materials may take advantage of subject offerings in all departments of the School.

Course XIII-A

This course provides appropriate academic background for naval officers who later actively participate in concept formulation, design, and construction of naval vessels. In addition to general engineering and science and a core program of subjects in ocean engineering, each student follows one of several specialized curricula in aspects of, or applicable to, naval construction and engineering.

In addition to full-time study at the Institute for six academic terms and two summer terms, the Course provides, during the summer preceding the final year, either appropriate nonresident work experience or an additional term of full-time resident academic study.

The Course leads to the Ocean Engineer or Master of Science. For programs leading to the Ocean Engineer, a Master of Science may be awarded simultaneously upon recommendation of the Department or of some other department related to the student's specialty. For programs leading to the Master of Science, an additional Master of Science may be awarded simultaneously in a second field of specialization upon recommendation of the department represented by that field.

The Master of Science awarded by the Department to students who successfully complete the relevant portion of the Course XIII-A program is in Naval Architecture and Marine Engineering or in Ocean Engineering. A Master of Science awarded by another department in fulfillment of its requirements would be labeled in accordance with its program, for example Master of Science in Mechanical Engineering.

Admission to Course XIII-A requires that the Department's entrance requirements for graduate study be satisfied.

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 Alfred P. Sloan School of Management, and the Department of Ocean Engineering. They may also 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.

Course XIII-W

A joint program with the Woods Hole Oceanographic Institution is intended for students whose primary career objective is ocean engineering in connection with oceanography. 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 Course XIII students. The program is described in more detail under the section on M.I.T.'s Joint Program in Ocean 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 should be equal in quality, quantity, and breadth of coverage to the Department's undergraduate curricula.

If undergraduate preparation has been lacking in any area, the deficiencies must be made up prior to the award of any of the degrees with specification. This may be accomplished concurrently with graduate work, usually by successfully completing one or a few upper level undergraduate subjects, if the deficiencies are not extensive. Undergraduate subjects so required may not count toward advanced degree requirements. Somewhat less broad undergraduate work is required of candidates for the degree of Master of Science without specification, provided that the student has a correspondingly increased competence in areas pertinent to his proposed graduate program.

Inquiries

Requirements for Completion of Graduate Degrees

The program of studies for an advanced degree must meet the general requirements specified by the Institute in Chapter III and must be acceptable to the Departmental Committee on Graduate Students.

Unless special approval is given by this Committee, candidates for any graduate degree are expected to include in their programs at least one term of advanced mathematics beyond the requirements of the Department's undergraduate curricula.

The program for a Master of Science must include a minimum of 72 subject units plus a thesis acceptable to the Department. A minimum of 48 of the 72 units must be "A" subjects. The master's thesis should represent the equivalent of a half term of full-time work.

A program for an Engineer's degree ordinarily includes two subjects in the areas of economics, industrial management, public policy, or law, and at least 12 units of comprehensive design. Should the student be working toward the simultaneous award of the Engineer's and master's degrees, a single thesis will generally be acceptable, provided it is appropriate to the specifications of both degrees and demonstrates the educational maturity expected of candidates for the higher degree.

Additional Departmental requirements applicable to the S.M. and Ocean Engineer's degrees, and a statement regarding Departmental policy with respect to combinations of degrees, are available from the Departmental Student Information and Records Office.

In addition to the Institute requirements for the doctoral program, the Department requires that a student successfully complete qualifying examinations before being admitted to a doctoral program. The programs of students must be acceptable to the Departmental Committee on Graduate Students, both with respect to depth in the major area and broadness in collateral areas. Details of the examination and other special Departmental requirements, including those for the doctoral thesis, may be obtained from the Departmental Student Information and Records Office.

The Department interprets its program rather broadly. Thus a program for a degree with specification can include selected subjects in other departments, such as mathematics, aeronautics and astronautics, or civil or mechanical engineering. The thesis may be in another department if it is directly applicable to the respective graduate degree program.

Assistantships and Graduate Scholarships

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. An assistant may not register for more than 24-36 units per term, depending on the appointment held. Additional registration may be allowed when directly connected with an assistant's assigned duties.

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, generally to students who are graduates of the Department or who have completed some graduate work in the Department. Fellowships are also awarded each year by the Society of Naval Architects and Marine Engineers. These fellowships are valid for study at any institution of the recipient's choice and are usually awarded to applicants who, through their education or their professional work, have evidenced strong interest in some field of ocean engineering.

Prospective students are invited to communicate with the 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.

Additional information concerning academic programs, research opportunities, admissions, financial aid, etc. may be obtained by writing to the Department of Ocean Engineering, Room 5-325, M.I.T., Cambridge, Massachusetts 02139, (617)253-4335.

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.

13.U.R.	Undergraduate Research
13.001	Introduction to Marine Applied Mechanics
13.002	Marine Applied Mechanics
13.01	Applied Hydrostatics
13.02	Marine Hydrodynamics (A)
13.021	Hydrodynamics for Ocean Engineers (A)
13.03	Advanced Hydromechanics of Ship Design (A)
13.04	Hydrofoils and Propellers (A)
13.07	Free Surface Hydrodynamics (A)
13.08	Stability and Motion Control of Ocean Vehicles (A)
13.09	Potential Flows (A)
13.10	Introduction to Structural Mechanics
13.11	Theory of Plates and Shells (A)
13.12	Marine Structures (A)
13.13	Plastic Analysis of Structures (A)
13.14J	Structural Mechanics in Nuclear Power Technology (A)
13.15J	Materials for Ocean Engineering
13.16J	Fracture of Structural Materials (A)
13.17J	Welding Engineering (A)
13.21	Ship Power and Propulsion (A)
13.22	Naval Ship Propulsion (A)
13.25J	Thermodynamics of Power Systems
13.26J	Thermal Power Systems (A)
13.27	Ocean Engineering Power Systems (A)
13.30	Ship Structural Analysis and Design
13.31	Ship Structural Design
13.32	Ocean Engineering Structures (A)
13.34	Ship Structural Design (A)
13.36	Ocean Engineering Structural Design (A)
13.39	Analysis of Techniques for Fabricating Structures (A)
13.405	Introductory Ocean Engineering Design
13.41	Principles of Ship Design (A)
13.42	Design of Ocean Engineering Systems (A)
13.43	Naval Ship System Design I (A)
13.44	Naval Ship-System Design II (A)
13.45	Principles of Naval Ship Design (A)
13.46	Conceptual Design of Naval Ships (A)
13.47J	Special Studies in Systems Engineering (A)
13.50	Computer Applications to Marine Problems
13.501	Introduction to Computer Applications To Marine Problems
13.61	Network Scheduling, Routing and Planning (A)
13.62J	Engineering Systems Analysis
13.63	Reliability, Availability, and Maintainability of Systems (A)
13.64J	Water, Air and Interface Vehicles
13.65	Ship Production Analysis (A)
13.66	Marine Transportation Economics (A)
13.67	Marine Decision Making Under Uncertainty (A)
13.68	Management of Marine Systems (A)
13.69	International Shipping (A)
13.70	Special Projects in Ocean Engineering
13.700–13.709	Special Problems in Ocean Engineering
13.71	Special Projects in Ocean Engineering (A)
13.710–13.719	Special Problems in Ocean Engineering (A)
13.72	Random Processes in Ocean Engineering (A)
13.73	A Survey of Ocean Engineering
13.74J	Marine Data Systems (A)
13.77J	Invention
13.771–13.773	Industrial Practice in Ocean Engineering
13.774	Industrial Practice in Ocean Engineering
13.79	Applied Ocean Engineering
13.80	Mechanical Vibration and Noise for Ship Designers (A)
13.81J	Principles of Acoustics (A)
13.82	Acoustics and Shock Response of Marine Structures (A)
13.84J	Flow Noise (A)
13.85	Fundamentals of Underwater Sound Applications (A)
13.86	Sound Transmission in the Ocean (A)
13.90	Ocean Engineering Laboratory
13.92	Public Policy and Use of the Sea (A)
13.93	Evolution and Utilization of Marine Resources
13.94J	Engineering and Law Seminar (A)
13.96	Marine Resource Economics
13.98J	Coastal Zone Management (A)
13.990	Oceanographic Systems I
13.991	Oceanographic Systems II
13.993	Deterioration of Materials in the Ocean (A)
13.994	Buoy Engineering (A)
13.995	Oceanographic Deep Submergence Engineering (A)
13.999	Special Projects in Ocean Engineering (A)

*Full descriptions of all subjects are given in the catalogue entitled **Courses and Degree Programs, 1974–75**, which may be obtained by writing to the Institute Information Services, Room 7-111, M.I.T.

Joint Program in Ocean Engineering with the Woods Hole Oceanographic Institution

The Woods Hole Oceanographic Institution and M.I.T. offer joint programs of education and research in oceanography, biological oceanography, and ocean engineering. (See also the corresponding section following the School of Science.) These programs are administered by committees drawn from the faculty and staff of the two institutions and lead to degrees awarded jointly by the two institutions. Extensive resources for advanced study and research are available at both M.I.T. and the Woods Hole Oceanographic Institution.

Subjects are offered at both institutions, and bus service is provided to make it possible for a student to be resident at either Cambridge or Woods Hole. Most fundamental subjects are taught at M.I.T., while thesis research may be carried on at either institution.

The Woods Hole Oceanographic Institution operates a fleet of research ships, submarines, and aircraft, and has extensive laboratory facilities and an active research staff. A modest marine facility is maintained by M.I.T. at Boston Harbor consisting of dock space and a small research vessel, and a laboratory capability is also maintained during the summer in Penobscot Bay, Maine, with the cooperation of the Maine Maritime Academy.

Ocean Engineering

The Department of Ocean Engineering offers a joint program in Ocean Engineering with the Woods Hole Oceanographic Institution leading to the degrees of Ocean Engineer, Doctor of Philosophy, or Doctor of Science awarded jointly by the two institutions. Students in this program choose to specialize in those areas of ocean engineering related to advancements in marine geophysics, marine geology, oceanography, ocean instrumentation, and ocean measurement systems.

Applicants to this program should have an undergraduate degree in one of the fields of engineering or applied sciences appropriate to ocean engineering and have a sound foundation in engineering sciences or pure sciences and related mathematics.

The general requirements for the degrees are the same as for the corresponding M.I.T. degrees given in Chapter IV and the requirements of the Department of Ocean Engineering. A student with preparation in pure sciences generally is required to bolster his or her background in engineering sciences and vice versa. A student normally spends at least the first graduate year at M.I.T., and for the engineer's degree at least another year at Woods Hole. A total of three years divided between the two institutions would be considered normal. The candidates for the doctorate spend more time at both institutions. Students are strongly encouraged to spend the summer preceding the first academic year at the Woods Hole Oceanographic Institution and normally are required to spend the following summer there. Subjects in ocean engineering and the related engineering sciences are offered by the Department of Ocean Engineering and at the Woods Hole Oceanographic Institution. Several other M.I.T. departments, especially Civil Engineering, Earth and Planetary Sciences, Electrical Engineering, and Meteorology, offer subjects in fields related to ocean engineering. The Departments of Earth and Planetary Sciences and of Meteorology also offer subjects given at Woods Hole in connection with the joint doctoral program in oceanography.

A limited number of fellowships and graduate assistantships for the joint program is available on a competitive basis. Further information and applications may be obtained from the Head of the Department of Ocean Engineering at M.I.T. and from the Dean of Graduate Studies of the Woods Hole Oceanographic Institution.

Application for admission to the joint program or for financial aid should be made on the M.I.T. Graduate Application Form, copies of which may be obtained from the Director of Admissions at M.I.T. or from the Woods Hole Oceanographic Institution. Requests for further information relating to the joint program may be addressed to the Head of the Department of Ocean Engineering of M.I.T. or to the Dean of Graduate Studies of the Woods Hole Oceanographic Institution.

Center for Advanced Engineering Study

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 programs of the Center include the Advanced Study Program, the Advanced Study Program in Air Transportation, the Advanced Study Program in International Nutrition Planning, and the Education for Public Management Program; short programs in specialized areas of science and engineering; and interdisciplinary projects concerned with the potential contributions of new and advanced technological developments to important and complex problems.

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.

The entire offering of M.I.T. undergraduate and graduate subjects, seminars, and colloquia are 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 on-going educational and research activities of the Flight Transportation Laboratory, the Center for Advanced Engineering Study, and other centers, laboratories, and academic departments at 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 U.S.A.

Advanced Study Program in International Nutrition Planning

The Center for Advanced Engineering Study, in collaboration with the M.I.T. International Nutrition Planning Program, offers a special nine-month Advanced Study Program for Fellows in International Nutrition Planning. This Advanced Study Program is designed primarily for officials of governments and international agencies who are involved in or are likely to become involved in the planning, implementation, or evaluation of programs designed to combat malnutrition. It is intended to provide orientation in multisectoral nutrition planning and an understanding of the dynamics and tools of nutrition intervention.

A small number of persons will be accepted each year as Fellows for this nondegree program. Each person accepted undertakes a special program of course work, seminars, and in some cases, field work, developed in a way which most sensibly supplements existing talents and experience, whether in public health, finance and economics, or administration.

The format of this Advanced Study Program is one of great flexibility, wherein an individual study plan can be tailored to the background and needs of each Fellow. All Fellows in International Nutrition Planning participate in course work on international nutrition and come together for a special seminar lasting the entire academic year. This seminar and the nutrition course work are intended to provide useful means of pursuing essential steps in the planning process, specifically:

1
Assessment of the nature and magnitude of existing malnutrition problems, particularly with regard to young children, among whom the consequences and implications of malnutrition are most critical;

2
Analysis aimed at identifying the relative importance of and interactions among the determinants of the malnutrition, for example: income, commodity prices, systemic and enteric infection, belief patterns, and the nutritional content of foods;

3
Determination of effective technological and economic means of affecting the determinants or problems found to be most important in the first two steps, including the projected costs and benefits of various forms of information dissemination, food fortification, plant breeding, subsidized food availability, modified agricultural price policy, and public health programs.

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. The following special subjects of broad interdisciplinary interest are also offered within the Center for participants in the Programs:

1.157	Simulation Methods
6.271J	Introduction to Operations Research
6.272J	Introduction to Operations Research
15.872	Principles of Dynamic Systems I
16.713	Probability Theory and Random Processes
Special Studies	Random Processes

The following subjects are offered for Fellows in the Center's Education for Public Management Program. These subjects are also open to Fellows in the Advanced Study Program.

16.701	Principles of Systematic Policy Analysis
16.702	Seminar in Systematic Policy Analysis
16.711	Introduction to Statistics and Probability
16.712	Applications of Statistical Analysis

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 $2,700 for the fall or spring term, $5,400 for the two-term school year, $2,150 for the regular summer term, and $1,000 for Calculus Revisited. A limited number of scholarships from the grant provided by the Alfred P. Sloan Foundation to establish the Center may be awarded to faculty participants from other colleges and universities to pay part or all 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.

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 avilable from the Center for Advanced Engineering Study, Room 9-221. 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 and 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:

Calculus Revisited
Part 1
Calculus of a Single Variable
Part 2
Calculus of Several Variables
Part 3
Introduction to Complex Variables, Differential Equations, and Linear Algebra

Probability

Random Processes

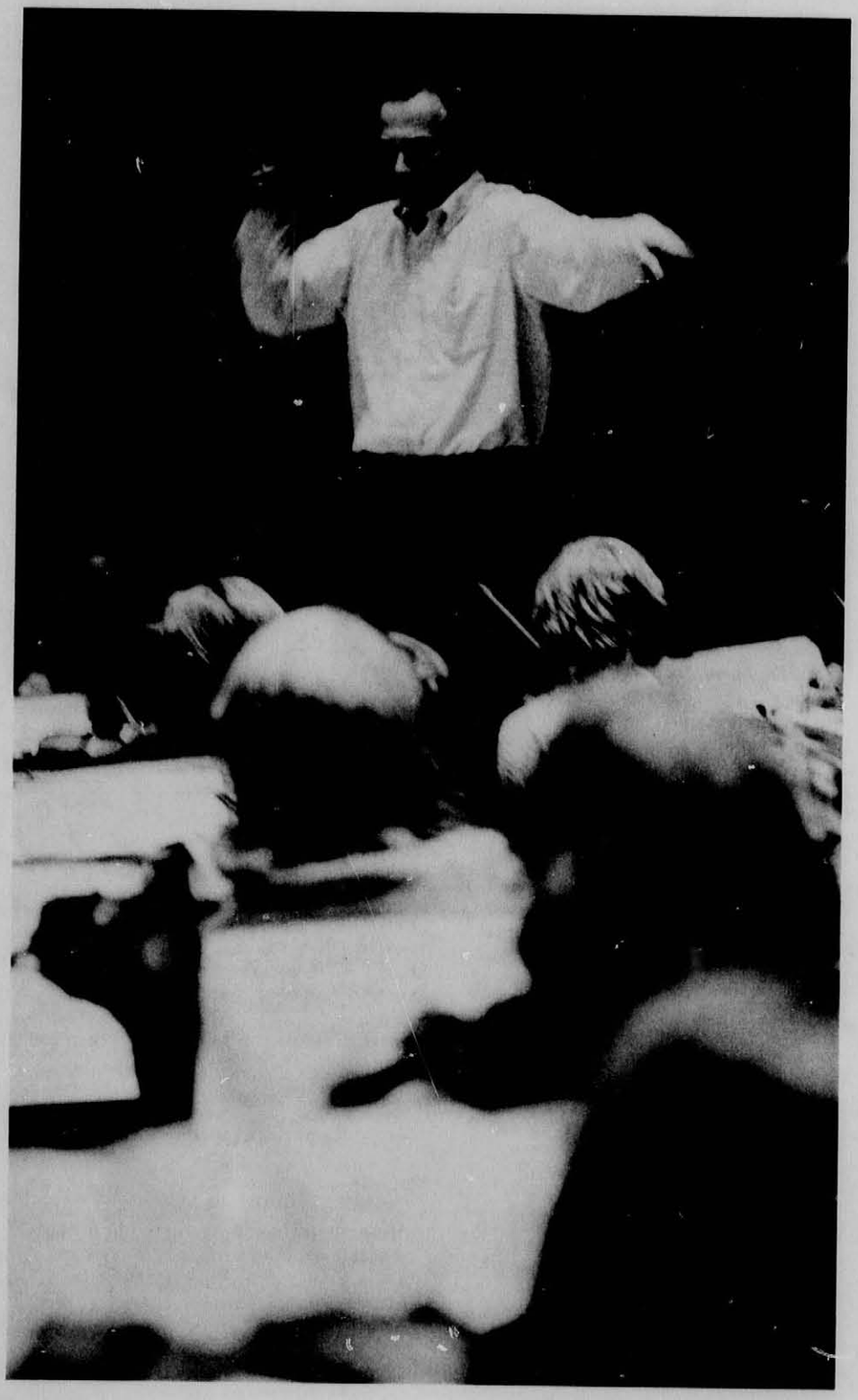
Colloid and Surface Chemistry
Part 1
Surface Chemistry
Part 2
Lyophobic Colloids
Part 3
Electrokinetics and Membrane Potentials
Part 4
Lyophilic Colloids

Introduction to Experimentation

Nonlinear Vibrations

Information regarding the rental or lease of these self-study subjects can be obtained by writing to the Center, Room 9-232.

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, 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 Studies, the Energy Laboratory, the Research Laboratory of Electronics, and West European Studies at Harvard. Some of the graduate programs stress the use of mathematical and computer oriented skills, but many doctoral theses are concerned with non-quantitative social science or humanistic topics. Moreover, graduate students are not entirely confined to the established doctoral programs. There is always room for the occasional highly motivated student to develop a special program of his or her own.

The research achievements of the School are perhaps best known to the world at large through the widely publicized achievements of certain distinguished members of the faculty. The chief emphasis of research in the School, however, as in the rest of the Institute, has been less on the activities of brilliant individuals than on teamwork. In the field of communications, for example, there are many interdisciplinary projects, some involving collaboration between linguistics, philosophy, and psychology, all of which 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 the 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, in foreign languages, in archaeology and anthropology, in history, in music and drama, and in 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 60 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.

This does not mean 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.

Dean of the School of Humanities and Social Science

Department of Economics

Edgar Cary Brown, Ph.D.
Professor of Economics
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.
Professor of Economics

Robert Lyle Bishop, Ph.D.
Professor of Economics

Peter Arthur Diamond, Ph.D.
Professor of Economics

Evsey David Domar, Ph.D.
Ford Professor of Economics

Richard Samuel Eckaus, Ph.D.
Professor of Economics

Franklin Marvin Fisher, Ph.D.
Professor of Economics

Harold Adolph Freeman, S.B.
Professor of Statistics

Everett Einar Hagen, Ph.D.
Professor of Economics and
Political Science, Emeritus
Senior Lecturer

Robert Ernest Hall, Ph.D.
Professor of Economics

Karl Gustave Jungenfelt, Fil. Dr.
Visiting Professor of
Economics (Spring Term)

Charles Poor Kindleberger, Ph.D.,
D.H.C.
Ford Professor of Economics

Edwin Kuh, Ph.D.
Professor of Economics

Franco Modigliani, D.Jur.,
D.Soc.Sci.,LL.D.
Institute Professor
Professor of Economics
Professor of Finance

Charles Andrew Myers, Ph.D.
Professor of Industrial Relations
Sloan Fellows Professor of
Management

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

Robert Merton Solow, Ph.D., LL.D.
Institute Professor
Professor of Economics

Peter Temin, Ph.D.
Professor of Economics

Lester Carl Thurow, Ph.D.
Professor of Economics
Professor of Management

Martin Lawrence Weitzman, Ph.D.
Professor of Economics

Associate Professors

Robert Fry Engle, III, Ph.D.
Associate Professor of Economics

Stanley Fischer, Ph.D.
Associate Professor of Economics

John Rees Harris, Ph.D.
Associate Professor of Economics

Michael Joseph Piore, Ph.D.
Associate Professor of Economics

Assistant Professors

Jerry Allen Hausman, D.Phil.
Assistant Professor of Economics

Paul Lewis Joskow, Ph.D.
Assistant Professor of Economics

Hal Ronald Varian, Ph.D.
Assistant Professor of Economics

William Cody Wheaton, Ph.D.
Assistant Professor of Economics

Administrative Officer

Idella Lyman Tapley, A.B.

Professors Emeriti

Everett Einar Hagen, Ph.D.
Professor of Economics and
Political Science, Emeritus
Senior Lecturer

Paul Pigors, Ph.D.
Professor of Industrial Relations,
Emeritus

Paul Narcyz Rosenstein-Rodan,
Dr. Rer.Pol.
Professor of Economics, Emeritus

Donald Skeele Tucker, Ph.D.
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 U.S. and world economy; and to develop in students the capability for quantitative research and independent thought. These aims roughly correspond to the requirements of theory, electives, statistics, and research.

The requirements allow substantial freedom for students both in designing individual programs within economics and in balancing the programs with subjects in other disciplines. The large amount of unrestricted elective time encourages students to shape programs close to their own needs and interests.

Students who have taken 14.01 Economic Principles I and 14.02 Economic Principles II by the end of their second year can follow a program which permits considerable depth in electives in the third and fourth years. The most satisfactory plan is to take 14.04 Intermediate Microeconomic Theory and 14.06 Intermediate Macroeconomic Theory in successive terms of the third year and to complete 14.30 Introduction to Statistical Method in Economics before the end of the third year. This satisfies prerequisites for all subjects, including 14.39 Economic Research Seminar, which prepares students for thesis research.

The Department specifies one science distribution subject, but strongly recommends that all students take an additional subject in computer techniques and, if professionally interested in economics, further work in mathematics.

Bachelor of Science in Economics Course XIV

	General Institute Requirements				Total units
	Specific science and humanities and social science subjects[1]				132
	The Science Distribution Requirement will be satisfied by 14.30, which is required in the Departmental Program, plus appropriate subjects				24
	Laboratory Requirement				12
	Departmental Program				
	Required Subjects				75
14.01	Economic Principles I	3	0	6	
14.02	Economic Principles II	3	0	6	
14.04	Intermediate Microeconomic Theory	4	0	8	
14.06	Intermediate Macroeconomic Theory	4	0	8	
14.30	Introduction to Statistical Method in Economics[2]	4	0	8	
14.39	Economic Research Seminar[3]	2	0	10	
	Thesis			9	
	Restricted Electives				65
	Elective subjects in economics			39	
	A coherent program in a field related to economics but outside the Department as agreed on between the student and the Faculty Counselor. Subjects which also satisfy the General Institute Requirement may be used with a corresponding increase in unrestricted electives			24	
	Unrestricted Electives				54
	Total Units Required for the S.B. Degree				360

1
Subjects in Field Six (Economics) and Field Eight (Labor Relations) may not be used for the humanities and social science requirement.

2
Or an approved alternative in statistics.

3
14.31 Econometrics (3-4-5) or 14.U.R. Undergraduate Research (12), approved as to content, may be substituted for 14.39.

Graduate Study

Entrance Requirements for Graduate Study

The Department specifies the following prerequisites for graduate study in economics: one full year of college mathematics, including at least one term of calculus; one full year of college work in science; at least six term subjects in English, history, and other humanities or social science subjects (not in the candidate's own professional field) equivalent to those included in the undergraduate curriculum at 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.

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 III.

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 fields may be satisfied by one year of course work. Among the four elective fields are advanced economic theory, monetary economics, fiscal economics, industrial organization, international economics, economic development, Russian economics, comparative economic systems, urban economics, labor economics, economic history, statistical theory, econometrics, human resources and the distribution of income and wealth, and, outside the Department, finance, production, and operations research. The econometrics requirement may be satisfied by offering it as a field or by taking 14.388 Applied Econometrics and, in either case, completing a major piece of empirical research. The minimal economic history requirement can be satisfied by taking one subject in the field.

No stated number of graduate subjects in the Department is required. However, the candidate ordinarily needs two full academic years of study to prepare himself adequately for the General Examination and to meet the other pre-thesis requirements. The doctoral thesis must be written in residence; as a rule, it represents at least one year's research.

The Department has no general foreign language requirements. When a foreign language is essential for full access to the literature in the field of major interest (for example, European economic history, Russian economics) or to thesis research, a language requirement is imposed by the Department upon the recommendation of the thesis supervisor or the Graduate Registration Officer. Such a requirement is administered by the Department of Foreign Literatures and Linguistics and can be met by satisfactory course work at other schools or at M.I.T. or by examination.

Students interested in developing professional competence in economics and planning problems of the city may elect an interdepartmental program in the Departments of Economics and Urban Studies and Planning. Depending on background, candidates can expect two and one-half academic years of work to prepare for the General Examination.

Teaching and Research Assistantships

A limited number of students are supported by teaching and research assistantships. Typically, these appointments are available only to students who have passed their general examinations, but in special circumstances, research assistantships may be held by second-year students.

Inquiries

Additional information concerning academic programs in the Department, admissions, financial aid, etc. may be obtained by writing to Professor Peter A. Diamond, M.I.T., E52-380, 50 Memorial Drive, Cambridge, Massachusetts 02139, (617) 253-2675.

Subjects in Economics*

(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
	General Economics and Theory
14.01	Economic Principles I
14.02	Economic Principles II
14.03	Applied Microeconomics
14.04	Intermediate Microeconomic Theory
14.06	Intermediate Macroeconomic Theory
14.09	Reading Seminar in Economics
14.101	Mathematics for Economists
14.102	Mathematics for Economists
14.11	Mathematical Economics
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 Programming and Economic Theory (A)
14.143	Advanced Theory of the Market III (A)
14.144	Applied Price Theory (A)
14.145	Economics of Uncertainty (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)
14.198	First-Year Graduate Seminar (A)
	Industrial Economics
14.20	Industrial Organization and Public Policy
14.22	Economics of Particular Industries
14.23	Economics of Fuel and Power
14.24	Economic Analysis of Law (A)
14.271	Problems in Industrial Economics (A)
14.272	Government Regulation of Industry (A)
14.291	Industrial Economics Seminar (A)
14.292	Industrial Economics Seminar (A)
	Statistics
14.30	Introduction to Statistical Method in Economics
14.31	Econometrics
14.371	Statistical Inference (A)
14.373	Time-Dependent Probability (A)
14.374	Design and Analysis of Scientific Experiments(A)
14.381	Statistical Method in Economics
14.382	Econometrics I (A)
14.383	Econometrics II (A)
14.386	Advanced Topics in Econometrics (A)
14.388	Applied Econometrics (A)
14.39	Economic Research Seminar
14.391	Workshop in Economic Research (A)
14.392	Workshop in Economic Research (A)
	National Income and Finance
14.40	Monetary and Banking Policy
14.41	Distribution of Income and Employment Opportunity
14.42	Economics of Pollution
14.43	Public Finance
14.451	Macroeconomic Theory I (A)
14.452	Macroeconomic Theory II (A)
14.453	Macroeconomic Theory III (A)
14.454	Macroeconomic Theory IV (A)
14.458	Advanced Topics in Macroeconomic Theory (A)
14.459	Advanced Topics in Macroeconomic Theory (A)
14.462	Monetary Economics I (A)
14.463	Monetary Economics II (A)
14.471	Fiscal Economics I (A)
14.472	Fiscal Economics II (A)
14.482	Income Distribution Economics
	International, Interregional, and Urban Economics
14.51	Urban Economics
14.52	Economics of the Soviet Union
14.53	Comparative Economic Systems
14.54	International Trade
14.572	Regional Economic Analysis (A)
14.573J	Urban Economic Analysis I (A)
14.574J	Urban Economic Analysis II (A)
14.581	International Economics I (A)
14.582	International Economics II (A)
	Labor Economics and Industrial Relations
14.63	Labor in Industrial Society
14.64	Labor Economics and Public Policy
14.671J	Labor Economics (A)
14.672J	Public Policy on Employment and Industrial Relations (A)
14.674J	Comparative Systems of Industrial Relations and Human Resource Development (A)
14.691J	Research Seminar in Industrial Relations (A)
14.692J	Research Seminar in Industrial Relations (A)
	Economic History
14.71	Economic History
14.731	American Economic History (A)
14.732	Problems in Russian Economic History (A)
14.733	European Economic History (A)
14.734	Problems in Economic History (A)
	Economic Development
14.74	Economic Growth and Development
14.771	Problems of Economic Development (A)
14.772	Theory of Economic Development (A)
14.773	Optimal Growth Theory (A)
14.774J	Transfer and Adaptation of Technology in Developing Countries (A)
14.782	Capitalism, Socialism and Growth (A)
14.783	Theory of Central Planning (A)

*Full descriptions of all subjects are given in the catalogue entitled **Courses and Degree Programs, 1974–75**, which may be obtained by writing to the Institute Information Services, Room 7-111, M.I.T.

Department of Foreign Literatures and Linguistics

James Wesley Harris, Ph.D.
Professor of Spanish and Linguistics
Head of the Department

Professors

Noam Avram Chomsky, Ph.D.
Ferrari P. Ward Professor of Modern Languages and Linguistics

Martin Dyck, Ph.D.
Professor of German and Literature

Kenneth L. Hale, Ph.D.
Professor of Linguistics

Morris Halle, Ph.D.
Professor of Modern Languages

Robert Emmet Jones, Ph.D.
Professor of French and Humanities

René Paul Viktor Kiparsky, Ph.D.
Professor of Linguistics

Wayne O'Neil, Ph.D.
Professor of Literature

Krystyna Pomorska, Ph.D.
Professor of Russian

John Robert Ross, Ph.D.
Professor of Linguistics

Associate Professors

Catherine Vakar Chvany, Ph.D.
Associate Professor of Russian

David M. Perlmutter, Ph.D.
Associate Professor of Linguistics

Assistant Professors

Robert C. Channon, M.A.
Assistant Professor of Russian

Gordon Eugene Nelson, Ph.D.
Assistant Professor of German

Marcia G. Williams, Ph.D.
Assistant Professor of French and Humanities (Absent, Fall)

Lecturers

Primus Benedict Bon, M.A.
Renata Hofman Briggs
Stella Berger Greenfield, M.A.
Claire Jeanne Kramsch, M.A.
Katherine T. O'Connor, Ph.D.
Ilona Ricardo-Kinzer, Ph.D.
Martha M. Schecter, M.A.
Magda Tisza, M.L.S. (Absent, Fall)

Administrative Officer

Margot H. Pelkey

Professors Emeriti

Margaret Zaroodny Freeman, S.M.
Associate Professor of Russian, Emerita

Roman Jakobson, Ph.D.
Institute Professor, Emeritus

Herman Klugman, Ph.D.
Assistant Professor of Modern Languages, Emeritus

Richard Felix Koch, A.M.
Assistant Professor of Modern Languages, Emeritus

William Nash Locke, Ph.D.
Professor of Modern Languages
Director of Libraries, Emeritus

George Alexandrovich Znamensky, B.D., Ed.M.
Assistant Professor of Russian, Emeritus

The Department of Foreign Literatures and Linguistics provides instruction on several levels in German, French, and Russian and on the elementary level in Spanish. 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, and compositions and discussions in the foreign language based on the reading material. Advanced subjects, normally 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 provides facilities for hearing and speaking languages at all levels.

Undergraduate Study

The Department of Foreign Literatures and Linguistics has no undergraduate degree program, but students may major in an area of Humanities, concentrating in French, Russian, or German Literature, or may take subjects in foreign literatures and linguistics for elective credit in other degree programs.

Certain subjects offered by the Department appear on the Distribution list of the Institute Requirement in the Humanities, Arts, and Social Sciences. The Department also offers subjects that can make up a concentration under the same requirement. The Department cooperates with the Department of Humanities in the Interdepartmental Russian Studies Program.

Undergraduate subjects offered in linguistics permit students to explore the structural and semantic relationships of language and to examine problems in linguistics and their possible solutions.

In choosing language subjects, students should bear in mind that credit towards graduation will not be given for repeating work offered for admission.

Graduate Study

The Department offers subjects for graduate students in several foreign languages and literatures and in linguistics. It also provides a program leading to the Doctor of Philosophy.

For departments which have a foreign language requirement, two-term subjects in French, German, and Russian, open to graduate students only, are designed to help develop intermediate competence in the reading of both technical and general materials. There are parallel two-term subjects in the same languages, also open to graduate students only, which aim to develop intermediate competence in the listening, speaking, and reading skills. Subjects 23.371 Spanish I and 23.372 Spanish II are open to both undergraduates and graduate students.

Doctor of Philosophy

The program of study leading to the Doctor of Philosophy 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 III and, in general, must have done well in previous academic work. The student must also be formally accepted by the Department of Foreign Literatures and Linguistics as a degree candidate. The Department does not require that applicants have taken any particular set of subjects or that they be trained in any particular discipline. Instead, applicants must present evidence that they are able to engage in serious study of complex subject matter. As examples of such evidence we might cite: 1) mastery in depth of a language or group of languages, e.g. classical Greek, Semitic, Japanese; 2) original research (publications, projects, etc.); 3) academic work of high quality in mathematics, the natural sciences, philosophy, psychology, history, linguistics, theory of literature, etc.; and 4) work experience in a relevant area, especially if it required considerable application, imagination, or ingenuity.

The following subjects are normally required of all doctoral candidates in linguistics, unless they have obtained adequate preparation elsewhere:

23.751	Introduction to Linguistics I: Syntax
23.761	Introduction to Linguistics II: Phonology
23.752	Introduction to Linguistics III: Theory of Grammar
23.762	Advanced Phonology
23.782	Linguistic Change
23.771	Mathematical Backgrounds for Communication Sciences
23.792	Survey of General Linguistics
23.741	*or* 23.742 Topics in the Grammar of a Non-Indo-European Language
23.755	Linguistic Structure

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 papers, one on phonology and the other on syntax, the topics to be chosen in consultation with members of the faculty. 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.

Inquiries

Additional information concerning academic programs in the Department, admission, financial aid, etc. may be obtained from Professor James W. Harris, M.I.T., Room 14N-207, Cambridge, Massachusetts 02139, (617) 253-4771.

Subjects in Foreign Literatures and Linguistics*

(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.

23.011	The Greek Tradition
23.021	The Judaeo-Christian Tradition
23.031	The Nature of Literature
23.11	German I
23.12	German II
23.13	German III
23.14	German IV
23.141	Introduction to German Poetry
23.143	German Civilization I (1848–1945)
23.144	German Civilization II (1945 to the Present)
23.15	Goethe's Poetry
23.171	Spoken German I
23.172	Spoken German II
23.173	German Reading I
23.174	German Reading II
23.19	Goethe's "Faust"
23.20	Seminar in German Poetry
23.21	Modern German Drama
23.22	Modern German Fiction
23.23	German Comedy
23.24	The World of Kafka
23.25	Brecht and German Literature between the Wars
23.371	Spanish I
23.372	Spanish II
23.51	French I
23.52	French II
23.53	French III
23.54	French IV
23.541	French Civilization I
23.543	French Civilization II
23.571	Spoken French I
23.572	Spoken French II
23.573	French Reading I
23.574	French Reading II
23.580	Seminar on Voltaire
23.582	Seminar on Rousseau
23.61	Contemporary French Drama
23.62	French Romanticism
23.631	French Prose Fiction III
23.632	French Prose Fiction I
23.634	French Prose Fiction II
23.64	Seminar in French Literature
23.65	Classical French Drama
23.66	Modern French Poetry
23.700J	Language and Its Structure
23.702	Seminar on Current Issues in Linguistics
23.705	Seminar on Poetic Form
23.706J	Linguistics and Literary Study (A)
23.711	Special Problems in Language and Literature
23.712	Special Problems in Language and Literature
23.723J	Semantics and the Philosophy of Language (A)
23.724J	Advanced Semantics (A)
23.731	Linguistic Structures: Romance (A)
23.733J	History of the English Language (A)
23.734	Structure of Russian (A)
23.736	Structure of German (A)
23.741	Topics in the Grammar of a Non-Indo-European Language (A)
23.742	Topics in the Grammar of a Non-Indo-European Language (A)
23.751	Introduction to Linguistics I: Syntax
23.752	Introduction to Linguistics III: Theory of Grammar (A)
23.753	Advanced Grammar I (A)
23.754	Advanced Grammar II (A)
23.755	Linguistic Structure (A)
23.756	Introduction to Linguistics IV: Universal Grammar (A)
23.759	Workshop in Syntax (A)
23.761	Introduction to Linguistics II: Phonology
23.762	Advanced Phonology (A)
23.764	Theory of Phonology
23.766J	Laboratory on the Physiology, Acoustics and Perception of Speech (A)
23.768J	Speech Communication (A)
23.769	Workshop in Phonology (A)
23.771	Mathematical Backgrounds for Communication Sciences
23.782	Linguistic Change (A)
23.792	Survey of General Linguistics I (A)
23.793	Tutorial in Linguistics and Related Fields (A)
23.91	Russian I
23.92	Russian II
23.922	Russian Review
23.93	Russian III
23.94	Russian IV
23.951	Russian Civilization
23.952	Structure of Russian
23.953	History of the Russian Language
23.960	Introduction to Russian Literature I
23.962	Introduction to Russian Literature II
23.963	Studies in Russian Prose: Gogol
23.965	Modern Russian Poetry
23.967	Contemporary Russian Prose and Poetry
23.971	Spoken Russian I
23.972	Spoken Russian II
23.973	Russian Reading I
23.974	Russian Reading II
23.980	Classical Writers and Literary Methodology in Russia
23.981	How is Poetry Made?
23.982J	How is Prose Made?
23.985	The Russian Short Story and the 19th Century
23.986	Russian Prose and the "Thaw"
23.987	Classics of the 19th Century Russian Prose
23.989	Tolstoy's "Anna Karenina"
23.993	Seminar on Tolstoy's "War and Peace"
23.994	Mayakovsky and Pasternak
23.995	Seminar on the Prose of A. Solzhenitsyn
23.996	Chekhov as Prose Writer
23.997	Dostoevsky
23.998	Symbolist and Experimentalist Prose of the Early Soviet Period

*Full descriptions of all subjects are given in the catalogue entitled **Courses and Degree Programs, 1974–75**, which may be obtained by writing to the Institute Information Services, Room 7-111, M.I.T.

Department of Humanities

Harold John Hanham, Ph.D.
Professor of History and Political Science
Acting Head of the Department
Dean of the School of Humanities and Social Science

Professors

Lynwood Silvester Bryant, A.M.
Professor of History and American Studies, Emeritus
Senior Lecturer

Richard Mateer Douglas, Ph.D.
Professor of History

David Mayer Epstein, Ph.D.
Professor of Music
Conductor of the M.I.T. Symphony Orchestra

Joseph Dee Everingham, M.A.
Professor of Literature
Director of Drama

Eugene Goodheart, Ph.D.
Professor of Literature

Albert Ramsdell Gurney, Jr., M.F.A.
Professor of Literature

Edward Neal Hartley, A.M.
Professor of History
Institute Archivist

Louis Kampf, B.A.
Professor of Literature

Alvin Charles Kibel, Ph.D.
Professor of Literature

Roy Lamson, Ph.D.
Class of 1922 Professor of Literature, Emeritus
Senior Lecturer
Special Assistant to the President for the Arts

Klaus Liepmann
Professor of Music, Emeritus
Director of Music, Emeritus
Senior Lecturer

Robert Ellsworth MacMaster, Ph.D.
Professor of History and Literature

Thomas Henry Donald Mahoney, Ph.D.
Professor of History

Bruce Mazlish, Ph.D.
Professor of History

Wayne O'Neil, Ph.D.
Professor of Literature

Robert Reynolds Rathbone, A.M.
Professor of Literature

Harald A. T. Olsen Reiche, Ph.D.
Professor of Classics and Philosophy

Robert I. Rotberg, Ph.D.
Professor of History and Political Science

Nathan Sivin, Ph.D.
Professor of the History of Science and of Chinese Culture

Barry Bernard Spacks, M.A.
Professor of Literature

Theodore Wood, Jr., S.B., A.M.
Professor of Literature and American Studies

Associate Professors

John La Boiteaux Buttrick, M.S.
Associate Professor of Music

Martin Diskin, Ph.D.
Associate Professor of Anthropology

Stephen Erdely, Ph.D.
Associate Professor of Music

Robert M. Fogelson, Ph.D.
Associate Professor of History and City Planning

John Harbison, M.F.A.
Associate Professor of Music

Arthur Daniel Kaledin, Ph.D.
Associate Professor of History and American Studies

Heather Nan Lechtman, M.A.
Associate Professor of Archaeology and Ancient Technology

Travis Rhodes Merritt, Ph.D.
Associate Professor of Literature

David Bird Ralston, Ph.D.
Associate Professor of History
(Absent)

Arthur Steinberg, Ph.D.
Associate Professor of History and Archaeology

Barry Lloyd Vercoe, D.M.A.
Associate Professor of Music

William Braasch Watson, Ph.D.
Associate Professor of History
(Absent)

Assistant Professors

Elizabeth C. Altman, Ph.D.
Assistant Professor of History

Floyd Barrington Barbour, A.B.
Assistant Professor of Literature

Donald Howard Bell, Ph.D.
Assistant Professor of History

Alan Victor Berger, M.A.
Assistant Professor of Literature
(Absent)

Murray John Kingston Biggs, M.A.
Assistant Professor of Literature

Myra Brenner, Ph.D.
Assistant Professor of Literature

Elzbieta Chodakowska-Ettinger, Ph.D.
Assistant Professor of Literature
(Visiting)

Patricia Cumming, M.A.
Assistant Professor of Literature

Peter Samuel Donaldson, Ph.D.
Assistant Professor of Literature

Martin D. Farren, Ph.D.
Assistant Professor of Music

Michael Brewster Folsom, Ph.D.
Assistant Professor of Literature and American Studies

Rufus Eugene Hallmark, Jr., M.A.
Assistant Professor of Music

Peter Herman, M.A.
Assistant Professor of Literature

Nancy Jo Hoffman, Ph.D.
Assistant Professor of Literature
(Absent)

Janet Ruth Horowitz, Ph.D.
Assistant Professor of Literature

James Howe, Ph.D.
Assistant Professor of Anthropology

Jean Elizabeth Jackson, Ph.D.
Assistant Professor of Anthropology

Sanford Kaye, M.A.
Assistant Professor of Literature

Richard Max Koffler, Ph.D.
Assistant Professor of Literature
(Absent)

Ruth Perry, Ph.D.
Assistant Professor of Literature

Donald Sur, M.F.A.
Assistant Professor of Music

Marcus Aurelius Thompson, D.M.A.
Assistant Professor of Music

Dan Seligsberger White, Ph.D.
Assistant Professor of History

Lewis David Wurgaft, Ph.D.
Assistant Professor of History

Lecturers

Paul Bontemps, B.A.
Joseph Stanley Brown, M.A.
John Cook, Mus.B.
Institute Organist
Nancy Zilboorg Dworsky, Ph.D.
Adrianus Johanes Maria Houtsma, Ph.D.
Barbara Jane Sirota, M.A.
Richard Wayne Wertz, Ph.D.
(Absent)

Instructors

Anne Vaughan Hallmark, M.F.A.
Wilma E. Wetterstrom, M.A.

Administrative Officer

Ruth Eleanor Dubois, A.B., S.B.

Professors Emeriti

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Dean of the School of Humanities and Social Science, Emeritus

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Professor of Literature, Emeritus

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Professor of Music, Emeritus
Director of Music, Emeritus
Senior Lecturer

Cyril Stanley Smith, Sc.D.
Institute Professor, Emeritus
Professor of the History of Science and Technology, Emeritus
Professor of Metallurgy, Emeritus

Robert Smith Woodbury, S.B., A.M.
Professor of the History of Technology, Emeritus

Department of Humanities

In its efforts to achieve a balanced curriculum for all undergraduates, the Department of Humanities provides both a required and an elective program in history, literature, history and philosophy of science, anthropology/archaeology, music, drama, and writing. In addition, the Department of Humanities offers three undergraduate programs which combine the basic subjects in science and engineering with a concentrated program in the humanities; these programs are Humanities and Engineering (Course XXI-A) and Humanities and Science (Course XXI-B, Programs 1 and 2).

Bachelor of Science in Humanities and Engineering
Course XXI-A; and
Bachelor of Science in Humanities and Science
Course XXI-B, Program 1

These two undergraduate programs in humanities and engineering and humanities and science offer an education from which students have gone on to graduate study in engineering, science, and the humanities, and into teaching, law, linguistics, medicine, business, as well as a variety of other fields.

Because of their flexibility, these programs provide a wide choice of electives, especially in the third and fourth years. Students may devote more than half of their studies to humanities and the remainder to science or engineering, developing special interests in any combination of the subject areas. Both programs lead to a Bachelor of Science at the end of the senior year. Students may continue for a fifth year to earn a second Bachelor of Science in the particular field of science or engineering studied as an undergraduate. In some cases the fifth year may lead to a Master of Science.

Built on the base provided by the Institute's general requirements in mathematics, physics, chemistry, and the humanities, arts, and social sciences, each of these programs provides a total curriculum of unusual scope and balance. One part is the undergraduate curriculum of a science or engineering department, shortened through omission of certain of the more specialized or technical subjects. The other part consists of subjects in the humanities, chosen by each student in consultation with a faculty advisor from one of the various disciplines of the Department of Humanities or the Department of Foreign Literatures and Linguistics. Fields available for concentration include: literature (English, American, French, German, Russian, or comparative literature); history; anthropology/archaeology; philosophy; or music. Study combining psychology and humanities is also available. Beginning in 1974–75 students will also have available to them programs in American Studies, Russian Studies, and Writing and Literature. See below for descriptions of these and other new programs.

An experimental program in Social Inquiry, consisting of seminars and subjects in different disciplines, provides an option in which students in Course XXI-A and Course XXI-B, Program 1 can combine a field of engineering or science with the study of social, political, and cultural issues in contemporary society. The option is also available to students in Course XXI-B, Program 2 as a way of satisfying the minor field requirement.

In the fourth year members of Course XXI-A and Course XXI-B, Program 1 participate in a humanities seminar, interdisciplinary in character, which examines a single topic from several perspectives. A senior thesis is also required of students in both dual degree programs (Courses XXI-A and XXI-B, Program 1) and in most of the Course XXI-B, 2 Programs.

Bachelor of Science in Humanities and Engineering
Course XXI-A

	General Institute Requirements		Total Units
	Specific science and humanities and social science subjects		132
	Science Distribution Requirement		36
	Laboratory Requirement		12
	Departmental Program		
	Required Subjects[1]		
21.08	Humanities Seminar	3 0 9	26
	Thesis	14	
	Restricted Electives[2]		102
	Elective Subjects restricted to one of the following Humanities disciplines Fields or Programs: History, Literature, Philosophy, Music, Anthropology/Archaeology, Social Inquiry, Russian Studies, American Studies, Writing & Literature	54	
	Elective subjects restricted to one of the engineering curricula	48	
	Unrestricted Electives		52
	Total Units required for the S.B. Degree		360

1
Students in the American Studies program are also required to take 21.082 (Seminar in American Studies), thus increasing the required units to 35 and reducing unrestricted elective units to 43. Students in the Writing & Literature program are also required to take the senior Writing Seminar; their required units will be 35, while their unrestricted elective units will be 43. Students in Music may be required to take a General Examination in Music rather than write a thesis. Such students will take two additional subjects in Music. For students in Anthropology/Archaeology, 21.025 is strongly recommended. For students in Russian Studies the "thesis" may consist of a special project such as field work or a translation, a general examination, or a regular research thesis.

2
Students in the American Studies program are asked to take at least two subjects in American History, at least 2 in American Literature, and the rest from a list of American Studies subjects selected from various fields. Students in Writing & Literature are asked to take three subjects in Writing and three in Literature. Students in Russian Studies are required to take at least two subjects on Russian society (e.g. history, political science) and at least two on Russian Culture (e.g. literature).

Bachelor of Science in Humanities and Science
Course XXI-B, Program 1

	General Institute Requirements		Total Units
	Specific science and humanities and social science subjects		132
	Science Distribution Requirement		36
	Laboratory Requirement		12
	Departmental Program		
	Required Subjects[1]		
21.08	Humanities Seminar	3 0 9	26
	Thesis	14	
	Restricted Electives[2] Elective Subjects restricted to one of the following Humanities disciplines, Fields or Programs: History, Literature, Philosophy, Music, Anthropology/Archaeology, Social Inquiry, Russian Studies, American Studies, Writing & Literature	54	102
	Elective subjects restricted to one of the science curricula or to psychology		48
	Unrestricted Electives		52
	Total Units required for the S.B. Degree		360

1
Students in the American Studies program are also required to take 21.082 (Seminar in American Studies), thus increasing the required units to 35 and reducing unrestricted elective units to 43. Students in the Writing & Literature program are also required to take the senior Writing Seminar; their required units will be 35, while their unrestricted elective units will be 43. Students in Music may be required to take a General Examination in Music rather than write a thesis. Such students will take two additional subjects in Music. For students in Anthropology/Archaeology, 21.025 is strongly recommended. For students in Russian Studies the "thesis" may consist of a special project such as field work or a translation, a general examination, or a regular research thesis.
2
Students in the American Studies program are asked to take at least two subjects in American History, at least 2 in American Literature, and the rest from a list of American Studies subjects selected from various fields. Students in Writing & Literature are asked to take three subjects in Writing and three in Literature. Students in Russian Studies are required to take at least two subjects on Russian society (e.g. history, political science) and at least two on Russian Culture (e.g. literature).

Bachelor of Science in Humanities and Science
Course XXI-B, Program 2

This program provides a concentration or a major in history, literature, anthropology, music, or writing and literature. Like other branches in the Department of Humanities, the program is based on the regular Institute requirements in science and humanities, but provides an opportunity to study the humanities 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 related fields 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 taught in the Institute, allowing students to increase their concentrations in chosen disciplines or to broaden intellectual interests by studies in fields outside the areas of concentration. Depending upon the field of specialization, a seminar devoted to advanced study may be required in the junior or senior year and a thesis 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.

Bachelor of Science in Humanities and Science
Course XXI-B, Program 2

	General Institute Requirements		Total Units
	Specific science and humanities and social science subjects		132
	Science Distribution Requirement		36
	Laboratory Requirement		12
	Departmental Programs		
	Restricted Electives One of the following:		126 to 144
	History		
21.081	History Seminar	2 0 8	
	Thesis	14	
	Elective subjects in History	72	
	Elective subjects in a second discipline of humanities, social science, visual arts, foreign literatures or linguistics, social inquiry	36	
	Literature		
	Elective subjects in Literature	90	
	Elective subjects in a second discipline of humanities, social science, visual arts, foreign literatures or linguistics, social inquiry	36	
	Music[1]		
	Thesis or General Examination	18	
	Four subjects in Writing and Analysis (21.821, 21.822, 21.823 and 21.824)	36	
	Four subjects in the history of Music	36	
	Two additional electives in Music	18	
	Elective subjects in a second discipline of humanities, social science, visual arts, foreign literatures or linguistics, social inquiry.	36	
	Restricted Electives continued		
	Anthropology/Archaeology[2]		
	Thesis	18	
	Elective subjects in Anthropology/Archaeology (to include 21.061, 21.062, and 21.063)	72	
	Elective subjects in a second discipline of humanities, social science, visual arts, foreign literatures or linguistics, social inquiry	36	
	Writing and Literature[3]		
	Thesis and Thesis Seminar	23	
	Four subjects in Writing (including at least one in prose or narrative)		
	Four subjects in Literature	72	
	Elective subjects in a second discipline of humanities, social science, visual arts, foreign literatures or linguistics, social inquiry	36	131
	Unrestricted Electives		54 to 36
	Total units required for the S.B. degree		360

1
Students in Music will also be required to take ear training and basic piano as a non-credit adjunct to the writing subjects, as well as at least two semesters of ensemble work, also non-credit. Music majors will ordinarily take a General Examination in Music during the final term, investigating their writing skills, hearing ability, historical knowledge and general background. Especially qualified students may be permitted to substitute an analytical or historical thesis, or one in strict composition.
2
Students in Anthropology/Archaeology are strongly urged to take 21.025, An Introduction to Anthropology, in addition to the required program. The thesis might consist of a field project, a special senior seminar, or a regular research thesis.
3
Students in Writing and Literature are strongly urged to take 21.023 and 21.024, Writing and Experience.

Special Interdisciplinary Programs

Beginning in 1974–75, several new interdisciplinary programs will be available to undergraduates. These are described below. Interested students may obtain more information about them in the Course XXI office, 14N–305, 253-4446.

Crossroads

Crossroads is a program that draws on the insights of literature, history, philosophy (and other disciplines as appropriate) to define the cultural focus of particular periods and places in our tradition. Among the subjects there are many differences of theme and emphasis arising from the varying nature of the material, as well as from the diverse interests and expertise of individual teachers. There are, however, two general features common to all. One is a concern, within each period of study, with the most vital elements of the culture in question — what gave the culture its specific intellectual or artistic or political distinction, and in particular with those clashes of thought and perspective, either within the culture itself or in contrast with other cultures, that rendered it memorable for subsequent ages. The second concern is with the means by which these periods have made themselves available to us, especially with those articles in the written record which not only were significant in their original context but have proved to be unusually suggestive to and influential upon the minds of later generations. The aim of the program is to make available to students the opportunity to gain a deeper understanding both of particular significant eras in the cultural past and of important changes and continuities in western culture. Beginning in 1974–75, Crossroads will be available to students as a concentration.

21.011	The Greeks
21.012	The Bible and Western Values
21.013	The Northern Renaissance and the Reformation
21.014	The Enlightenment: Reason and Religion
21.015	Romanticism and Ideas of Revolution
21.016	Ideology and the Modern Ideas

American Studies

American Studies at M.I.T. offers undergraduates the opportunity to organize subjects from various disciplines into coherent interdisciplinary programs, as a way both of exploring different approaches to the study of society and culture and of gaining an integrated understanding of American society and culture. Beginning in 1974 students will be able to major in American Studies as part of the dual degree programs (Course XXI-A and Course XXI-B, Program 1) in the Department of Humanities. Planning is under way to establish a full major in 1975. Though the American Studies subjects listed below are drawn wholly from the various curricula of the Department of Humanities, selected subjects from other Departments (e.g., 17.08, 17.21–.29, 14.71, 11.05, 11.05, 11.10, 11.50, 11.561, 4.651, 4.655, 4.675 among others) will be considered suitable for students in this field and will formally be added to the American Studies list in the future. American Studies will also be available as a Field of Concentration to students. Each student in American Studies, whether majoring or concentrating in the field, will shape his or her program in consultation with an American Studies advisor.

21.082	Seminar in American Studies
21.019	Culture and Society in America: The Rise of a Technological Civilization
21.020	Culture and Society in America: The Technological Society
21.021	Identity and Purpose in Black America
21.022	Myth, Legend, and Science: The Dilemma of the Black Bourgeoisie
21.042J	American Urban History
21.043J	American Urban History
21.05	Politics and Society in 20th Century America
21.051	American Intellectual History
21.055	Early America: From the Puritans to the Revolution
21.181	Black Literature in America
21.182	Black Literature II
21.183	Black Drama
21.184	Black Autobiography
21.251	Readings in Modern English and American Poetry
21.308	Literature and Lore of the American West
21.309	T. S. Eliot
21.314	Major Authors: Mark Twain
21.33	Popular Culture and Mass Media
21.351	Three American Novelists: Fitzgerald, Hemingway and Faulkner
21.418	Industrialization, Technology, and Social Change in Western Europe and America, 1750 to the Present
21.423	History of the Automobile
21.426	History of Technology in the United States
21.427	American Business History
21.519	Democracy in America and Its Critics
21.541	The American Revolution
21.883	American and European Musical Folklore
21.946	The Sociological Tradition II: Social Criticism and Social Science in America
21.958	Education and Society I
21.965	Religion and Society in America
21.972	Black Separatism and Black Culture
21.973	Black Cultural Adaptations to Machine-Age Society
21.997	American Values of the 1920's
21.998	American Values of the 1930's
21.901	Special Topics in Interdisciplinary Studies
21.902	Special Topics in Interdisciplinary Studies

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 a concentration 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, anthropology, music, 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 contact Professors Eugene Goodheart or Alvin C. Kibel at M.I.T.

The following subjects will be offered by the Cambridge Humanities Seminar in 1974–1975 (see subject listings for fuller descriptions):

21.751	The Aesthetic Movement in the Nineteenth Century
21.752J	Concepts of Love in the Western World
21.753	Utopian Fiction
21.754	Fathers and Sons
21.755	The Strategies of "Modernism" in the Arts
21.757	The Family in Latin America
21.758	Classic to Romantic: Blake

Russian Studies

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 man 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 regular Institute Humanities Concentration Requirement or, more intensively, for work toward the degree in Course XXI-A or XXI-B, Program 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.

The following is the present list of subjects within the Russian Studies Program:

	Imperial and Soviet Russia
21.04	Revolution in the Twentieth Century
21.517	Russia: Orthodoxy, Autocracy and Rebellion
21.29	Dostoevsky, Tolstoi, Chekhov: Russia and the Modern Age
23.987	Classics of 19th Century Russian Prose
	Soviet Russia
17.801	Communism and Revolution
21.522	Marx, Darwin, and Freud
23.986	Russian Prose and the "Thaw"
23.994	Mayakovsky and Pasternak
23.995	The Prose of Alexander Solzhenitsyn
23.998	Symbolist and Experimentalist Prose of the Early Soviet Period
	Seminars
23.993	Tolstoi's *War and Peace*
23.997	Dostoevsky
21.901	Special Topics in Interdisciplinary Studies
21.902	Special Topics in Interdisciplinary Studies

Writing and Literature

The degree programs in Writing and Literature represent a new approach to the task of linking humanistic study and scientific education, offering to students in the humanities, as well as to those in science, the opportunity to develop a high level of competency in writing at the same time as they are engaged in studying the best literature of the past. Hence, the student's educational experience, involving both theory and practice provides, as well, the necessary perspective of tradition, whether in the history of imaginative literature, or in a specific field of interest selected for a joint major in humanities and science. The subjects in writing open to undergraduates at M.I.T. are listed below. New subjects will be added in the coming year. (Literature subjects are described under Course XXI.) Each student in a Writing and Literature degree program structures his or her course of study in consultation with an advisor from the writing staff. Available as options in the XXI-A, XXI-B-1, and XXI-B-2 programs.

21.023	Writing and Experience I
21.024	Writing and Experience II
21.10	Scientific and Engineering Writing
21.101	Writing Workshop
21.102	The Writing of Fiction
21.103	The Writing of Poetry
21.105	The Writing of Prose
21.106	Prose Writing
21.96	Special Topics in Education
4.056	Evaluating Photography
21.945	Rhetoric and Journalism
21.083	Thesis Seminar
21.391	Special Topics in Literature
21.392	Special Topics in Literature

Inquiries

Additional information concerning academic programs in the Department, admission, financial aid, etc. may be obtained from the Director of Course XXI, Room 14N-305, M.I.T., Cambridge, Massachusetts 02139, (617) 253-4446.

Subjects in the 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.

21.U.R.	Research in Humanities
21.011	The Greeks
21.012	The Bible and Western Values
21.013	The Northern Renaissance and the Reformation
21.014	The Enlightenment: Reason and Religion
21.015	Romanticism and Ideas of Revolution
21.016	Ideology and the Modern Age
21.019	Culture and Society in America: The Rise of a Technological Civilization
21.020	Culture and Society in America: The Technological Society
21.021	Identity and Purpose in Black America
21.022	Myth, Legend and Science: The Dilemma of the Black Bourgeoisie
21.023	Writing and Experience I
21.024	Writing and Experience II
21.025	An Introduction to Anthropology
21.027	Modern World History I
21.028	Modern World History II
21.03	Approaches to Literature: Criteria for Judgment
21.031	Approaches to Literature: Structure and Technique in Literature
21.032	Approaches to Literature: The Adolescent in Literature
21.033	Approaches to Literature: Introduction to Literary Analysis
21.034	Approaches to Literature — Brave New Worlds: Modern America and Russia
21.04	Revolution in the Twentieth Century
21.041	Rationalism and Radicalism: The Dilemma of Liberal Society from Cromwell to Hitler
21.042J	American Urban History
21.043J	American Urban History
21.044	Intellectual History of Modern Europe, 1850 to the Present
21.045	Intellectual History of Modern Europe, 1750–1850
21.046	Europe, 1763–1848: The Era of Revolutions
21.047	Europe, 1848–1919: Nationalism, Liberalism, Democracy and War
21.048	Europe 1917–1948: The Era of Mass Politics
21.049	Reconstruction of Europe, 1945–65
21.05	Politics and Society in 20th Century America
21.051	American Intellectual History
21.052	The Emergence of Modern Africa
21.053J	Introduction to Africa
21.054	China, Japan, and the West
21.055	Early America: From the Puritans to the Revolution
21.061	Studying Cultures
21.062	Approaches to Archaeology
21.063	Issues and Ideas in Anthropology
21.07	Introduction to Music
21.08	Humanities Seminar
21.081	History Seminar: Problems of Historical Inquiry
21.082	Seminar in American Studies
21.083	Thesis Seminar

Subjects in Writing

21.10	Scientific and Engineering Writing
21.101	Writing Workshop
21.102	The Writing of Fiction
21.103	The Writing of Poetry
21.105	The Writing of Prose
21.106	Prose Writing

Literature

21.12	What is Literature?
21.121	Greek Literature I
21.122	Greek Literature II
21.13	The Epic
21.132	The Realistic Novel
21.15	Shakespeare
21.151	Shakespearean Tragedy
21.152	Shakespeare's Contemporaries in the Theatre
21.16	Chaucer
21.169J	How is Prose Made?
21.17	Renaissance Literature 1500–1660: Magic and the Arts of Government
21.173	Romanticism
21.181	Black Literature in America
21.182	Black Literature II
21.183	Black Drama
21.184	Black Autobiography
21.251	Readings in Modern English and American Poetry
21.261J	Philosophy of the Arts
21.273	Lyric Poetry: Practice and Theory
21.276	The Short Story
21.28	Theatre Arts: Elementary Stagecraft and Production Studies
21.281	Modern Drama
21.283	Tragedy
21.284	Comedy
21.285	Film: Watching/Analyzing
21.286	Pageants, Progresses, Street Theatre and Other Improvisations
21.29	Dostoevsky, Tolstoi, Chekhov: Russia and the Modern Age
21.302	Chinese Literature
21.308	Literature and Lore of the American West
21.309	T. S. Eliot

*Full descriptions of all subjects are given in the catalogue entitled **Courses and Degree Programs, 1974–75**, which may be obtained by writing to the Institute Information Services, Room 7-111, M.I.T.

21.31	Modern Fiction
21.312	Ulysses: Text and Context
21.313	Major Authors: Dostoevsky
21.314	Major Authors: Mark Twain
21.315	Dickens and Twain
21.316	Novels by Women
21.317	Poetry and the Female Consciousness
21.318J	Language and Its Structure
21.319J	History of the English Language (A)
21.32	Victorian Literature
21.322	Contemporary Literature
21.323	Problems of Contemporary Art
21.33	Popular Culture and Mass Media
21.331	Fantasy Fiction
21.34	Realism and Surrealism
21.35	Hardy and Lawrence
21.351	Three American Novelists: Fitzgerald, Hemingway, and Faulkner
21.361	The Origins of the Novel
21.363	Sex Roles and Literature I
21.364	Sex Roles and Literature II
21.365	Sexual Politics in Modern Literature
21.37	Madness
21.371	Traditions of Science in Literature

Special Seminars in Literature

21.381	Revolutionary Attitudes
21.384J	Linguistics and Literary Study (A)
21.391	Special Topics in Literature
21.392	Special Topics in Literature

History

21.411	History of Engineering
21.412	History of Engineering
21.418	Industrialization, Technology, and Social Change in Western Europe and America, 1750 to the Present
21.423	History of the Automobile
21.426	History of Technology in the United States
21.427	American Business History
21.473	Rome: Reality and Idea
21.476	The Italian Renaissance
21.489	The Family in Industrial Society
21.514	The Old Regime in Transition
21.517	Russia: Orthodoxy, Autocracy, and Rebellion
21.518	Anarchism
21.519	Democracy in America and Its Critics
21.522	Marx, Darwin, and Freud
21.523	Psychoanalytic Social Thought
21.524	History and Psychoanalysis: Life History
21.525	History and Psychoanalysis: Group History
21.541	The American Revolution
21.548	Vienna and Versailles
21.551J	Nationalism and Nation Building in 20th Century Africa
21.552	The Soviet Union: A Communist Society in Historical Perspective
21.554	Spanish Civil War, 1936–39
21.578J	Research Seminar in Imperialism and Colonialism (A)
21.579J	Race Relations, Politics and Development in the Caribbean (A)
21.581	Special Topics in History
21.582	Special Topics in History

Anthropology

21.621	Cultures and Societies of Modern Mexico
21.623	Cultures and Societies of South America
21.632	Mesoamerican and Andean Prehistory — An Ecological Perspective
21.641J	Art, Materials, and Culture
21.642	Archaeology of Technology
21.643J	Comparative Ancient Technologies
21.651	Archaeology of Urbanization
21.682	Archaeological Theory and Methods
21.683	Language and Culture
21.684	Peasant Society
21.685	Hunting and Gathering Peoples
21.686	Symbolic Anthropology
21.687	Political Anthropology
21.691	Women in Cross-Cultural Perspective
21.692	Nutrition in Sociocultural Systems
21.698	Special Topics in Anthropology
21.699	Special Topics in Anthropology

The Cambridge Humanities Seminar

21.751	The Aesthetic Movement in the Nineteenth Century
21.752J	Concepts of Love in the Western World
21.753	Utopian Fiction
21.754	Fathers and Sons
21.755	The Strategies of "Modernism" in the Arts
21.756	Film Theory
21.757	The Family in Latin America
21.758	Classic to Romantic: Blake

Continued on next page

	Music
21.80	Elements of Music
21.811	History of European Music I
21.812	History of European Music II
21.813	The Symphony
21.814	The Orchestra From Monteverdi to Stravinsky
21.82	Practical Harmony
21.821	Writing and Analysis I
21.822	Writing and Analysis II
21.823	Writing and Analysis III
21.824	Writing and Analysis IV
21.826	Analysis of Musical Structure
21.827	Strict Composition
21.828	Electronic Music Composition
21.83	Music in the Middle Ages
21.831	Music in the Renaissance
21.832	The First Musical Revolution
21.84	Music in the Baroque Period
21.841	J. S. Bach
21.842	Keyboard Music in the Baroque Epoch
21.851	Haydn, Mozart and Beethoven
21.86	Music in the Romantic Period
21.861	Beethoven
21.862	Poetry and Song
21.863	Music from Wagner to Schoenberg
21.871	Twentieth-Century Music
21.872	Twentieth-Century Music: Schoenberg, Berg and Webern
21.88	The Opera
21.881	Seminar in Music
21.882	Performance and Analysis
21.883	American and European Musical Folklore
21.884	Asian Music
21.885	Italian Opera
21.891	Special Topics in Music
21.892	Special Topics in Music
21.893	M.I.T. Symphony Orchestra: Analysis and Performance

	Special Interdisciplinary Subjects
21.901	Special Topics in Interdisciplinary Studies
21.902	Special Topics in Interdisciplinary Studies
21.903	Seminar on International Students and Participation in Development
21.904J	Special Topics in Graphic Communication
21.92J	Musical Acoustics
21.921	European Society and Culture in the Age of Revolution, 1760–1848
21.922	Musical Instrument Design
21.923	Musical Instrument Construction
21.931	Mathematics and Society
21.941J	Seminar in Technology and Society: Ethical and Social Issues in Bio-Medicine
21.945	Rhetoric and Journalism
21.946	The Sociological Tradition II: Social Criticism and Social Science in America
21.947	The Sociological Tradition I: The Classic European Sociologists
21.948	Greek Philosophy and Science I: The Presocratics
21.949	Greek Philosophy and Science II: Aristotle vs. Plato
21.951	Introduction to the Far East
21.952	Seminar in Chinese Culture
21.953	Marx and Marxism
21.955	Chinese Science and Natural Philosophy
21.956J	Science, Technology and Ritual
21.957	History and Theory of Nonviolent Action
21.958	Education and Society I
21.959	Education and Society II
21.96	Special Topics in Education
21.961	Seminar on Technology and Society: The Future
21.963	Technology, Values and Social Choice
21.964	Technology, Power, and Values
21.965	Religion and Society in America
21.972	Black Separatism and Black Culture
21.973	Black Cultural Adaptations to Machine-Age Society
21.981	Spectator Sports
21.995	Intellectuals and Social Change
21.997	American Values of the 1920's
21.998	American Values of the 1930's

Department of Philosophy

Richard Lee Cartwright, Ph.D.
Professor of Philosophy
Head of the Department

Professors

Sylvain Bromberger, Ph.D.
Professor of Philosophy

Jerry Alan Fodor, Ph.D.
Professor of Philosophy
Professor of Psycholinguistics

Jerrold Jacob Katz, Ph.D.
Professor of Philosophy
(Absent)

Irving Singer, Ph.D.
Professor of Philosophy

James Frederick Thomson, M.A.
Professor of Philosophy

Judith Jarvis Thomson, Ph.D.
Professor of Philosophy

Associate Professors

George Stephen Boolos, Ph.D.
Associate Professor of Philosophy

Boruch Alter Brody, Ph.D.
Associate Professor of Philosophy

Assistant Professors

Ned Joel Block, Ph.D.
Assistant Professor of Philosophy

Barbara Herman, B.A.
Assistant Professor of Philosophy

Paul Horwich, M.A.
Assistant Professor of Philosophy

James Kostman, B.Phil.
Assistant Professor of Philosophy

Izchak Miller, B.A.
Assistant Professor of Philosophy

Miles Morgan, B.A.
Assistant Professor of Philosophy

Administrative Assistant

Marilyn Matthes Silva, A.B.

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.

Although philosophy is a discipline in its own right, and one that places severe and somewhat unusual demands on its practitioners, it is also a discipline that requires acquaintance with other areas of inquiry. Students who concentrate in philosophy are therefore advised to acquire as thorough a knowledge as time permits of one or two other disciplines. Many disciplines are relevant to philosophy; among the more prominent of these are mathematics, physics, psychology, and linguistics.

Department of Philosophy

Undergraduate Study

Bachelor of Science in Philosophy Course XXIV

The Course leading to the Bachelor of Science in Philosophy 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.

Bachelor of Science in Philosophy Course XXIV

			Total units
	General Institute Requirements		
	Specific science and humanities and social science subjects		132
	Science Distribution Requirement		36
	Laboratory Requirement		12
	Departmental Program		
	Required Subjects		45
24.201	History of Philosophy I	3 0 6	
24.202	History of Philosophy II	3 0 6	
24.211	Theory of Knowledge	3 0 6	
24.231	Ethics	3 0 6	
24.241	Symbolic Logic	3 0 6	
	Restricted Electives A coherent program of 54 units of which 18 must be in philosophy and 36 in advanced subjects in some other discipline		54
	Unrestricted Electives		81
	Total Units Required for the S.B. Degree		360

Graduate Study

Doctor of Philosophy

The program of studies leading to the Doctor of Philosophy is designed to provide comprehensive training in modern philosophy, emphasizing particularly its analytical aspects. An arrangement is also available whereby selected students may pursue a program in the philosophy of a special science — linguistics, mathematics, physics, or psychology — while taking graduate work in that science.

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 Philosophy. Students planning to avail themselves of the arrangement to work on the philosophy of a special science must meet the requirements for admission to graduate study in that science. For all other students, the Department specifies the following prerequisites in place of the general requirements for admission: one full year of college mathematics; one full year of college work in science; and at least six term subjects in literature, history, or other humanities subjects equivalent in scope to those included in the undergraduate humanities curriculum of the Institute. Students with high academic ratings who are deficient to a minor extent in one or more of the above requirements may be permitted graduate registration while fulfilling the requirements at the Institute.

Before beginning dissertation research, students are required 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 are encouraged to take a minor in a field other than philosophy. Possibilities include linguistics, mathematics, physics, psychology, and other humanities or social sciences. There is no general language requirement for the doctorate, except in those cases where 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 Professor Richard L. Cartwright, Room 14N–434, M.I.T., Cambridge, Massachusetts 02139, (617) 253-4141.

Subjects in Philosophy*

(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.U.R.	Undergraduate Research
24.01	Contemporary Moral Issues
24.03	Logic, Language, and Science
24.05	Science and Philosophy
24.101	Problems of Philosophy
24.112	Modern Social Theory
24.113	Problems in the Theory of Sex
24.114J	Concepts of Love in the Western World
24.115	Private Property
24.116J	Seminar in Technology and Society: Ethical and Social Issues in Bio-Medicine
24.117J	IQ, Heredity and Inequality
24.121J	Philosophy of the Arts
24.131	Existentialism
24.151	Introduction to Philosophy of Language
24.161	Classics in the Philosophy of Science
24.201	History of Philosophy I
24.202	History of Philosophy II
24.208	Wittgenstein
24.211	Theory of Knowledge
24.221	Metaphysics
24.223	Philosophy of Mind
24.225J	Conceptual Problems in Psychology
24.231	Ethics
24.233J	Political Philosophy
24.241	Symbolic Logic
24.251	Philosophy of Science
24.253	Induction and Probability
24.261	Philosophy of Religion
24.271	Phenomenology
24.272	Topics in Phenomenology
24.292	Special Topics in Philosophy
24.293	Special Topics in Philosophy
24.401	Plato's Later Dialogues (A)
24.403	Aristotle (A)
24.411	The British Empiricists (A)
24.413	The Continental Rationalists (A)
24.415	Seminar on Kant's Ethics (A)
24.421	Background of Contemporary Philosophy (A)
24.425	Philosophy of G Frege (A)
24.501	Problems in Metaphysics (A)
24.511	Problems in Theory of Knowledge (A)
24.521	Topics in Philosophy of Mind (A)
24.525	Topics in the Theory of Action (A)
24.601	Moral Philosophy (A)
24.611J	Topics in Political Philosophy (A)
24.621	Aesthetics (A)
24.701	Topics in Logic (A)
24.703	Set Theory (A)
24.711	Philosophy of Logic (A)
24.723J	Semantics and the Philosophy of Language (A)
24.724J	Advanced Semantics (A)
24.727	Logic and Language (A)
24.801	Philosophy of Mathematics (A)
24.811	Philosophy of Physics (A)
24.821	Philosophy and the Life Sciences (A)
24.851	Problems of Explanation and Theory Formation (A)
24.921	Special Advanced Topics in Philosophy (A)
24.922	Special Advanced Topics in Philosophy (A)

*Full descriptions of all subjects are given in the catalogue entitled **Courses and Degree Programs, 1974–75**, which may be obtained by writing to the Institute Information Services, Room 7-111, M.I.T.

Department of Political Science

Myron Weiner, Ph.D.
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Head of the Department

Professors

Hayward Rose Alker, Jr., Ph.D.
Professor of Political Science

Donald Lawrence Morton Blackmer, Ph.D.
Professor of Political Science
Associate Dean, School of Humanities and Social Science

Lincoln Palmer Bloomfield, Ph.D.
Professor of Political Science

Walter Dean Burnham, Ph.D.
Professor of Political Science
(Absent)

Frederick Ward Frey, Ph.D.
Professor of Political Science

William Edgar Griffith, Ph.D.
Ford Professor of Political Science

Harold John Hanham, Ph.D.
Professor of History and Political Science
Dean, School of Humanities and Social Science

Harold Robert Isaacs, A.B.
Professor of Political Science

Willard Raymond Johnson, Ph.D.
Professor of Political Science

William Weed Kaufmann, Ph.D.
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Daniel Lerner, Ph.D.
Professor of Sociology

Ithiel de Sola Pool, Ph.D.
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Lucian Wilmot Pye, Ph.D.
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George William Rathjens, Ph.D.
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Robert Irwin Rotberg, D.Phil.
Professor of History and Political Science

Eugene Bertram Skolnikoff, Ph.D.
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Director, Center for International Studies

Associate Professors

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Lorenzo Morris, Ph.D.
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Jeffrey Leonard Pressman, Ph.D.
Assistant Professor of Political Science

Lecturers

Alan Anthony Altshuler, Ph.D.
Edwin Diamond, M.A.
David Myron Griffel, B.S.
Albert Gordon Hill, Ph.D.
James Rhyne Killian, Jr., LL.D., Sc.D., D.Eng., D.Appl. Sci., Ed.D., HH.D.
Franklin James Levinson, Ph.D.
Louis Menand, III, Ph.D.
Joel Yellin, Ph.D.

Instructor

Miles Morgan, B.A.

Administrative Officer

Elizabeth Terlingen-Merkle, Pharm.

Research Associates

Michael James Mitchell, M.A.
John Michael Ross, B.A.

Research Affiliates

E. Lovell Dyett, A.B.
Eugene Lichtenstein, Ph.D.

Professor Emeritus

Everett Hagen, Ph.D.
Professor of Economics and Political Science, Emeritus

Department of Political Science

Undergraduate Study

Political science is the systematic study of conflict and cooperation among people as members of society. As such, it explores the various roles of people in political conflict situations, the distribution and use of power, and the means and modes of conflict resolution. Instruction in the Department seeks to provide the professional competence that enables students to analyze, understand, and propose operative solutions to political conflicts of consequence to the national society and the international community. Undergraduate and graduate subjects equip each student with skills now available to assemble and structure empirical observations — including opinion surveys, political gaming, systems analyses, and computer simulation. Instruction focuses also on contemporary political conditions, born of sustained technological advance, rapid population increase, and changing economic circumstance as reflected in substantive areas of political science. Finally, within a diverse, yet increasingly rigorous discipline, emphasis falls on encouraging the general intellectual attributes of the scholar. Hence the stress is upon empirical and interdisciplinary research to ensure the widest possible grounding in knowledge relating to political values, behavior, and institutions.

Bachelor of Science in Political Science
Course XVII

	General Institute Requirements		Total units
	Specific science and humanities and social science subjects[1]		132
	Science Distribution Requirement[2]		36
	Laboratory Requirement		12
	The subject 17.01 which is among the Restricted Electives appears on the list of Laboratory Subjects and can be used to satisfy the Laboratory Requirement.		
	Departmental Program		
	Required Subjects		18
17.69	Pre-Thesis Reading Seminar	3 0 6	
	Thesis	9	
	Restricted Electives		81 or 84
	At least one subject from three of the following five groups		

1
Subjects in Field Seven (Political Science) may not be used for the humanities and social science requirement.

2
1.00 Information Systems (3-3-6). 18.312 Statistics for Applications (3-0-9) and 14.30 Introduction to Statistical Method in Economics (4-0-8) are suggested.

Bachelor of Science in Political Science
Course XVII

The political science curriculum for undergraduates introduces students to the normative and empirical theories and methodologies of the discipline. Additional subjects may be chosen from a wide variety of key specialized fields, including offerings solely for undergraduates (numbered 17.01–17.69), as well as a large number of graduate subjects in which undergraduates may normally enroll. Students' individualized programs are worked out with the aid of faculty counselors.

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. For this purpose, each undergraduate student is assigned a faculty thesis advisor. After deciding on the thesis topic during the junior year, the student must register for 17.69 Pre-thesis Reading Seminar (9 units) in the fall term and for Thesis (9 units) in the spring term of the senior year. In the Pre-thesis Seminar, the student is required to write a paper which is in effect a major part of the thesis. The paper is read at the end of the fall term, as is the final product at the end of the spring term, by one other faculty member in addition to the advisor. The Pre-thesis Seminar is on a pass-fail basis.

	Restricted Electives continued	
	Group 1	
17.21	Introduction to the American Political Process	3 0 6
17.31	Urban Politics	3 0 6
17.41	Science, Technology and Politics	3 0 6
	Group 2	
17.49	Mass Politics in Latin America	3 0 6
17.50	Political Crises in South Asia: India, Pakistan, Bangladesh, Sri Lanka and Nepal	3 0 6
17.51	Introduction to Political Development	3 0 6
17.53	Political and Economic Development of Tropical Africa	3 0 6
17.55J	Nationalism and Nation Building in 20th Century Africa	3 0 6
	Group 3	
17.56	International Relations: War and Peace	3 0 6
17.57	American Foreign Policy in a Changing World	3 0 6
	Group 4	
17.12	Political Ideas and Industrial Society	3 0 6
17.14	Revolution and the Theory of Politics	3 0 6
17.15J	Political Philosophy	3 0 6
17.825	Radical and Revolutionary Ideologies	3 0 6
17.946J	Modern Social Theory	3 0 6

3
Up to 18 additional units of 17.68 may be taken as Unrestricted Elective.

4
Students electing 17.01 may use it to satisfy the General Institute Laboratory Requirement, thus making available 12 additional units of Unrestricted Elective.

	Restricted Electives continued	
	Group 5	
17.01	Political Science Laboratory	2 6 4
17.838	Principles of Systematic Policy Analysis	3 0 6
	Restricted elective subjects chosen by the student in consultation with his advisor which may include the following: up to 27 units[3] of 17.68 Cooperative Work-Study Program; political science subjects, in addition to those taken to fulfill the requirement in Groups 1–5; and not more than two subjects outside the Department taken from the following list.	
14.30	Introduction to Statistical Methods in Economics	4 0 8
14.41	Distribution of Income and Employment Opportunity	3 0 6
21.753	Utopian Fiction	3 0 6
21.045	Intellectual History of Modern Europe	3 0 6
21.518	Anarchism	3 0 6
21.946	The Sociological Tradition II Social Criticism and Social Science in America	3 0 6
21.963	Technology, Values, and Social Choice	3 2 5
21.995	Intellectuals and Social Change	3 0 6
24.112	Modern Social Theory	3 0 6
	All 200 and 300 Wellesley College Political Science subjects	
	All 100, 200, and 300 Wellesley College Anthropology and Sociology subjects	
	Unrestricted Electives[4]	**81 or 78**
	Total Units Required for the S.B. Degree	**360**

Graduate Study

Cooperative Program

In recognition of the Department's belief that much relevant learning in political science takes place outside the university, regular academic credit in political science may be obtained for related "work experience" in a cooperative program. This work may be done in local, state, or national government, in public or private social and welfare agencies, in private research oriented organizations, or in law firms. The Department encourages this work to be done either during the summer or in the second term of the junior year. Application for a proposed cooperative program must be made to the Department's Advisor on the Cooperative Program at least three months before the program begins. The application is governed by the following regulations: 1) The Committee requires supplementary academic output, normally a paper, on the student's part in addition to the work experience itself. The paper must be submitted by the end of the term following the term of the work experience. 2) An approved summer program generally carries 9 units credit. No more than 18 units may be taken during any single summer. 3) Term-time work approved for credit is only for one term and is judged by more stringent standards of academic relevancy than a summer program. This work normally carries no more than 27 units. In no event shall term-time work carry more than 45 units. Nor more than a total of 45 units of work experience may be applied toward the Bachelor of Science. Of those 45, no more than 27 may be applied to the political science restricted elective requirement, and up to 18 units may be taken as unrestricted elective.

The Department of Political Science offers work leading to the Master of Science in Political Science and the Doctor of Philosophy.

Entrance Requirements for Graduate Study

The Department specifies the following prerequisites for graduate study in political science: one full year of college mathematics, including at least one term of statistics; and 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 should normally be in other than the candidate's own professional field.

Students may remove a deficiency in mathematics by completing a special two-term sequence in formal political analysis, 17.930 Concept Formation and Research Technique in the Social Sciences, 17.952 Statistics for the Social Sciences, 17.955 Introduction to Mathematical Models in the Social Sciences. A student whose deficiencies are of minor extent will be permitted graduate registration while taking appropriate subjects to remove them.

Master of Science in Political Science

Almost all of the 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 III. Subjects are wholly elective and are not restricted to those given by the Department. The program of study must be well balanced, however, and meet with the approval of the student's Advisory Board.

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. Applications for the program may be made in the spring term of the junior year or before November 1 of the senior year. Notification about admission will be sent in December of the senior year. This 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

A candidate for the doctorate must prepare himself 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, and urban politics.

Approved combinations of some of these fields together with economics, industrial management, sociology, social psychology, or science and engineering fields may be acceptable. A program in urban politics and planning is offered jointly with the Department of Urban Studies and Planning. There are also a variety of joint M.I.T.-Harvard University teaching programs in subjects such as Analysis of Complex Systems and West European Studies.

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.

No stated number of graduate subjects in the Department of Political Science is required; however, the candidate ordinarily needs two full academic years of work to prepare himself adequately for his General Examination and to meet the other pre-thesis requirements. The doctoral dissertation as a rule requires at least one additional year of original research and analysis, with the collection of data often conducted in the field.

Candidates must satisfy a Departmental language requirement in one foreign language. This may be done either by providing evidence of satisfactory completion of at least one year of intermediate-level course work at college, or by translating a passage (with dictionary) of moderate length and difficulty from a book or article relevant to the student's general field of interest. This requirement must be satisfied before the General Examinations may be taken.

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 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 Chairman, E53-450, M.I.T., Cambridge, Massachusetts 02139, (617) 253-5262.

Subjects in Political Science*

(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.

	Undergraduate Subjects
	General Subjects
17.U.R.	Undergraduate Research
17.01	Political Science Laboratory
17.02	Man and Society
17.05	The Quest for Equality and Development in Third World Countries
17.06	Modernization of Industrial Societies
17.07	Aggression, War and Civilization
17.08	American Politics and Social Change
	Normative and Empirical Political and Social Theory
17.12	Political Ideas and Industrial Society
17.14	Revolution and the Theory of Politics
17.15J	Political Philosophy
17.17	Power, Influence and Policy Decisions
	American Political Process
17.21	Introduction to the American Political Process
17.22	Political Parties
17.23	The Supreme Court and Constitutional Processes
17.24	Politics and Television
17.25	Bureaucracy
17.27	Television Workshop
17.28	Congress and the American Political System
17.29	Ideology and Participation in Black American Politics
	Urban Politics
17.31	Urban Politics
17.32J	Politics, Planning, and Public Policy
17.34	The Governance of Cambridge
17.35	Politics of Poverty: Community Organization
17.36	Politics of Urban Education
	Science and Public Policy
17.41	Science, Technology and Politics
	Defense Policy
17.43	Determinants of Strategic Nuclear Forces
17.44	Determinants of General Purpose Forces
	Political and Social Psychology
17.46	Political Psychology
17.47	Ego and Youth
	Political Development and Comparative Politics
17.48J	Nutrition, National Development and Planning
17.49	Mass Politics in Latin America
17.50	Political Crises in South Asia: India, Pakistan, Bangladesh, Sri Lanka and Nepal
17.51	Introduction to Political Development
17.53	Political and Economic Development of Tropical Africa
17.54J	Introduction to Africa
17.55J	Nationalism and Nation Building in 20th Century Africa
	International Relations and Foreign Policy
17.56	International Relations: War and Peace
17.57	American Foreign Policy in a Changing World
17.58	Seminar in International Politics
17.59J	Energy
17.60	Causes of War and Conditions for Peace
17.61	Arms Trade and Foreign Policy
	Miscellaneous Seminars
17.62–17.66	Reading Seminar in Social Science
17.67	Undergraduate Research Seminar
17.68	Cooperative Work-Study Program
17.69	Pre-thesis Reading Seminar
	Graduate Subjects
	Political Communication and Behavior
17.701	Public Opinion and Propaganda (A)
17.705	Mass Media and Communication Systems (A)
17.710	Political Socialization (A)
17.715	The Analysis of Power (A)
17.720	Survey Research Methods (A)
17.725	Changing Outlooks and Identities in World Affairs (A)
17.727	Political Culture
17.730	Identity and Ideology
17.731	Graduate Seminar in Political Psychology (A)
17.732	Seminar in Political Sociology
17.735	Research Seminar in International Communications (A)
17.736	Research Seminar in International Communications (A)
17.738	Field Seminar in Political Communications and Behavior
	American Government
17.743	Graduate Seminar in American Politics (A)
17.744	Federal Programs and City Politics
17.745	Dynamics of Electoral Politics
17.746	The Federal Bureaucracy and the Policy Process (A)
17.747	Research Seminar on Congress
17.755	Field Seminar in American Government
	Comparative Politics
17.760	Comparative Asian Politics (A)
17.765	Chinese Politics (A)
17.767	Political Development in South Asia (A)
17.770	Comparative African Politics: Research Seminar (A)

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17.771	Comparative Afro-American and African Politics (A)
17.775	African Philosophy and Political Thought
17.780	Theories and Approaches to the Study of Comparative Politics (A)
17.782J	Race Relations, Politics, and Development in the Caribbean (A)
17.783	Comparative Politics of Latin America (A)
17.784	Race Relations and Politics in Latin America
17.785	Euratlantica: Western Europe in World Politics
17.790	Domestic Politics of Western Europe (A)
17.793	Research Seminar in Comparative Politics: Western Europe
17.795	Politics in the Transitional Middle East (A)
17.797	Field Seminar in Comparative Politics

Communist Studies

17.801	Communism and Revolution
17.805	Soviet and Chinese Foreign Policy and the Communist World
17.808	Soviet Political System (A)
17.813	Soviet and Chinese Foreign Policy and the Non-Communist World
17.820	Domestic and Foreign Politics of East Europe
17.825	Radical and Revolutionary Ideologies
17.827	Field Seminar in Communist Studies

Defense Policy

17.830	Development of Strategic Nuclear Forces (A)
17.832	Development of General Purpose Forces (A)
17.835	Defense Issues and Budgets (A)
17.838	Principles of Systematic Policy Analysis (A)
17.841J	The Nuclear Arms Race and Arms Control — Technology and Government Policy (A)
17.846	Field Seminar in Defense Policy

Science and Public Policy

17.850	Science, Technology and the State (A)
17.855	Seminar on Health Policy (A)
17.860	Topics in the Public Management of Science and Technology (A)
17.861	Seminar in Systematic Policy Analysis (A)
17.865	International Response to Science and Technology (A)
17.866	Comparative Science Policy: National Development and International Politics
17.867J	Transfer and Adaptation of Technology in Developing Countries (A)
17.875	Field Seminar in Science and Public Policy

International Relations and Foreign Policy

17.880	Theories of International Relations (A)
17.881	Methods Seminar in International Politics
17.890	Comparative Foreign Policy
17.893J	Research Seminar in Imperialism and Colonialism (A)
17.894	The Politics of the Middle East
17.895	U.S. Foreign Policy — Contemporary Directions (A)
17.897	U.S. Foreign Policy — Plans and Strategies (A)
17.899	Research: International Relations and Foreign Policy (A)

Political and Economic Development

17.901	Personality, Social Stability, and Social Change (A)
17.915	Theories of Political Development (A)
17.917	Migration and Political Development
17.920	Field Research in Political Development (A)
17.927	Field Seminar in Political and Economic Development

Political Analysis

17.930	Concept Formation and Research Technique in the Social Sciences
17.940	Introduction to the Social Sciences (A)
17.946	Modern Social Theory
17.948J	Topics in Political Philosophy (A)
17.952	Statistics for the Social Sciences
17.955	Introduction to Mathematical Models in the Social Sciences
17.957	The Uses of Multi-Purpose Programming Languages in the Social Sciences
17.958	Secondary Analysis of Social Survey Data
17.962	Ecology of the Social Sciences
17.964	Field Seminar in Political Analysis
17.973	Multivariate Political Analysis (A)

Concepts and Methods

17.975	Seminar on Complex Models of Social Systems (A)
17.976	Advanced Topics in Statistical Modelling
17.977	Historiographical and other Primary Methodologies (A)
17.978	Collective Decisions (A)
17.979	Field Seminar in Concepts and Methods

Urban Studies

17.980	Seminar in Urban Politics (A)
17.982J	Urban Politics and Public Policy
17.983J	Suburban and Metropolitan Politics (A)
17.984J	Transportation and Energy for Greater Boston and New England
17.987	Politics of Urban Bureaucracy
17.988	Community Development in Urban Ghettos
17.989	Comparative Urban Politics
17.990	Politics of Urbanization
17.992	Field Seminar in Urban Studies

Reading Seminars

17.995–17.999	Reading Seminar in Social Science (A)

Department of Psychology

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Professor of Psychology
Head of the Department

Professors

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Professor of Neurophysiology

Stephan Lewis Chorover, Ph.D.
Professor of Psychology

Jerry Alan Fodor, Ph.D.
Professor of Psycholinguistics
Professor of Philosophy

Alan Hein, Ph.D.
Professor of Psychology

Richard Marx Held, Ph.D.
Professor of Experimental Psychology

Walle Jetze Harinx Nauta, M.D., Ph.D.
Professor of Neuroanatomy
Institute Professor

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R. Wayne Hurt, Ph.D.
James R. Lackner, Ph.D.
David Miller, M.D.
Thomas Evans Twitchell, M.D.
François Vital-Durand

Administrative Officer

Daniel Carrier

Department of Psychology

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 man, who has achieved considerable mastery over the world around him, might also come closer to an understanding of himself.

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 interrelated areas: the study of relationships between brain and behavior (physiological psychology); the study of perception and learning (general experimental psychology); and the study of origins of individual behavior (developmental and cognitive psychology; psycholinguistics). Accordingly, instruction in psychology on all levels, undergraduate, graduate, and postdoctoral, is organized to fall into these three areas which border on such diverse fields as anatomy, computer science, biophysics, neurology, neurophysiology, 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 learning, 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 neurochemistry) for comparative studies of animal behavior, for observations on perception and memory in man in normal and abnormal states, and for the study of early stages in the acquisition by children of language, logic, and social values.

Undergraduate Study

Psychology subjects at the undergraduate level begin with 9.00 Introduction to Psychology and Brain Science, which is the prerequisite for all the subsequent undergraduate subjects. The remaining subjects fall into the three areas covered by the Department: physiological psychology, experimental psychology, and developmental psychology. There is at present no undergraduate major in psychology at M.I.T.; however, undergraduate psychology subjects are open to all undergraduates as electives and can serve in fulfilling the undergraduate requirements for electives in the humanities and social sciences.

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. The program permits concentration in any one of the three areas already described: physiological psychology, experimental psychology, and developmental-cognitive psychology, including psycholinguistics. Throughout graduate study, students are involved in research projects occupying at least one-half of their time; aptitude is assessed as much in the light of demonstrated research abilities as in performance in seminars or tutorials.

Entrance Requirements for Graduate Degrees

Approximately one-half of the incoming graduate students have majored in psychology or related fields; the balance are promising candidates with other backgrounds. For admission, students are expected to have the equivalent of one year of college-level work in three of the following four areas: physics, chemistry, biology, and mathematics. Minor deficiencies in the undergraduate preparation can be removed, with the permission of the Department, by taking the appropriate subjects at the Institute.

Master of Science in Psychology and Brain Science

In order to provide better preparation for students desiring graduate study in medicine, biology, psychology, and neurophysiology, the Department of Psychology offers a five-year program in psychology and the brain sciences. This program allows a limited number of undergraduate students to spend a fifth year at M.I.T., following which they are awarded two degrees: a Bachelor of Science (awarded by a department other than Psychology) and a Master of Science awarded by the Department of Psychology. In order to enter this program, the undergraduate must be accepted in the Graduate School by the Department of

Psychology, and following acceptance, must obtain approval by another department to delay the awarding of the Bachelor of Science until the end of the fifth year.

Students enrolled in the five-year program are provided a firm foundation in the physical 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. Since only a very limited number of Master of Science candidates can be accommodated in the Department, it is imperative that students wishing to enter the five-year program begin their research experience in psychology as early as possible and no later than the second half of the junior year.

In this way, a good portion of the senior year and almost the entire fifth year may be devoted to research and thesis.

In order to aid students in planning a flexible undergraduate curriculum which could lead into the five-year program, a list of recommended basic subjects is given below. Many of these subjects can be incorporated into any undergraduate curriculum. Following this list are guidelines that suggest three possible distributions of graduate electives, each group forming a cohesive unit in one of three areas: neurosciences, perceptual mechanisms, or cognitive systems. Substitutions appropriate to individual objectives are proposed when applying at the end of the junior year to the Graduate School for admission to the five-year program.

Master of Science in Psychology and Brain Science
Course IX

	General Institute Requirements	Total units
	Specific science and humanities and social science subjects.	132
	The Science Distribution Requirement will be satisfied by 5.41, 7.01, and 18.03, which are required in the Department program (see below).	36
	The Laboratory Requirement will normally be satisfied by 9.50 or the sequence 9.014-9.015	12

	Departmental Program	Additional Graduate Units
	Basic Subjects	**60**
5.41	Introduction to Structure, Bonding and Mechanism (1-1)	5 0 7
7.01	General Biology (3-1)	4 0 8
9.00	Introduction to Psychology and Brain Science (1-2)	3 0 6
9.01	Physiological Psychology (2-1)	4 0 6
9.35	Perception: Mechanisms and Models (2-2)	3 0 6
9.921	Research in Psychology (4-1, 2)	0 24 0
18.03	Differential Equations (2-1)	4 0 8
	Thesis (5-1, 2)	0 36 0
	Additional undergraduate subjects including those required by the Departmental Program.	120
	Suggestions for specialization (elect one of the following three areas):	

	Area I: Neurosciences			**66**
6.071	Introduction to Electronics	4	2 6	
7.05	General Biochemistry	4	0 8	
9.015	Practicum in Physiological Psychology II	2	4 6	
9.013	Outline of Mammalian Neuroanatomy	3	0 6	
9.021	Topics in Brain and Behavior	3	0 6	
9.361	Electrophysiology of the Visual System	3	0 6	
20.80	Neuroendocrine Regulation	4	0 8	
	Area II: Perceptual Mechanisms			**66**
6.034	Introduction to Artificial Intelligence	3	0 9	
6.083	Programming of Small-Scale Computers	3	3 6	
7.36	Advanced Neurophysiology	2	0 4	
9.341J	Seminar in Sensorimotor Processes	3	0 6	
9.361	Electrophysiology of the Visual System	3	0 6	
9.37	Color Science and Color Vision	3	0 6	
23.768J	Speech Communication	3	0 6	
	Area III: Cognitive Systems			**66**
1.00	Information Systems	3	3 6	
6.034	Introduction to Artificial Intelligence	3	0 9	
6.071	Introduction to Electronics	4	2 6	
9.591	Seminar in Psychology of Language and Communication	3	0 6	
9.88	Seminar in the Origins of Behavior	3	0 6	
23.768J	Speech Communication	3	0 9	
	Total Units Required for S.B. and S.M. Degrees			**426**

1 Recommended year and term.

2 Substitutions should be proposed when applying for admission to the five-year program.

Doctor of Philosophy

The doctoral program begins with 9.001 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 sufficient professional significance.

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 E10-014, M.I.T., Cambridge, Massachusetts 02139, (617) 253-5751.

Subjects in Psychology*

(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.

9.00	Introduction to Psychology and Brain Science
9.001	Proseminar in Psychology I (A)
9.002	Proseminar in Psychology II (A)
9.01	Physiological Psychology
9.012	Seminar in Physiological Psychology (A)
9.013	Outline of Mammalian Neuroanatomy
9.014	Practicum in Physiological Psychology I (A)
9.015	Practicum in Physiological Psychology II (A)
9.016J	The Human Nervous System (A)
9.021	Topics in Brain and Behavior (A)
9.023	Topics in Neurophysiology of Movement (A)
9.031J	Pharmacology of Behavior
9.032J	Neuroendocrine Regulation
9.04	From the Mammalian Visual and Oculomotor Systems to Sensory Neurophysiology
9.05	Psychotechnology: Scientific and Ethical Issues in Behavior Control
9.30	Animal Behavior
9.341J	Seminar in Sensorimotor Processes (A)
9.35	Perception: Mechanisms and Models
9.351	Seminar on Sensation and Perception
9.361	Electrophysiology of the Visual System (A)
9.37	Color Science and Color Vision
9.371	Color Science (A)
9.381	Visual Space Perception (A)
9.40	Learning
9.50	Research in Psychology
9.59	Psychology of Language and Communication
9.591	Seminar in Psychology of Language and Communication I (A)
9.592	Seminar in Psychology of Language and Communication II (A)
9.60	Personality Structure and Development
9.64J	IQ, Heredity and Inequality
9.65	Cognitive Processes
9.651	Cognitive Processes (A)
9.652J	Cognitive Development (A)
9.66J	Conceptual Problems in Psychology
9.70	Social Psychology
9.80	Behavior in Groups
9.88	Seminar in the Origins of Behavior
9.881	Seminar in the Origins of Behavior (A)
9.89	Developmental Psychology
9.92	Topics in Psychology
9.921	Research in Psychology (A)
9.922	Research in Psychology (A)
9.923	Research in Psychology (A)

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Alfred P. 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; a nine-week Program for Senior Executives in executive development; and a four-week Program for Urban Executives for those involved in the management of city, county, and state governments. Over the past several years the School has developed a large number of summer subjects designed primarily to meet the needs of practicing professionals in the various areas of the School's program.

In its efforts, the Sloan School is committed to educating enterprise managers — men and women who have the will to manage and to risk, who can deal with complex systems, who have insight into themselves as well as others, who understand the total environment in which they live, and who continue to learn. In fulfilling this commitment, the School provides students with a solid grounding in the academic disciplines relevant to management — economics, mathematics, and the behavioral sciences — and develops their awareness of the multiple facets which characterize important management problems, from technical data to human factors. The School also endeavors to teach students to make decisions and to move decisively and responsibly in an increasingly complex world. The opportunities for such graduates in a society full of challenge, both social and technical, are substantial and growing, in fields which include industrial management, the management of health services, the management of education, and the management of public and urban affairs.

In addition to educating men and women for management, the Sloan School is equally committed to research directed at new understanding of and better solutions to management problems. Together, research and education are mutually reinforcing goals, and the School is confident of their continued impact on the fields of management and management education.

Dean of the Alfred P. Sloan School of Management

Alfred P. Sloan School of Management

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 for Teaching Programs
Senior Lecturer

Thomas Mason Hill, A.B., M.B.A.
Professor of Management
Associate Dean for Administration

Professors

Sidney Stuart Alexander, Ph.D.
Professor of Management and Economics

Thomas John Allen, Jr., Ph.D.
Professor of Organizational Psychology and Management

William Filbert Bottiglia, Ph.D.
Professor of Management and Humanities

John Frederick Collins, Ph.D.
D.C.L.
Consulting Professor of Urban Affairs

Jay Wright Forrester, D.Eng.
Germeshausen Professor of Management

Murray A. Geisler, Ph.D.
Professor of Management Science (Visiting)

Mason Haire, Ph.D. (Absent)
Alfred P. Sloan Professor of Management

James Suren Hekimian, D.B.A.
Professor of Management (Visiting)

Thomas Mason Hill, A.B., M.B.A.
Professor of Management
Associate Dean for Administration

Daniel Mark Holland, Ph.D.
Professor of Finance

Henry Donnan Jacoby, Ph.D.
Professor of Management

Gordon Mayer Kaufman, D.B.A.
Professor of Operations Research and Management

Edwin Kuh, Ph.D.
Professor of Finance and Economics

John Dutton Conant Little, Ph.D.
Professor of Operations Research and Management
Director, Operations Research Center

Paul Webster MacAvoy, Ph.D.
Henry R. Luce Professor of Environment and Public Policy

Robert Cox Merton, Ph.D.
Professor of Finance

Franco Modigliani, D.Jur., D.Soc. Sci., LL.D.
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Professor of Finance and Economics

Leo Benjamin Moore, S.M.
Professor of Management

Charles Andrew Myers, Ph.D.
Sloan Fellows Professor of Management
Director, Industrial Relations Section

William Frank Pounds, Ph.D.
Professor of Management
Dean

Edward Baer Roberts, Ph.D.
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Richard Dunlop Robinson, Ph.D.
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Alvin John Silk, Ph.D.
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Lester Carl Thurow, Ph.D.
Professor of Management and Economics

Phyllis Ann Wallace, Ph.D.
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Carroll Louis Wilson, Sc.D.
Mitsui Professor in Problems of Contemporary Technology

Zenon Soteriou Zannetos, Ph.D.
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Ernest Eugene Carter, Ph.D.
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John Joseph Donovan, Ph.D.
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George Franklin Farris, Ph.D.
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Acting Director of the Industrial Relations Section

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Special Assistant to the Chancellor

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Michael Stewart Scott Morton, D.B.A. (Absent)
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Alfred P. Sloan School of Management

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Ezio Tarantelli, Laurea
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Eric Arthur von Hippel, Ph.D.
Assistant Professor of Management

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David Elmer Berlew, Ph.D.
Gordon Falk Bloom, Ph.D., J.D.
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Herbert Franklin Goodwin, S.B.
Stanley Martin Jacks, A.M., LL.B.
Advisor to Prelaw Students
Harlan C. Meal, Ph.D. (Visiting)
Richard Stetson Morse, D.Eng., D.Sc.
John Fralick Rockart, Ph.D.
Leon Seligsberger White, Ph.D. (Absent)
Douwe Bosey Yntema, Ph.D.
Director of Project Cambridge

Lecturers

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Irwin Martin Rubin, Ph.D.

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Assistant to the Dean

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Administrative Assistant for Undergraduate Programs

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Martin Barry Zimmerman, Ph.D.

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Professor of Industrial Management, Emeritus

Edward Pennell Brooks, D.S.C.
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

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William Roy McLennan, B.A., M.A.
Roger Emil Miller, Ph.D.

Senior Research Associates

Robert Barnard O'Connor, Jr., Ph.D.

Norman Leo Rasmussen, M.S.
Acting Director, Center for Information Systems Research

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.

A proposed program should contain a specified series of subjects, planned and designated in advance of proposal submission, totaling between 54 and 82 Institute credit units. No more than one-third of these credits may be in Special Studies subjects. Not all of the individual subjects need be offered by the Sloan School of Management; however, the program as a whole will be judged for its relevance and importance to management.

Program 1
Special Program in Management

	General Institute Requirements		Total units
	Specific science and humanities and social science subjects.[1]		132
	Science Distribution Requirements.[2]		36
	The subject 15.301, which is required in the Departmental Program, appears on the list of Laboratory Subjects and can be used to satisfy the Laboratory Requirement		
	Departmental Program		
	Required Subjects		45
15.001	Managerial Economics	4 0 8	
15.251	Managerial Environment	4 0 8	
15.301	Managerial Psychology Laboratory	2 6 4	
15.501	Information and Decision Systems	3 0 6	
	Restricted Electives[3] A minimum of 18 units to be selected from the following list of electives:		72 to 100
15.412	Financial Management	4 0 8	
15.761	Operations Management	3 0 6	
15.812	Marketing Management	3 0 6	
	A coordinated program of professional electives relevant to management should be developed by the student, subject to faculty approval.	54 to 82	
	Unrestricted Electives		75 to 47
	Total Units Required for the S.B. Degree		360

1
The upperclass program in the humanities and social sciences is to be chosen in consultation with the student's faculty counselor.

2
One or two science distribution subjects may be required as part of an approved professional program. See, for example, the specified curricula of the Behavioral Science, Management Science, and Dynamics of Management Systems Programs.

3
The student has the option of designing his own professional program of electives (subject to faculty approval) or of selecting one of the previously designated professional programs in Course XV. For examples of the latter option see the curricula of the Behavioral Science Program, the Management Science Program, and the Dynamics of Management Systems Program.

Program 2
Behavioral Science in Management

This program is designed to provide students with the proper tools for the utilization of behavioral science theory and research knowledge in the managerial context.

The curriculum pursues a spiral course exposing students to the same basic behavioral science principles at several levels of complexity, and each time, from a somewhat different vantage. In following such a course, students develop the structure necessary for the accomplishment of a major learning experience, the research practicum, in the senior year. In other words, following an introductory survey in 15.301 Managerial Psychology Laboratory (a "core" subject), students go through a second cycle of the spiral process as they study behavioral science concepts and their interrelations in depth in two subjects Social Psychology and Complex Organizations. In the senior year students encounter the third cycle, that of actual experiences in searching for new knowledge and interpreting their findings.

This combination of theory, research, and practical experience in behavioral science enables students to pursue graduate study in many applied fields, with a firm groundwork in the fundamentals of behavioral science.

Program 2
Behavioral Science in Management

	General Institute Requirements		Total units
	Specific science and humanities and social science subjects.[1]		132
	The Science Distribution Requirement will be satisfied by 1.00 and 18.05, which are required in the Departmental Program, plus appropriate subjects totaling		12
	The subject 15.301, which is required in the Departmental Program, appears on the list of Laboratory Subjects and can be used to satisfy the Laboratory Requirement.		
	Departmental Program		
	Required Subjects		117
1.00	Information Systems	3 3 6	
9.70	Social Psychology	3 0 6	
15.001	Managerial Economics	4 0 8	
15.251	Managerial Environment	4 0 8	
15.301	Managerial Psychology Laboratory	2 6 4	
15.304	Complex Organizations	3 0 6	
15.306	Behavioral Science Research Methods	3 0 9	
15.307	Behavior Science Research Practicum	2 8 8	
15.501	Information and Decision Systems	3 0 6	
18.05	Introduction to Probability and Statistics	3 0 9	
	Restricted Electives A minimum of 18 units to be selected from the following list of electives:		42
15.412	Financial Management	4 0 8	
15.761	Operations Management	3 0 6	
15.812	Marketing Management	3 0 6	
	A minimum of 24 units of additional engineering or science electives.		
	Unrestricted Electives[2]		57
	Total Units Required for the S.B. Degree		360

1
The upperclass program in the humanities and social sciences is to be chosen in consultation with the student's Faculty Counselor.
2
Schedules of students in Course XV, Program 2, may always be arranged to leave available 12 units of unrestricted elective in the second year.

Program 3
Management Science

The Management Science program caters to mathematically and scientifically oriented undergraduates who would like to participate in solving some of the technical problems central to successful management of a complex society. The program is difficult and challenges even superior students.

In recent years the rise of the computer, along with the development of mathematical models of systems and the collection of large quantities of data, has stimulated the growth of a technology of management. This is the domain of operations research and management science, two names commonly used to describe the field. The knowledge and methods being developed are applicable to problem solving in business, government, and other public and private organizations. The elements of the technology are the interrelated techniques of systems analysis, mathematical models, statistics, and computer science. In systems analysis, problem solving is approached by identifying the system, establishing its objectives, and setting down measures of its performance. Then the variables or actions under managerial control are determined and a model is constructed to relate the controllable variables to the measures of system performance. Thereafter, the variables can be set to optimize performance.

The Management Science program develops an underlying competence in mathematical models, optimization techniques, statistics, and computers. This provides wide flexibility in career choice. It prepares students for immediate participation in systems analysis or operations research activities in industry or government. Alternatively, it provides a basic groundwork for pursuing graduate work in several directions, either more broadly toward management and social science or more technically toward a research career in operations research, computer science, or applied mathematics.

Program 3
Management Science

	General Institute Requirements		Total units
	Specific science and humanities and social science subjects.[1]		132
	The subjects 6.041, 15.053, and 18.031, which are required in the Departmental Program, appear on the list of Science Distribution Subjects and can be used to satisfy the Science Distribution Requirement.		
	The subject 15.301, which is required in the Departmental Program, appears on the list of Laboratory Subjects and can be used to satisfy the Laboratory Requirement.		
	Departmental Program		
	Required Subjects		108
6.041	Probabilistic Systems Analysis	4 0 8	
15.001	Managerial Economics	4 0 8	
15.053	Introduction to Management Science	4 0 8	
15.065	Decision Analysis	3 0 6	
15.251	Managerial Environment	4 0 8	
15.301	Managerial Psychology Laboratory	2 6 4	
15.501	Information and Decision Systems	3 0 6	
15.564	Management Information Technology I	3 0 6	
15.761	Operations Management	3 0 6	
18.031	Introduction to Linear Algebra and Applications	3 0 9	
	Restricted Electives A minimum of 9 units from		18
15.412	Financial Management	4 0 8	
15.812	Marketing Management	3 0 6	
	A minimum of 9 units are to be selected from the following list of electives:		
6.045	Theoretical Models for Computation	3 0 9	
6.262J	Advanced Markov Models and Their Applications	3 0 9	
6.861J	Artificial Intelligence and Heuristic Programming	3 0 9	
14.371	Statistical Inference	3 0 9	
15.073	Stochastic Systems	3 0 6	
15.081	Mathematical Programming	3 0 6	
15.571	Advanced Computer Systems	3 0 6	
15.874	Industrial Dynamics	3 0 9	
	Unrestricted Electives[1,2]		102
	Total Units Required for the S.B. Degree		360

1
The upperclass program in the humanities and social sciences is to be chosen in consultation with the student's Faculty Counselor.
2
Schedules of students in Course XV, Program 3, may always be arranged to leave available 24 units of unrestricted elective in the second year.

Graduate Study

Program 4
Dynamics of Management Systems

The Dynamics of Management Systems program focuses on the feedback structure of organizations. The unifying concepts of feedback processes are stressed to show how the same principles are encountered in management, economics, engineering, life processes, and the humanities.

The systems of interest to the manager are multi-loop, contain both positive and negative feedback, and are of high order and non-linear. 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 E52-480A, (617) 253-2931.

Program 4
Dynamics of Management Systems

	General Institute Requirements		Total units
	Specific science and humanities and social science subjects.[1]		132
	The Science Distribution Requirement will be satisfied by 15.852, which is required in the Departmental Program, and 2.02 or 6.011, and 18.03 or 18.031, which appear on the list of restricted electives.		
	The subject 15.301, which is required in the Departmental Program, appears on the list of Laboratory Subjects and can be used to satisfy the Laboratory Requirement.		
	Departmental Program		
	Required Subjects		**66**
15.001	Managerial Economics	4 0 8	
15.251	Managerial Environment	4 0 8	
15.301	Managerial Psychology Laboratory	2 6 4	
15.501	Information and Decision Systems	3 0 6	
15.852	Principles of Dynamic Systems I	3 0 9	
15.875	Applications and Implementation of Industrial Dynamics	3 0 6	
	Restricted Electives		**78**
18.03	Differential Equations	4 0 8	
	or		
18.031	Introduction to Linear Algebra and Applications	3 0 9	
	and		
2.02	Engineering Modeling and Analysis	4 0 8	
	or		
6.011	Introductory Network Theory	4 0 8	
	and		
2.14	Control System Principles	3 1 8	
	or		
6.015	Signals and Systems	4 0 8	
	or		
6.072	Systems, Networks, and Computation	3 0 9	
	A minimum of 18 units to be selected from the following list of electives:		
15.412	Financial Management	4 0 8	
15.761	Operations Management	3 0 6	
15.812	Marketing Management	3 0 6	
	A minimum of 24 units to be selected from the following list of electives:		
15.873	Principles of Dynamic Systems II	3 0 9	
15.874	Industrial Dynamics	3 0 9	
15.878	Research Seminar in Dynamics of Management Systems I	3 0 6	
15.879	Research Seminar in Dynamics of Management Systems II	3 0 6	
	Unrestricted Electives[2]		**84**
	Total Units Required for S.B. Degree		**360**

1
The upperclass program in the humanities and social sciences is to be chosen in consultation with the student's Faculty Counselor.

2
Schedules of students in Course XV, Program 4 may always be arranged to leave available 24 units of unrestricted elective in the second year.

The Sloan School of Management offers graduate work leading to the Master of Science in Management and the Doctor of Philosophy. Short-term, nondegree programs for executive development are also offered.

Entrance Requirements for Graduate Study

Undergraduate preparation for the graduate programs should include: mathematics (through college algebra and differential calculus) and principles of economics. A year of an experimental science at the college level and an introduction to psychology are considered desirable. The Graduate Committee is willing to consider any applicant strongly motivated to study in the School who has demonstrated high intellectual capacity, and is prepared to eliminate any deficiencies in preparation before entering the program. All candidates for admission to graduate study in the Alfred P. Sloan School of Management, other than applicants for the Executive Development Programs, are required to take the Admission Test for Graduate Study in Business. This test is administered by the Educational Testing Service, Princeton, New Jersey 08540. Information about dates and locations at which the test will be administered may be obtained from that agency. The January test is the latest one appropriate for admission in the same year.

Master of Science in Management

The course of study leading to this degree is designed to prepare men and women for careers as professional managers in either private or public sector organizations. Reflecting faculty research interests in practical applications of economic and organization theory, quantitative method, and systems analysis to the complex problems of enterprise administration, these programs are characterized by relatively heavy emphasis on the basic disciplines pertinent to managerial decision making.

Degree candidates are normally admitted in September to a program of study ex-

tending over two academic years. Those who have had one 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 twelve months.

Terms 1 and 2 of the two-year program are normally devoted largely to required core subjects: 15.012, 15.014 Economics for Management; 15.061, 15.062 Mathematics for Management; 15.311 Human Factors in Management and 15.663 Labor-Management Relations; 15.515 Information and Decision Systems I; any pair of 15.412 Financial Management, 15.761 Operations Management, and 15.812 Marketing Management; and at least one elective. The accelerated program core differs in that 15.915 Information and Decision Systems II is substituted for the 15.412/15.761/15.812 requirement. All students must, in addition, satisfy a basic computer programming requirement shown in the subject listing as 15.561 Benchmark Computer Programming.

In the two-year program, satisfaction of core requirements by waiver examination and/or credit for comparable subjects taken elsewhere will make room for additional electives or, in some cases, make it possible to obtain the degree in less than four terms. The accelerated course is less flexible in this respect because the subject content of the summer term — 15.011 (equivalent to 15.012 and 15.014), 15.060 (equivalent to 15.061 and 15.062), 15.311, 15.515, and 15.915 — is fixed and required of all participants.

For the two-year candidate, the typical second-year load consists of 15.931, seven or more elective subjects, and a thesis. Following the summer term, the accelerated program merges with the two-year course and differs from it primarily in that completion of the core requirements necessitates a minimum load of ten subjects plus thesis. It should be noted, however, that the confinement of elective choices to only two terms inevitably results in some diminution of opportunity for depth of concentration and/or breadth of exposure.

In choosing electives, all students are expected to satisfy a concentration requirement by selecting three or more subjects in at least one of the following areas: finance, industrial relations, international management, management planning and control, management information systems, marketing, operations management, operations research/statistics, organization studies, public sector management, or system dynamics. With the approval of a faculty member, some other set of managerially relevant and logically interrelated subjects may be proposed for consideration. Multiple concentrations are possible but not recommended, on the grounds that some electives are preferably employed to expand the individual's breadth of perspective.

The master's thesis, approximately equivalent to two subjects, provides opportunity for intensive study of a specific management problem selected by the student. Thesis research is conducted under supervision of a faculty committee, also of the candidate's choosing, whose members share an interest in the topic. Joint theses, which permit attacking problems of somewhat larger scale, are generally encouraged. In addition to that offered by the thesis *per se*, management students may gain experience 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 familiarity with applied work in management, as well as with 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 or two years are devoted to the doctoral dissertation. Of course, a candidate entering with an advanced degree may be able to finish with less time depending on previous experience in research.

The basic disciplines are economics, behavioral science, and mathematics. Doctoral candidates are expected to have a full and clear understanding of research methods in these fields, since they have direct application to the functional areas of management.

Candidates are required to demonstrate this ability in three qualifying examinations. These are normally offered at the end of the first year in residence, but some students delay the exams until June of the second year in order to devote more of the first year to the major field. Also, the exams are available upon entrance into the program for those who have already done advanced work. There are no subject requirements in the disciplines, although entering doctoral candidates are offered special subject sequences in preparation for the qualifying examinations.

The qualifying examinations are required of all students; the only exceptions occur when students wish to proceed immediately to more advanced work in one or more of the three disciplines. Satisfactory performance in advanced work is construed as satisfying the qualifying examination requirement.

In addition to preparing for the qualifying examinations, entering students take subjects and do individual reading in the major field of their choice. In order to gain preliminary experience in research techniques, students also work with faculty advisors in research apprenticeships which are planned and initiated during the fall term. Then, in the second year of study, the student masters the "major

field'' and the underlying theoretical discipline designated as the minor field. Also, he or she demonstrates the ability to formulate, conduct and present a research study. Candidates and their advisors design an appropriate program of subjects and individual research to prepare for General Examinations in the major and minor fields at the end of the second year. In recent years, candidates have taken major field examinations in finance, industrial dynamics, industrial relations, international management, management science and organization studies. Candidates have offered economics, behavioral science and operations research as minor fields.

In addition to preparing for General Examinations students in the second year are required to write a paper of article length and quality for inclusion in the Sloan School Working Paper Series. The paper will be evaluated by members of the faculty in terms of general standards for Sloan School Working Papers. Work in the major field and minor field and performance on the research paper are used to evaluate students' progress at the end of the second year.

The final part of the Ph.D. program centers on the doctoral dissertation, which 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. Because Ph.D. candidates are likely to be involved in some form of teaching, whether in a university, or a less formal ''classroom'' in industry, doctoral students are partially responsible for conducting a Sloan School subject in the first year in this part of the program. In the conduct of that subject they teach in close cooperation with a faculty member. Students may conduct the subject jointly with a senior faculty member, or they may serve as a discussion or section leader.

Teaching and Research Assistantships

Except for limited funds designated by donors for the support of 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 are eligible for the approximately 100 part-time research and teaching assistantships available each year.

Inquiries

Additional information concerning graduate programs, admission, financial aid, etc., may be obtained from the Graduate Program Office, Room E52-480, Sloan School of Management, M.I.T., Cambridge, Massachusetts 02139, (617)253-3730.

Programs for Executive Development in Management

Alfred P. Sloan Fellows Program

Each year the Alfred P. Sloan Fellows Program admits some 45 exceptionally able young executives (approximately 32 to 38 years of age) who have demonstrated potential for filling positions of more general management responsibility in the future. These young executives 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 intimate contact with business and government leaders here and abroad, is taken in conjunction with the regular graduate program and leads to the Master of Science in Management.

M.I.T. Program for Senior Executives

The Program for Senior Executives is an intensive nine-week course of study designed for the mature executive already in or preparing for a position of major managerial responsibility. Enrollment is limited to 25 qualified executives in each of the two nine-week sessions held in the fall and spring each year. Participants reside at Endicott House in Dedham, Massachusetts, taking their course work on campus at the Sloan School, and at Endicott House. A short trip to Washington, D.C. to visit policy makers of the Federal government is an important part of the Program.

M.I.T. Program for Urban Executives

The M.I.T. Program for Urban Executives is a four-week program available for those municipal, county, and state governments which manage and which deal with the complex issues that confront career, nonelected administrators. The Program enjoys the active support of the National League of Cities, the U.S. Conference of Mayors, the International City Management Association, and the American Society for Public Administration.

Detailed information about these programs may be obtained by writing to the Associate Dean for Teaching Programs, 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.

15.U.R.	Undergraduate Research

Managerial Economics

15.001	Managerial Economics
15.011	Economics for Management
15.012	Microeconomics for Management
15.014	Macroeconomics for Management
15.018	Economics of International Business (A)
15.024	Economics and Finance: Principles and Policies I
15.025	Economics and Finance: Principles and Policies II
15.026	Economics and Finance: Principles and Policies III (A)
15.039	Microeconomics for Management
15.041	Macroeconomics for Management
15.042	Seminar in Economics for Management (A)

Operations Research / Statistics

15.053	Introduction to Management Science
15.060	Mathematics for Management
15.061	Mathematics for Management I
15.062	Mathematics for Management II
15.063	Statistics for Model Building (A)
15.065	Decision Analysis (A)
15.071	Quantitative Methods
15.073	Stochastic Systems (A)
15.075	Statistical Theory and Application (A)
15.077	Bayesian Analysis Studies (A)
15.079	Data Analysis Workshop (A)
15.081	Mathematical Programming (A)
15.083	Combinatorial Optimization (A)
15.084J	Theory of Mathematical Programming and Discrete Time Optimal Control (A)
15.094J	Optimization in Finite and Infinite Dimensions (A)
15.099	Seminar in Management Science (A)

International Business

15.221	International Business Management I (A)
15.222	International Business Management II (A)
15.223	International Business Environments (A)
15.224	Intercultural Communication I (A)
15.225	Intercultural Communication II (A)
15.227	International Technology Transfer (A)
15.228J	Ocean Engineering and Law Seminar (A)

History and Environment

15.251	Managerial Environment
15.262	Private Industry and Social Probiems
15.266	Crises of Contemporary American Society (A)
15.268	Readings in Power and Responsibility (A)

Organization Studies

15.301	Managerial Psychology Laboratory
15.304	Complex Organizations
15.306	Behavioral Science Research Methods
15.307	Behavior Science Research Practicum
15.311	Human Factors in Management
15.314	Organization Theory (A)
15.317	Comparative Studies of Organization (A)
15.318	Organization (A)
15.319	Seminar on Organization Change (A)
15.321	Theories of Planned Change (A)
15.322	Organizational Psychology (A)
15.332	Administrative Theory and Practice (A)
15.333	Management of Industrial Change (A)
15.334	Practicum in Organization Development I (A)
15.335	Practicum in Organization Development II (A)
15.341	Seminar in Behavioral Sciences I
15.342	Seminar in Behavioral Sciences II
15.343	Advanced Seminar in Social Psychology (A)
15.344	Doctoral Seminar on Career Development and Adult Socialization (A)
15.345	Doctoral Seminar in Organization Studies I (A)
15.346	Doctoral Seminar in Organization Studies II (A)
15.347	Doctoral Seminar in Research Methods I (A)
15.348	Doctoral Research Seminar (A)

Management of Innovation

15.351	Research and Development Management (A)
15.353	Seminar on Management of Technology (A)
15.355	New Enterprises (A)
15.357	Management of the Innovation Process (A)

Finance

15.412	Financial Management (A)
15.414	Business Forecasting (A)
15.415	Finance Theory I (A)
15.416	Finance Theory II (A)
15.418	Taxation and Business Management (A)
15.423	The Management of Financial Intermediaries (A)
15.432	Capital Markets and Financial Institutions (A)
15.433	Advanced Capital Market Theory (A)
15.434	Advanced Financial Administration (A)
15.436	International Managerial Finance (A)
15.441	Research Seminar in Finance (A)

*Full descriptions of all subjects are given in the catalogue entitled **Courses and Degree Programs, 1974–75**, which may be obtained by writing to the Institute Information Services, Room 7-111, M.I.T.

	Management Planning and Control
15.501	Information and Decision Systems
15.511	Management Accounting and Control Systems
15.515	Information and Decision Systems I
15.516	Managerial Accounting (A, except XV)
15.521	Managerial Information and Controls (A)
15.532	Advanced Concepts in Managerial Planning and Control (A)
15.541	Mathematical Elements of Planning and Control (A)
15.544	Measurement Theory and Problems (A)
15.545	Control Processes and Systems (A)

	Management Information Systems
15.561	Benchmark Computer Programming
15.564	Management Information Technology I (A)
15.565	Management Information Technology II (A)
15.568	Management Information Systems (A)
15.569	Management Decision Systems (A)
15.571	Advanced Computer Systems (A)
15.572	Systems Simulation (A)

	Law
15.612	Structure of American Law
15.616	American Legal System (A)
15.625	Labor Law (A)

	Industrial Relations
15.662	Collective Bargaining and Public Policy (A)
15.663	Labor-Management Relations
15.664	Management of Human Resources (A)
15.671J	Labor Economics (A)
15.672J	Public Policy on Employment and Industrial Relations (A)
15.674J	Comparative Systems of Industrial Relations and Human Resource Development (A)
15.675	Business and Public Policy on Human Resources Development (A)
15.691J	Research Seminar in Industrial Relations (A)
15.692J	Research Seminar in Industrial Relations (A)

	Management Laboratory
15.703	Management Laboratory
15.714	Advanced Management Laboratory (A)

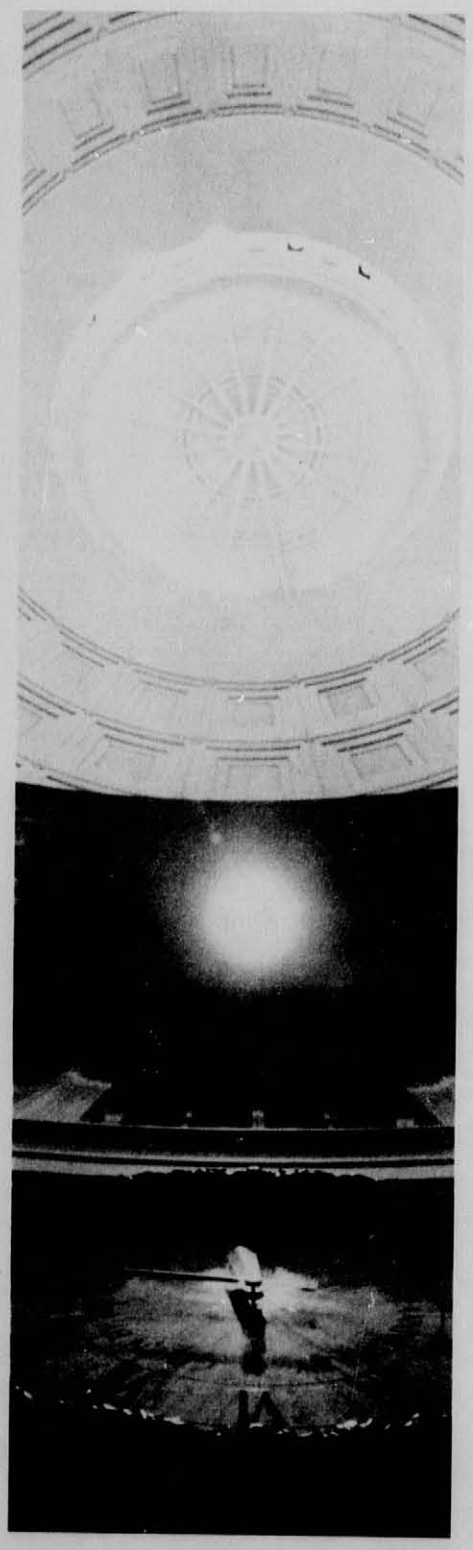
	Operations Management
15.761	Operations Management (A)
15.762	Management Planning and Control (A)
15.781	Capacity Planning: Production and Distribution Systems (A)
15.791	Operations Planning and Control Systems (A)
15.792	Organization Design for Operations (A)
15.793	Studies in Public Operations Management (A)
15.795	Seminar in Operations Management (A)

	Marketing
15.811	Marketing (A)
15.812	Marketing Management (A)
15.823	Business Game (A)
15.824	Marketing Communications (A)
15.825	Marketing Models (A)
15.826	Marketing Issues in Public Systems (A)
15.832	Measurement for Management (A)
15.838	Research Seminar in Marketing (A)

	System Dynamics
15.852	Principles of Dynamic Systems I
15.872	Principles of Dynamic Systems I (A)
15.873	Principles of Dynamic Systems II (A)
15.874	Industrial Dynamics (A)
15.875	Applications and Implementation of Industrial Dynamics (A)
15.876	Dynamics of Health Service Systems (A)
15.878	Research Seminar in Dynamics of Management Systems I (A)
15.879	Research Seminar in Dynamics of Management Systems II (A)

	General Policy and Special
15.901	Undergraduate Studies Program
15.915	Information and Decision Systems II
15.918J	The Construction of Buildings (A)
15.931	Corporate Strategy, Policy, and Planning (A)
15.936	Seminar in Administration
15.937	Seminar in Administration
15.938	Seminar in Administration (A)
15.939	Seminar in Administration (A)
15.951	Special Studies in Management
15.961	Special Studies in Management (A)
15.962–15.969	Special Seminars in Management (A)

School of Science



Science is concerned with the understanding of the physical world, and the range of this search for understanding extends from the innermost events in the atomic nucleus to the farthest detectable reaches of the universe. Modern science has proved useful in many important ways, but the search for understanding is also carried out because people are curious about the world around them.

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.

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.

The sciences may be broadly classified as earth and planetary sciences, life sciences, mathematics, and physical sciences. At M.I.T., instruction is provided in all of these fields at the undergraduate and graduate levels. The various programs are described on the following pages.

The science programs at M.I.T. profit from the availability of laboratories of an interdepartmental nature which facilitate work in fields which cross the lines of traditional disciplines. Some of these facilities include the Center for Materials Science and Engineering, the Center for Space Research, the Information Processing Center, the Laboratory for Nuclear Science, the Lincoln Laboratory, the Francis Bitter National Magnet Laboratory, and the Research Laboratory of Electronics. Through these laboratories and through personal contacts by members of the science departments within the Institute and outside, the sciences are brought to bear on problems of importance to the surrounding academic community, industry, and government. The School of Science provides the possibility of study and research in the most basic scientific and mathematical areas and also for the use of these ideas in a wide variety of disciplines.

Dean of the School of Science

Department of Biology

Boris Magasanik, Ph.D.
Professor of Microbiology
Head of the Department

Gene Monte Brown, Ph.D.
Professor of Biochemistry
Associate Head of the Department

Charles Edward Holt, III, Ph.D.
Associate Professor of Biology
Academic Officer

Professors

David Baltimore, Ph.D.
American Cancer Society Professor of Microbiology

Eugene Bell, Ph.D.
Professor of Biology

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.
Professor of Genetics

Bernard Sidney Gould, Ph.D.
Professor of Biochemistry

Howard Green, M.D.
Professor of Cell Biology

Vernon Martin Ingram, Ph.D., D.Sc.
Professor of Biochemistry

Har Gobind Khorana, Ph.D.
Alfred P. Sloan Professor of Biology and Chemistry

Jerome Ysrael Lettvin, M.D.
Professor of Communications Physiology

Irving M. London, M.D.
Professor of Biology
Director, Joint Harvard-M.I.T. Program in Health Sciences and Technology

Salvador Edward Luria, M.D., D.Sc.
Institute Professor
Director, Center for Cancer Research

Sheldon Penman, Ph.D.
Professor of Cell Biology

Alexander Rich, M.D.
Professor of Biophysics
Sedgwick Professor of Biology

Phillips Wesley Robbins, Ph.D.
Professor of Biochemistry

Francis Otto Schmitt, Ph.D., Sc.D.
Institute Professor, Emeritus
Professor of Biology, Emeritus

Ethan Roy Signer, Ph.D.
Professor of Biology

Irwin Whiting Sizer, Ph.D.
Professor of Biochemistry
Dean of the Graduate School

David Floyd Waugh, Ph.D.
Professor of Biophysics

Associate Professors

David Botstein, Ph.D.
Associate Professor of Genetics

Malcolm Lawrence Gefter, Ph.D.
Associate Professor of Biochemistry

Joel A. Huberman, Ph.D.
Associate Professor of Biology

Jonathan Alan King, Ph.D.
Associate Professor of Biology

Harvey Franklin Lodish, Ph.D.
Associate Professor of Biology

Mary Lou Pardue, Ph.D.
Associate Professor of Biology

Uttam Lal RajBhandary, Ph.D.
Associate Professor of Biochemistry

Paul Reinhard Schimmel, Ph.D.
Associate Professor of Biology and Chemistry

Phillip Allen Sharp
Associate Professor of Biology

Lisa Amelia Steiner, M.D.
Associate Professor of Immunology

Annamaria Torriani, Ph.D.
Associate Professor of Biology

Assistant Professors

Raymond Milton Baker, Ph.D.
Assistant Professor of Genetics

Boyce William Burge, Ph.D.
Assistant Professor of Biology

Paul David Gottlieb, Ph.D.
Assistant Professor of Immunology

Linda McIntyre Hall, Ph.D.
Assistant Professor of Biology

Nancy Haven Hopkins, Ph.D.
Assistant Professor of Biology

David Evan Housman, Ph.D.
Assistant Professor of Biology

Richard Olding Hynes, Ph.D.
Assistant Professor of Biology

Bonnie Moreland Tyler, Ph.D.
Assistant Professor of Microbiology

Christopher Walsh, Ph.D.
Assistant Professor of Chemistry and Biology

Robert Allen Weinberg, Ph.D.
Assistant Professor of Biology

Technical Instructor

Elaine Vyvyan Lenk

Operations Administrator

Edward Joseph Gaudiano

Financial Administrator

Elaine Mary Petrino

Personnel Administrator

Genevieve Mary O'Hehir

Research Associates

Israel Barzilay, Ph.D.
Carter Miles Becker, M.D.
Ramamoorthy Belagaje, Ph.D.
Frederick Richard Bloom, Ph.D.
Parul Chakrabarti
Michael John Clemans, Ph.D.
Albert Benjamin DeLeo, Ph.D.
Ching-Liang Fan, Ph.D.
George Barry Fitzgerald, Ph.D.
Pinhas Fuchs, Ph.D.
Michael John Gait, Ph.D.
Richard B. Goldberg, Ph.D.
Marian Gorecki, Ph.D.
Martin Hewlett, Ph.D.
Carlos Benjamin Hirschberg, Ph.D.
Bor Shyue Hong, Ph.D.
Wai Mun Huang, Ph.D.
Antonius Marinus Jetten, Ph.D.
Lee Frederick Johnson, Ph.D.
Byron Wilfred Kemper, Ph.D.
Jung Ja Kim, Ph.D.
John Fred Lechner, Ph.D.
Frederick Arthur McMorris, Ph.D.
Alexander McPherson, Ph.D.
Christine Ann Milcarek, Ph.D.
Ian James Molineux, Ph.D.
Mohamad-Kazem Mostafapour, Ph.D.
Peter Joseph Natale, Ph.D
Kjeld Erik Norris, Ph.D.
Marco Tulio Nunez, Ph.D.
Shiro Ohnoki, Ph.D.
Joseph Kenneth Paisley, Ph.D.
Amos Panet, Ph.D.
Charles Alfred Plate, Ph.D.
Robert Poss, Ph.D.
Charles W. Pratt, Ph.D.
Ranjit Kumar Ray, Ph.D.
Robert Rodvien, M.D.
Naomi Elizabeth Rosenberg, Ph.D.
Linda Sarah Saxe, Ph.D.
Bartholomew M. Sefton, Ph.D.
Takao Sekiya, Ph.D.
Allen Edgar Silverstone, Ph.D.
Margaret Louise Smith, Ph.D.
Werner Karl Steuernagel, E.E.
Stanley Louis Streicher, Ph.D.
Fred LeRoy Suddath, Jr., Ph.D.
Joan Lucia Suit, Ph.D.
Zin-May Renee Sung, Ph.D.
Tatsua Takeya, Ph.D.
Jiunn-Yann Tang, Ph.D.
Gary Flavel Temple, Ph.D.
Nelson N. H. Teng, Ph.D.
Muhammed Anwar Waqar, Ph.D.

Professors Emeriti

Kurt Siegfried Lion, Dr.Ing.
Professor of Applied Biophysics, Emeritus

Francis Otto Schmitt, Ph.D., Sc.D.
Institute Professor, Emeritus
Professor of Biology, Emeritus

Clair Elsmere Turner, Dr.Ph., Sc.D.
Professor of Public Health, Emeritus

Department of Biology

Undergraduate Study

The Department of Biology offers undergraduate, graduate, and postdoctoral training in basic biology, and in a variety of biological fields of specialization. The quantitative aspects of biology, including molecular biology, biochemistry, biophysics, genetics, and cell biology, represent the core of the program. Students in the Department are encouraged to acquire a solid background in the physical sciences not only to master the applications of mathematics, physics, and chemistry to biology, but also to develop an integrated scientific perspective. The various programs, emphasizing practical experimentation, combine a minimum of formal laboratory exercises with ample opportunities for research work both in project oriented laboratory subjects and in the Department's research laboratories. Students at all levels are encouraged to acquire familiarity with advanced research techniques and to participate in seminar activities.

Bachelor of Science in Life Sciences
Course VII

Two programs are offered leading to the Bachelor of Science in Life Sciences. The curriculum of **Program 1, Biology,** is designed to prepare students for a professional career in the area of the biological sciences. Graduates of this program are well prepared for positions in industrial or research institutes. However, experience has shown that most graduates will probably choose to continue their education at graduate schools in order to obtain a Ph.D. degree 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. degree, particularly if they plan to include laboratory investigations bearing on human disease as part of their careers.

The curriculum of **Program 2, 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.

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 such as medicine without laboratory research, 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.

The curricula for the three programs offered by the Department of Biology are given on the next page.

Although 5.31 Introduction to Chemical Experimentation is not a Departmental Requirement, this subject is particularly useful for students whose interest is in biochemistry; it may also be required for admission to medical school. Although 7.01 General Biology is not specifically required, most students will find it an important basis for the study of other biology subjects. Only those students with exceptional high school preparation in modern biology should elect *not* to take 7.01. As part of their elective programs, students are encouraged to enroll in the more advanced subjects offered by the Department.

Inquiries

Additional information regarding academic programs, research opportunities, admissions, financial aid, etc. may be obtained from Biology Headquarters, Room 56-509, M.I.T., Cambridge, Massachusetts 02139, (617) 253-4701.

Bachelor of Science in Life Sciences
Course VII
Program 1. Biology Curriculum

	General Institute Requirements	Total units
	Specific science and humanities and social science subjects.	132
	The subjects 18.03, and either 5.41 or 5.60, which are required in the Departmental Program, appear on the list of Science Distribution Subjects and can be used to satisfy the Science Distribution Requirement.	
	The subjects 7.031 or 7.041 or 7.051 or 7.061, which are among the restricted electives appearing on the list of Laboratory Subjects, can be used to satisfy the Laboratory Requirement.	

	Departmental Program Required Subjects				60
5.41	Introduction to Structure, Bonding and Mechanism[1]	4	0	8	
5.60	Chemical Equilibrium[1]	1	8	3	
7.011	Introduction to Experimental Biology	5	0	7	
7.05	General Biochemistry	5	0	7	
18.03	Differential Equations	4	0	8	

	Departmental Program continued				
	Restricted Electives				84
	Two of the following subjects:				
5.42	Organic Chemistry	4	0	8	
5.61	Physical Chemistry	4	0	8	
5.62	Physical Chemistry	4	0	8	
6.071	Introduction to Electronics	4	2	6	
7.07J	Biophysical Chemistry	3	0	9	
8.03	Physics III	5	0	7	
8.211	Introduction to Quantum Physics	4	0	8	
	Three of the following subjects:				
7.01	General Biology[1]	4	0	8	
7.03	Genetics	3	0	9	
7.04	Developmental Biology	3	0	9	
7.06	Cell and Organ Physiology	3	0	9	
7.21	General Microbiology	4	0	8	
	One of the following subjects:				
7.031	Experimental Microbial Genetics	2	16	6	
7.041	Experimental Cell Biology	2	16	6	
7.051	Experimental Biochemistry	2	16	6	
7.061	Experimental Behavioral Genetics	2	16	6	
	or				
	Acceptable research experience[3]	2	16	6	
	Unrestricted Electives[2]				84
	Total Units Required for the S.B. Degree				360

1
Students who take 5.41 or 5.60 to fulfill the General Institute Requirement for Chemistry/Biology must take 12 additional units of Unrestricted Elective; if 7.01 is taken to fulfill the General Institute Requirement in Chemistry/Biology, it may not be taken to fulfill part of the Restricted Elective program.

2
Schedules of students in Course VII, Program I, may always be arranged to leave available 24 units of Unrestricted Elective in the second year.

3
Procedures for substituting research for the 24 unit laboratory requirement are described in the current U.R.O.P. booklet.

Bachelor of Science in Life Sciences
Course VII
Program 2. Applied Biology Curriculum

See Department of Nutrition and Food Science for curriculum requirements.

Bachelor of Science
Course VII-A

	General Institute Requirements	Total units
	Specific science and humanities and social science subjects	132
	The Science Distribution Requirement will be satisfied by 7.01[1] and 5.41[1] and 5.60[1], which are required in the Departmental Program, plus appropriate subjects totaling	12
	Laboratory Requirement[2]	12

	Departmental Program Required Subjects				60
5.41	Introduction to Structure, Bonding and Mechanism[1]	5	0	7	
5.60	Chemical Equilibrium[1]	4	0	8	
7.01	General Biology[1]	4	0	8	
7.011	Introduction to Experimental Biology	1	8	3	
7.05	General Biochemistry	5	0	7	
	Restricted Electives				24
	Two of the following subjects:				
7.03	Genetics	3	0	9	
7.04	Developmental Biology	3	0	9	
7.06	Cell and Organ Physiology	3	0	9	
7.07J	Biophysical Chemistry	3	0	9	
7.21	General Microbiology	4	0	8	
	Unrestricted Electives				120
	Total Units Required for the S.B. Degree				360

1
Students who take 5.41 or 5.60 or 7.01 to fulfill the General Institute Requirement in Chemistry/Biology must take 12 additional units of Science Distribution Subjects.

2
Students interested in admission to Medical School are advised to consult the premedical advisory office for advice about choosing an appropriate laboratory subject that will meet the Institute Laboratory Requirement.

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 nontumor viruses), synthesis and structure of eukaryotic DNA, membrane structure and synthesis, sensory physiology, and differentiation. A major focus of the research in cell biology is the study of growth control and the aberrances of growth control in malignant cells.

Microbiology The aim of this program is to provide the student with an understanding of the fundamental aspects of the structure, genetics, and physiology of microorganisms. Current research projects are in the areas of the genetics of bacteria, yeast, and bacteriophage; the assembly of bacteriophage; the molecular biology of slime molds; the function of bacterial membranes; the regulation of the biosynthesis of bacterial enzymes; and the biology of animal viruses.

Biochemistry This program is designed to give the student training in the following areas of biochemistry: the chemistry of proteins and nucleic acids, physical biochemistry, intermediary metabolism, membrane biochemistry, enzymology and molecular biology. Examples of current research are the structure and biosynthesis of macromolecules such as DNA, RNA, and proteins; the biosynthesis of amino acids and coenzymes; the chemical mechanisms underlying the action of enzymes; the regulation of the biosynthesis of macromolecules; membrane biochemistry; the biochemistry of development; and immunochemistry.

Biophysics The objectives of research in this area are an understanding of function of biological systems in terms of the structures and interactions of molecules. These objectives are approached through the application of techniques such as X-ray diffraction, electron microscopy, ultracentrifugation, electrophoresis, spectroscopy, genetics, and a variety of other physiochemical and physiological approaches. Current examples of research interests lie in the areas of the mechanisms of formation of tertiary structure of proteins and nucleic acids; the physical chemistry of macromolecules and their interactions; molecular aspects of blood coagulation; molecular biology, including assembly of macromolecular structures such as phage; the mechanism of allosteric control; DNA replication and mechanisms of genetic recombination; biophysical aspects of neurobiology; and communications biophysics. A program is provided whereby students with a variety of educational backgrounds can make the transition into biology (biophysics). For this reason applications are welcome from those who have majored in physical chemistry or physics and also from those holding degrees in medicine. To accomplish the transition, the program in biophysics is deliberately flexible so that complementary education may be obtained as part of the graduate program.

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, see Joint Programs in Oceanography, M.I.T./Woods Hole, 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 modifies the general Institute requirements for graduate study as follows: 18.01, 18.02 Calculus; one year of college physics; 5.41 Introduction to Structure, Bonding and Mechanism; professional subjects including general biochemistry or microbiology. 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 III. There are no specific Departmental programs for the degree, since the subjects required vary with the field of specialization. Students select their own programs, according to certain broad principles, after consultation with the Graduate Committee of the Department.

Teaching and Research Assistantships

A number of qualified students are appointed each year as teaching or research assistants. Research assistants may be permitted to use the results of their assigned research work in graduate theses, with the possible acceleration of their programs. In addition, a number of predoctoral and postdoctoral fellowships are available in cell biology, microbiology, physiology, biochemistry, and biophysics.

Inquiries

Any additional information regarding graduate academic programs, research activities, admissions, financial aid, assistantships, etc. may be obtained from Biology Headquarters, Room 56-509. M.I.T., Cambridge, Massachusetts 02139, (617) 253-4701.

Subjects in Biology*

(A) following the name of subject indicates that it is an approved subject for a graduate degree and is given primarily for graduate students.

7.U.R.	Undergraduate Research
7.00	Perspective in Life Science
7.01	General Biology
7.011	Introduction to Experimental Biology
7.021	Experimental Immunology
7.03	Genetics
7.031	Experimental Microbial Genetics
7.04	Developmental Biology
7.041	Experimental Cell Biology
7.05	General Biochemistry
7.051	Experimental Biochemistry
7.06	Cell and Organ Physiology
7.061	Experimental Behavioral Genetics
7.07J	Biophysical Chemistry
7.08	Introduction to Biophysics
7.09J	Seminar in Technology and Society: Ethical and Social Issues in Biomedicine
7.11	Biology Teaching
7.13	The Biosphere
7.21	General Microbiology
7.211	Experimental Microbiology
7.23	Regulation in Microorganisms
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
7.28	Eukaryotic Microorganisms
7.30	Method and Logic in Molecular Biology (A)
7.31	Eukaryotic Chromosomes
7.32	Analysis of Differentiation and Development
7.36	Advanced Neurophysiology (A)
7.411–7.413	Seminars in Biological Oceanography (A)
7.43–7.49	Special Problems in Biological Oceanography (A)
7.491–7.497	Research in Biological Oceanography (A)
7.50	Physical Chemistry of Macromolecules
7.52	Structure and Assembly of Organisms, Organelles and Macromolecules
7.53	Laboratory in Biological Electron Microscopy
7.61	The Mammalian Cell
7.62	Tumor Biology (A)
7.63	Topics in Immunology (A)
7.64	Seminar in Tumor Viruses (A)
7.70	Seminar in Protein and Nucleic Acid Structure (A)
7.71	Physical Biochemistry
7.73	General Immunology
7.74J	Seminar in Biochemistry (A)
7.75	Advanced Biochemistry (A)
7.76	Membrane Biochemistry (A)
7.86	Molecular Genetics (A)
7.90	Special Problems in Biology for Undergraduates
7.93	Selected Topics in Biology (A)
7.941	Research Problems (A)
7.942	Research Problems (A)
7.97	Seminar in Neuroscience Research Topics (A)
7.99	Molecular Configuration in Biological Systems Seminar (A)

*Full descriptions of all subjects are given in the catalogue entitled **Courses and Degree Programs, 1974–75**, which may be obtained by writing to the Institute Information Services, Room 7-111, M.I.T.

Department of Chemistry

Glenn Allen Berchtold, Ph.D.
Professor of Chemistry
Head of the Department

John Withers Irvine, Jr., Ph.D., Sc.D.
Professor of Chemistry
Executive Officer

Professors

Robert Arnold Alberty, Ph.D., Sc.D.
Professor of Chemistry
Dean of the School of Science

Jack Edward Baldwin, Ph.D.
Professor of Chemistry

Klaus Biemann, Ph.D.
Professor of Chemistry

George Hermann Büchi, D.Sc.
Camille Dreyfus Professor of Chemistry

Alan Davison, Ph.D.
Professor of Chemistry

John Mark Deutch, Ph.D.
Professor of Chemistry

Carl Wesley Garland, Ph.D.
Professor of Chemistry

Frederick Davis Greene, II, Ph.D., Sc.D.
Professor of Chemistry

Richard Hadley Holm, Ph.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

James Lloyd Kinsey, Ph.D.
Professor of Chemistry

Richard Collins Lord, Ph.D., Sc.D.
Professor of Chemistry
Director of the Spectroscopy Laboratory

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

Clark Conkling Stephenson, Ph.D.
Professor of Chemistry

Charles Gardner Swain, Ph.D.
Professor of Chemistry

John Stewart Waugh, Ph.D.
Arthur Amos Noyes Professor of Chemistry

George McClelland Whitesides, Ph.D.
Professor of Chemistry

Associate Professors

John Simpson Lewis, Ph.D.
Associate Professor of Geochemistry

Paul Reinhard Schimmel, Ph.D.
Associate Professor of Biology and Chemistry

Karl Barry Sharpless, Ph.D.
Associate Professor of Chemistry

Robert James Silbey, Ph.D.
Associate Professor of Chemistry

Jeffrey Irwin Steinfeld, Ph.D.
Associate Professor of Chemistry

Assistant Professors

Robert Warren Field, Ph.D.
Assistant Professor of Chemistry

James Leslie Gole, Ph.D.
Assistant Professor of Chemistry

Sidney Michael Hecht, Ph.D.
Assistant Professor of Chemistry

Ellen Jane Henderson, Ph.D.
Assistant Professor of Chemistry

Richard James Lagow, Ph.D.
Assistant Professor of Chemistry

Christopher Thomas Walsh, Ph.D.
Assistant Professor of Chemistry

Mark Stephen Wrighton, Ph.D.
Assistant Professor of Chemistry

Lecturer

Daniel Dominick Traficante, Ph.D.

Instructor

Jeanne Kann Krieger, Ph.D.

Technical Instructors

Carl Richard Grant, Jr., S.B.
James Alexander Simms

Administrative Officer

John Emmett Jordan, Ph.D.

Professors Emeriti

James Alexander Beattie, Ph.D.
Professor of Physical Chemistry, Emeritus

Edmund Lee Gamble, Ph.D.
Professor of Inorganic Chemistry, Emeritus

Leicester Forsyth Hamilton, S.B.
Professor of Analytical Chemistry, Emeritus

Louis Harris, Ph.D.
Associate Professor of Physical Chemistry, Emeritus

Lawrence Joseph Heidt, Ph.D.
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Frederick George Keyes, Ph.D., Sc.D.
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Earl Bowman Millard, Ph.D.
Professor of Physical Chemistry, Emeritus

Avery Adrian Morton, Ph.D.
Professor of Organic Chemistry, Emeritus

Stephen Gershom Simpson, Ph.D.
Associate Professor of Analytical Chemistry, Emeritus

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.

Bachelor of Science in Chemistry Course V

	General Institute Requirements	Total units
	Specific science and humanities and social science subjects.	132
	The Science Distribution Requirement will be satisfied by 5.41 or 5.60, which are required in the Departmental Program, plus appropriate subjects totaling	24
	The subject 5.31, which is required in the Departmental Program, appears on the list of Laboratory Subjects and can be used to satisfy the Laboratory Requirement.	

	Departmental Program				
	Required Subjects				**105**
5.03	Principles of Inorganic Chemistry I	4	0	8	
5.31	Introduction to Chemical Experimentation	2	8	2	
5.32	Intermediate Chemical Experimentation	2	10	3	
5.33	Advanced Chemical Experimentation	2	12	4	
5.41	Introduction to Structure, Bonding and Mechanism[1]	5	0	7	
5.42	Organic Chemistry	5	0	7	
5.60	Chemical Equilibrium[1]	4	0	8	
5.61	Physical Chemistry	4	0	8	
	Restricted Electives				**9 or 12**
	At least one of the following subjects:				
5.43	Organic Chemistry	3	0	6	
5.62	Physical Chemistry	4	0	8	
5.64J	Biophysical Chemistry	3	0	9	
	Unrestricted Electives[2]				**90 or 87**
	Total Units Required for the S.B. Degree				**360**

1
Students who take either 5.41 or 5.60 to fulfill the General Institute Requirement in Chemistry/Biology must take 12 Additional Units of Unrestricted Elective.

2
The student's Faculty Counselor can offer suggestions for elective subjects, which are offered by this Department and by other departments, that will be of value in preparation for specialization in the various broad areas of chemistry. The proper choice of electives is particularly important for students planning to continue their education in a graduate school.

Graduate Study

The Department of Chemistry offers the Master of Science in Chemistry, the Doctor of Philosophy, and the Doctor of Science. The subjects offered for these degrees aim to develop a sound knowledge of fundamentals and a familiarity with current progress in the most active and important areas of chemistry. In addition to studying formal subjects, each student undertakes a research problem which forms the core of graduate work. Through the experience of conducting an investigation leading to the master's or doctoral thesis, a student learns general research attitudes and methods of approach and acquires training in some of the specialized techniques of research.

The areas of research in the Department are organic, inorganic, physical, analytical, geological, 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 is also an opportunity for research in cooperation with other departments such as Biology, Earth and Planetary Sciences, and Physics. Detailed information on the research activities of the faculty can be found in the *Directory of Graduate Research* published by the American Chemical Society.

During the first term of residence, all graduate students are encouraged to select research supervisors who will serve as advisors for the balance of their graduate careers. In particular, the final program of graduate subjects is established by each student and the research supervisor. In planning this program and in establishing the thesis problem, careful consideration is given to the candidate's academic record and professional experience, as well as to long-range objectives.

Entrance Requirements for Graduate Study

Students intending to pursue graduate work in the Department should have excellent undergraduate preparation in chemistry. The Department, however, is flexible in its attitude toward the specific mathematics and physics preparation; the essential requirement is demonstration of ability to progress with advanced study and research in some area of special interest. Mathematics and physics are important prerequisites for graduate work in physical chemistry or chemical physics. On the other hand, less preparation in mathematics and physics would be required for work in organic chemistry.

Applicants for graduate admission are not required to submit Graduate Record Examination scores; however, it is requested that the scores be submitted by those persons who are taking the G.R.E.

Since attainment of the Master of Science is not prerequisite to a program of study leading to a doctorate, new graduate students should register as doctoral candidates from the beginning of their graduate work. Applications for admission as a Master of Science candidate are not accepted unless there is some special reason to seek the M.S. as a terminal degree.

Master of Science in Chemistry

The general requirements for the Master of Science are listed in Chapter III of this Catalogue.

Doctor of Philosophy and Doctor of Science

The Department does not have any formal subject requirements for the doctoral degree. Each student, with the advice of a research supervisor, pursues an individual program of study which is pertinent to long-range research interests. For some students this includes the acquisition of proficiency in reading scientific German.

Written major examinations are cumulative, and a series of examinations is given each term. Separate examinations in physical, organic, and inorganic chemistry are offered each term, and additional examinations in analytical, biophysical chemistry, or other specialized areas are also 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 are also 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

Subjects in Chemistry*

(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)
5.121J	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)
5.31	Introduction to Chemical Experimentation
5.32	Intermediate Chemical Experimentation
5.33	Advanced Chemical Experimentation
5.41	Introduction to Structure, Bonding and Mechanism
5.42	Organic Chemistry
5.43	Organic Chemistry
5.50	Enzymatic Reaction Mechanism (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)
5.60	Chemical Equilibrium
5.61	Physical Chemistry
5.62	Physical Chemistry
5.64J	Biophysical Chemistry
5.68	Kinetics of Chemical Reactions (A)
5.70	Introduction to Statistical Thermodynamics (A)
5.71	Chemical Thermodynamics I (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)

*Full descriptions of all subjects are given in the catalogue entitled **Courses and Degree Programs, 1974–75**, which may be obtained by writing to the Institute Information Services, Room 7-111, M.I.T.

Department of Earth and Planetary Sciences

Frank Press, Ph.D., LL.D., D.Sc.
Robert R. Shrock Professor of Geophysics
Head of the Department

Professors

Keiiti Aki, Ph.D.
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Professor of Geology

Roger George Burns, Ph.D.
Professor of Geochemistry

Patrick Mason Hurley, Ph.D.
Professor of Geology

Theodore Richard Madden, Ph.D.
Professor of Geophysics

Gordon Hemenway Pettengill, Ph.D.
Professor of Planetary Physics

Irwin Ira Shapiro, Ph.D.
Professor of Geophysics
Professor of Physics

M. Gene Simmons, Ph.D.
Professor of Geophysics

M. Nafi Toksöz, Ph.D.
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Associate Professor of Geochemistry and Chemistry

John Simpson Lewis, Ph.D.
Associate Professor of Geochemistry and Chemistry

Thomas Bard McCord, Ph.D.
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Director, George R. Wallace, Jr. Astrophysical Observatory

William Hamet Pinson, Jr., Ph.D.
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John George Sclater, Ph.D.
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John R. Bennett
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Assistant Professor of Geology

Peter Molnar, Ph.D.
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Sean Carl Solomon, Ph.D.
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Honorary Lecturer

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Senator Thomas Desmond Instructor

Administrative Officer

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Katsuyuki Abe, Ph.D.
Aviva Brecher, Ph.D.
Anton Michael Dainty, Ph.D.
Anthony Irving, Ph.D.
David Kohlstedt, Ph.D.
Raul Madariaga, Ph.D.
Alan S. Parkes, Ph.D.
Barry Parsons, Ph.D.

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William A. Bassett, Ph.D.
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James D. Hedburg, Ph.D.
Crosby Visiting Professor

Mervyn S. Paterson, Ph.D.

Visiting Scientist

Henri Gaudette, Ph.D.

Professors Emeriti

Martin Julian Buerger, Ph.D.
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Professor of Mineralogy and Crystallography, Emeritus

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Senior Lecturer

Robert Rakes Shrock, Ph.D.
Professor of Geology, Emeritus
Senior Lecturer

Department of Earth and Planetary Sciences

Undergraduate Study

The study of earth and planetary sciences at M.I.T. includes 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; the dynamics of planet and satellite motions; and the nature of the interplanetary medium. Since no single department can fully cover all aspects of these areas, M.I.T. has developed a program of education and research concentrating on the modern aspects of mineralogy-crystallography; experimental petrology; rock mechanics; regional geology and geophysics; geochemistry; 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 measurements where possible, by laboratory studies on samples or models, and by theoretical-numerical studies influenced by the available data. 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 Observatory (optical telescopes); and in cooperating institutions such as the Woods Hole Oceanographic Institution.

Bachelor of Science in Earth and Planetary Sciences Course XII

The Department offers undergraduate preparation for professional careers in earth and planetary sciences. Some students specialize in specific fields such as geology, geochemistry, geophysics, meteorology, oceanography, planetary astronomy, or planetary physics or chemistry. Others choose to combine basic studies in mathematics, physics, or chemistry with applications to earth and planetary sciences gained through research and a limited number of subjects in Course XII.

The programs leading to the Bachelor of Science in Earth and Planetary Sciences contain a minimum number of specific requirements, which allows for maximum flexibility in choosing an individualized program of study. Students select personal faculty advisors shortly after entering Course XII and every year thereafter. In addition, students in each class are assigned a class advisor or registration supervisor. Programs of study are worked out in consultation with these advisors and with the help of published sample programs. Students are encouraged to enter the Department of Earth and Planetary Sciences at the beginning of the second year to obtain maximum benefit from these advisors; however, any interested student is encouraged to visit Department headquarters to obtain copies of sample programs or to arrange conferences with advisors.

Bachelor of Science in Earth and Planetary Sciences Course XII

	General Institute Requirements				Total units
	Specific science and humanities and social science subjects.				132
	The subjects 5.60, 8.03, and 18.03, which are required in the Departmental Program, appear on the list of Science Distribution Subjects and can be used to satisfy the Science Distribution Requirement.				
	Laboratory Requirement				12
	Departmental Program				
	Required Subjects				60
5.60	Chemical Equilibrium[1]	4	0	8	
8.03	Physics III	5	0	7	
12.091	Special Problems	0	12	0	
12.101	Physics of the Earth	3	0	9	
18.03	Differential Equations	4	0	8	
	Restricted Electives A coherent program of electives selected with the aid of Faculty Advisors and approved by the Departmental Committee on Undergraduates. See description below.				84
	Unrestricted Electives[2]				72
	Total Units Required for the S.B. Degree				360

1
Students who take 5.60 to fulfill the General Institute Requirement in Chemistry/Biology must take 12 additional units of Unrestricted Elective.

2
Schedules of students in Course XII may always be arranged to leave available 12 units of unrestricted elective in the second year.

Restricted Elective Requirements

Students should develop competence in some field, or fields, beyond the level of introductory subjects. Since the range of options relevant to earth and planetary sciences is too broad to convey in a simple list, the requirements are stated as a program of restricted electives.

Geology 12.00 Evolution of the Earth, 12.01 Earth Surface Processes, 12.02 Physics and Chemistry of Geological Materials, 12.03 Structural Geology, 12.061 Petrology I, 12.062 Petrology II, 12.064 Sedimentary Petrology, and Summer Field Camp.

Geochemistry 12.02 Physics and Chemistry of Geological Materials, 12.061 Petrology I, 12.062 Petrology II, 5.31 Introduction to Chemical Experimentation, 5.41 Introduction to Structure, Bonding, and Mechanism, and two physical chemistry subjects beyond 5.60 Chemical Equilibrium.

Geophysics and Planetary Science three physics subjects beyond 8.03 Physics III, 18.075 Advanced Calculus for Engineers, and 12.03 Structural Geology or 12.131J Planetary Physics and Chemistry I. Physics subjects can be experimental or theoretical or both, according to individual interests.

Physical Oceanography and Meteorology physics and mathematics subjects similar to the program in geophysics, plus 12.21 Physical Oceanography or 19.02 Descriptive Meteorology or 19.83 Physical Oceanography and one subject in fluid mechanics.

Environmental Earth Science 12.00 Evolution of the Earth, 12.01 Earth Surface Processes, 12.02 Physics and Chemistry of Geological Materials, 12.04 Mineral Resources Workshop, 12.20J Environmental Chemistry of the Ocean-Atmosphere System, and 12.081 or 12.082 Environmental Problems Seminars; plus 36 credits concentrating in geology, oceanography, basic science, civil engineering, or management. This program is appropriate for students interested in law school, government service, or certain Master of Science programs in environmental technology. Subjects developed for the environmental program can also be incorporated into more concentrated programs designed to prepare students directly for advanced graduate study.

The remaining restricted electives in these programs, or any alternate programs submitted, are approved to meet the needs and interests of individual students. Approval of these programs will be based on their scope, depth, and relevance to sound preparation in earth and planetary sciences. Programs normally should be submitted to the Departmental Committee on Undergraduates for approval by the middle of the student's third year.

Students who wish to defer choosing a field of concentration within Course XII can prepare for all of the options by completing 5.60 Chemical Equilibrium, 8.03 Physics III, 12.02 Physics and Chemistry of Geological Materials, and 18.03 Differential Equations during their second year.

Each student is required to undertake a minimum of 12 credits of research supervised in the Department. Many students take significantly more, and some petition for their individual research to satisfy the Laboratory Requirement. By petition to the Department Committee on Undergraduates, suitable planned and executed research or individual study can be substituted for classroom subjects.

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, 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 regarding academic and research programs, admission requirements, financial aid, etc. may be obtained by writing to Dr. Frank Press (Chairman), Department of Earth and Planetary Sciences, Room 54-912, M.I.T., Cambridge, Massachusetts 02139, (617) 253-3382.

Graduate Study

The Department of Earth and Planetary Sciences offers a wide choice of graduate study and research in geology, geochemistry, geophysics, solid earth and planetary physics, and oceanography. Advanced work in these fields leads to the Master of Science in Earth and Planetary Sciences and/or the Doctor of Philosophy, or the Doctor of Science with a thesis in the field of specialization.

The Department offers graduate students an unusual opportunity to pursue study and research in both theoretical and experimental aspects of the subjects. Modern laboratory facilities, electronic computers, research instruments, and extensive collections of specimens and materials are available to qualified graduate students. Field studies are regarded as 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 jointly awarded degrees of the Doctor of Philosophy or the Doctor of Science. For details of this program, see Joint Programs in Oceanography, M.I.T./Woods Hole, 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 program of subjects leading to 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 preparation in these areas while pursuing advanced work. The subjects taken for this purpose are selected by the students after their preparation and proposed programs of study have been considered by an advisory committee. The actual programs of advanced subjects and research leading to graduate degrees are arranged by both students and faculty advisors. A Departmental committee on academic performance reviews academic programs and assists students and advisors in planning individual programs.

Master of Science in Earth and Planetary Sciences or in Oceanography

In addition to the general and Departmental requirements stated in Chapter III and in the preceding paragraph, candidates for the Master of Science in Earth and Planetary Sciences or in Oceanography are required to pursue programs of advanced study and research in fields of specialization to be decided upon in consultation with faculty advisors. Possible fields of specialization include geology, geochemistry, geophysics, and solid earth and planetary physics.

Doctor of Philosophy and Doctor of Science

The general requirements for the completion of the Doctor of Philosophy or the Doctor of Science are given in Chapter III. The Department policy concerning the administration of these requirements is determined by the Department committees on academic performance and examinations. Oceanography students are in the jurisdiction of the joint oceanography program, which is administered by an interdepartmental committee from Earth and Planetary Sciences and Meteorology and the Woods Hole Oceanographic Institution.

The doctoral program can be entered without a Master of Science as a prerequisite. Qualification for entering the doctoral program, based on preparation and performance at the graduate level, is determined by the Department committee on academic performance in consultation with the student and the advisor.

A candidate's advanced study is expected to be broad and to include some course work in other departments. The general examination is designed to test research ability, as well as overall preparation. Students should begin thesis research after successful completion of the general examination. Thesis supervisors, who may be faculty members from other departments, should be chosen because of interest and knowledge in the general areas of the proposed research. The thesis is expected to meet high professional standards, and to contribute significantly to the field of interest. The thesis must be defended orally before a thesis committee including the candidate's thesis advisor, other specialists in the thesis area, and a department faculty member from a different field.

Teaching and Research Assistantships

The Department regularly appoints 45 to 50 assistants who are candidates for a graduate degree. Teaching assistants conduct scheduled laboratory sections and examinations, grade papers, and prepare teaching materials. Research assistants do assigned work on one of the Department's projects, and may be able to use some of the work done toward a thesis.

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 Dr. Frank Press (Chairman), Department of Earth and Planetary Sciences, Room 54-912, M.I.T., Cambridge, Massachusetts 02139, (617) 253-3382.

Subjects in Earth and Planetary Sciences*

(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.

	Undergraduate Subjects
12.U.R.	Undergraduate Research
12.00	Evolution of the Earth
12.001	Introductory Oceanography
12.002	The Earth and the Planets
12.003	Environmental Ecology I
12.004	Environmental Ecology II
12.01	Earth Surface Processes
12.02	Physics and Chemistry of Geological Materials
12.03	Structural Geology
12.04	Mineral Resources Workshop
12.061	Petrology I
12.062	Petrology II
12.064	Sedimentary Petrology
12.066	Analysis of Geological Materials
12.081–12.082	Environmental Problems Seminar
12.091–12.094	Special Problems
12.101	Physics of the Earth
12.102	Techniques and Topics in Regional Geophysics
12.103	Plate Tectonics
12.111	Survey of Astronomy I
12.112	Survey of Astronomy II
12.113	Astronomy I
12.115J	Dynamical Astronomy
12.116	Astronomy II
12.121	Exploration of the Solar System
12.131J	Planetary Physics and Chemistry I
12.132J	Planetary Physics and Chemistry II
12.143	Experimental Optical Astronomy
12.20J	Environmental Chemistry of the Ocean-Atmosphere System
12.21	Physical Oceanography
12.221–12.229	Project Studies in Oceanography

	Graduate Subjects
	Geology and Geochemistry
12.301–12.304	Seminar in Geology and Geochemistry (A)
12.32	Sedimentology and Sediment Movement (A)
12.33	Petroleum Geology
12.35	Rock Mechanics (A)
12.355	Seminar in Rock Mechanics (A)
12.362	Physics of Geologic Materials (A)
12.385–12.399	Special Problems in Geology–Geochemistry (A)
12.40	Chemistry of the Earth (A)
12.411	Isotope Geology (A)
12.42	Geochemistry of the Solid State (A)
12.45	Geochemistry (A)
12.47	Advanced Petrology I (A)
12.48	Advanced Petrology II (A)
	Geophysics and Planetary Physics
12.51	Signal Analysis and Data Processing (A)
12.512	Geoelectricity (A)
12.514	Geomagnetism (A)
12.521	Elements of Seismology (A)
12.522	Advanced Seismology (A)
12.524	Earthquakes (A)
12.53	Inverse Problems in Geophysics (A)
12.54	Planetary Interiors (A)
12.56	Plate Tectonics and Marine Geophysics (A)
12.581–12.589	Seminar in Geophysics (A)
12.591–12.599	Special Problems in Geophysics (A)
12.623	Planetary Surfaces (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)
12.691–12.699	Special Problems in Planetary Physics (A)

	Oceanography
12.71	Introduction to Physical Oceanography
12.73	Introduction to Marine Geology (A)
12.76	Seminar in Marine Physics (A)
12.781–12.789	Seminar in Oceanography at Woods Hole (A)
12.791–12.799	Special Problems in Oceanography at Woods Hole (A)
12.81	Waves and Tides (A)
12.83	Marine Geochemistry (A)
12.85	Oceanographic Time Series (A)
12.881–12.889	Seminar in Oceanography at M.I.T. (A)
12.891–12.899	Special Problems in Oceanography at M.I.T. (A)

*Full description of all subjects are given in the catalogue entitled **Courses and Degree Programs, 1974–75**, which may be obtained by writing to the Institute Information Services, Room 7-111, M.I.T.

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Professor of Mathematics
Head of the Department

Harvey Philip Greenspan, Ph.D.
Professor of Applied Mathematics
Chairman, Committee on Applied Mathematics

Franklin Paul Peterson, Ph.D.
Professor of Mathematics
Chairman, Committee on Pure Mathematics

Arthur Paul Mattuck, Ph.D.
Class of 1922 Professor of Mathematics
Chairman, Undergraduate Mathematics Committee

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

Alberto Pedro Calderon, Ph.D.
Professor of Mathematics
(Absent Spring Term)

Lennart A. E. Carleson, Ph.D.
Professor of Mathematics
(Visiting)

Hung Cheng, Ph.D.
Professor of Applied Mathematics

Herman Mordecai Chernoff
Professor of Applied Mathematics

Richard Mansfield Dudley, Ph.D.
Professor of Mathematics

Victor William Guillemin, Ph.D.
Professor of Mathematics

Sigurdur Helgason, Ph.D.
Professor of Mathematics
(Absent)

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Louis Norberg Howard, Ph.D.
Professor of Mathematics

Daniel Marinus Kan, Ph.D.
Professor of Mathematics

Daniel J. Kleitman, Ph.D.
Professor of Applied Mathematics

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(Absent Fall Term)

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Professor of Mathematics
Cecil and Ida Green Professor of Education
Co-Director, Artificial Intelligence Laboratory

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(Visiting, Fall Term)

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Professor of Mathematics

Hartley Rogers, Jr., Ph.D.
Professor of Mathematics
Associate Provost

Gian-Carlo Rota, Ph.D.
Professor of Applied Mathematics and Natural Philosophy

Gerald Enoch Sacks, Ph.D.
Professor of Mathematical Logic
(Absent)

Richard Donald Schafer, Ph.D.
Professor of Mathematics

Irving Ezra Segal, Ph.D.
Professor of Mathematics

Claude Elwood Shannon, Ph.D.
Donner Professor of Science
(Absent)

Isadore Manual Singer, Ph.D.
Norbert Wiener Professor of Mathematics

Harold Mead Stark, Ph.D.
Professor of Mathematics

William Gilbert Strang, Ph.D.
Professor of Mathematics

Dennis Parnell Sullivan, Ph.D.
Professor of Mathematics (Absent)

George Brinton Thomas, Jr., Ph.D.
Professor of Mathematics (Absent)

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(Absent Fall Term)

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(Visiting)

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Assistant Professor of Applied Mathematics

Alan Needleman, Ph.D.
Assistant Professor of Applied Mathematics

Joel Harold Spencer, Ph.D.
Assistant Professor of Applied Mathematics

Richard Peter Stanley, Ph.D.
Assistant Professor of Applied Mathematics

Paul Shyh-Horng Wang, Ph.D.
Assistant Professor of Applied Mathematics

Lecturers

Richard J. Fateman, Ph.D.
John Benjamin Friedlander, Ph.D.
Mark Lee Green, Ph.D.
William Messing, Ph.D.
Floyd Williams, Ph.D.

(continued)

Undergraduate Study

C. L. E. Moore Instructors

Allan Russell Adler, Ph.D.
Gerald Arthur Anderson, Ph.D.
Michael Walter Davis, Ph.D.
Josef Dodziuk, Ph.D.
Harold Gerald Donnelly, Ph.D.
Henryk Hecht, Ph.D.
Solomon Jekel, Ph.D.
Edward Yarnell Miller, Ph.D.
James Richard Wason, Ph.D.

Instructors

Arnold Irvin Barnett, Ph.D.
Gail Alexandra Carpenter, Ph.D.
Darell James Johnson, Ph.D.
Zvi Meir Kedem, Ph.D.
Nelly Sebilla Kroonenberg, Ph.D.
Robert Arthur LaBudde, Ph.D.
Yue-Ying Lau, Ph.D.
Philip William Lavori, Ph.D.
Anne Marie Leggett, Ph.D.
Shuo-Yen Robert Li, Ph.D.
Julian Ivanhoe Palmore III, Ph.D.
Steven Robbins, Ph.D.
Philip Trauber, Ph.D.
Da-Lun Wang, Ph.D.

Administrative Assistant

James Edward Dalton

Research Associate

Herm Jan Brascamp, Ph.D.

Professors Emeriti

Prescott Durand Crout, Ph.D.
Professor of Mathematics, Emeritus
Senior Lecturer

Raymond Donald Douglass, Ph.D., Sc.D.
Professor of Mathematics, Emeritus

Dirk Jan Struik, Ph.D.
Professor of Mathematics, Emeritus

George Proctor Wadsworth, Ph.D.
Professor of Mathematics, Emeritus

Bachelor of Science in Mathematics Course XVIII

Each undergraduate's program is arranged through continuous collaboration between the individual student and his or her faculty counselor, subject to a minimum set of specific requirements. In most 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.

The requirements are unspecific in order to accommodate those students who may not be professionally interested in mathematics but who wish to use it in connection with other work, and to give professionally oriented students maximum flexibility in exploring their interests in both pure and applied mathematics.

Bachelor of Science in Mathematics Course XVIII

	General Institute Requirements		Total units
	Specific science and humanities and social science subjects		132
	The Science Distribution Requirement will be satisfied by 18.03 or 18.031, which are among the Restricted Electives, plus appropriate subjects totaling		24
	Laboratory Requirement		12
	Departmental Program		
	Restricted Electives		108
	One of the following subjects:		
18.03	Differential Equations	4 0 8	
18.031	Introduction to Linear Algebra and Differential Equations	4 0 8	
		12	
	Course XVIII subjects of essentially different content, including at least six with the first decimal digit one or higher, and excluding 18.05, 18.051, and 6-unit electives.[1]	96	
	Unrestricted Electives		84
	Total Units Required for S.B. Degree		360

[1] Advanced standing credit will not fulfill any part of this requirement, but will be accepted as Unrestricted Elective.

Students who expect to pursue a career in **pure mathematics** should normally include in their program a year of analysis selected from 18.100 Analysis I, 18.101 Analysis II, 18.104 Seminar in Analysis, and 18.115 Functions of a Complex Variable or 18.284 Introduction to Functions of a Complex Variable.

They should also usually take a year of algebra in one of the sequences 18.701 Algebra I and 18.702 Algebra II, or 18.700 (or 18.710) Linear Algebra and 18.703 Modern Algebra, as well as 18.901 Introduction to Topology. The remaining subjects may be chosen from such areas as logic, number theory, differential topology, combinatorial theory, probability and statistics, or other applied mathematics subjects.

Professionally oriented pure mathematics students are strongly urged to plan their programs so that at least five of the upper-level subjects are completed by the end of the third year. It is also recommended that the overall program include at least one or two graduate-level subjects and a seminar. The faculty counselor can make useful suggestions concerning both the subjects themselves and the order in which students should take them, according to individual interests and abilities.

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. The following sequence of subjects is recommended because it provides a general introduction to most areas of applied mathematics and to several specific areas for study in greater depth.

Freshmen interested in applied mathematics should take 18.001 Calculus and 18.002 Calculus followed as soon as possible by 18.03 Differential Equations or 18.031 Introduction to Linear Algebra and Differential Equations. 18.03 and 18.002 may be taken during the same term.

Sophomores should survey the field of applied mathematics by enrolling in both 18.041 Principles of Applied Mathematics and 18.042 Principles of Applied Mathematics. 18.041, given in the fall term only, is devoted to the discrete aspects of the subject and may be taken concurrently with 18.03.

Juniors should deepen their understanding of general concepts and techniques by acquiring more intensive specialization in one of the following areas: 18.301 Introduction to Physical Mathematics I, 18.312 Statistics for Applications, 18.313 Probability (or 18.303 Probability and Random Variables and 18.304 Statistical Inference), 18.401 Control Theory, and 18.420 Introduction to the Mathematical Theory of Computation.

Subjects of equivalent content may be substituted for these. For further study in the junior or senior years, students should also consider 18.284 Introduction to Functions of a Complex Variable, 18.302 Introduction to Physical Mathematics II, 18.314 Applied Combinatorial Analysis, 18.330 Introduction to Elasticity, 18.350 Introduction to Fluid Mechanics, 18.370 Introduction to Dynamics in Astronomy and 18.411 Applied Algebra.

Sample programs emphasizing different specialities — continuum mechanics, combinatorics, numerical analysis, etc. — are available in the Undergraduate Mathematics office.

Various mixed strategies combining pure and applied mathematics subjects are possible. All students are encouraged to acquire as broad a background in both general areas as time and their inclinations will allow. The great majority of mathematics majors do in fact take both pure and applied subjects.

Students who wish to major in mathematics but do not intend to make a career of it are welcome in any of the above programs.

Inquiries

Any additional information regarding academic programs, admissions, financial aid, etc. may be obtained from the Undergraduate Mathematics Office, 2-108, M.I.T., Cambridge, Massachusetts 02139.

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 III. Specifically, a student must take not less than 72 units, including at least four 12-unit graduate ("A") subjects offered by the Department, as well as submitting an acceptable thesis. It is only rarely, however, that students are admitted to work specifically for the Master of Science; almost all 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 III, and the details of the program are outlined in a set of notes available from the Department. The first stage is to prepare for the general qualifying examination, and to fulfill the course requirements (132 hours of graduate credits). Doctoral candidates are also required to have a mathematical reading knowledge of French, German, or Russian.

Plan A In pure mathematics, the general examination is oral, and includes three areas which are chosen by the student in consultation with his advisor. (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.

By the end of the first year of study, the degree candidate in consultation with an advisor must submit a "plan of study" for approval by the Applied Mathematics Committee. In addition to a list of subjects related to the major field, this plan must include a minor, or its equivalent, to assure familiarity with the basic concepts of applied mathematics, i.e., propagation, equilibrium, stability, optimization, cybernetics, and random processes. In order to secure maximum flexibility, programs are considered individually.

Every student must pass the written *general examination* by the end of the second year of graduate study even if he or she is a part-time teaching or research assistant.

The *Guideline of Study for Doctoral Candidates in Applied Mathematics* which is distributed to entering students provides more complete information on degree requirements, academic standards, and financial support.

In either Plan A or Plan B, after successfully passing the general examination, the student may officially begin thesis research under the supervision of the thesis advisor. The thesis is expected to represent original research of high quality and should be finished normally by the end of the fourth year of graduate study. Upon submitting the thesis the student must pass an oral thesis examination.

In special circumstances students may receive permission to work under **Plan N**, in which regular subject requirements and written examinations in mathematics subjects are omitted. Students admitted to this program are given oral examinations on their mathematical progress.

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 2-363, 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.

	General Mathematics
18.U.R.	Undergraduate Research
18.001	Calculus
18.002	Calculus
18.01	Calculus
18.02	Calculus
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
18.051	Surveys of Higher Mathematics
18.075	Advanced Calculus for Engineers (A)
18.076	Advanced Calculus for Engineers (A)
18.085	Methods of Applied Mathematics for Engineers (A)
18.089	Review of Mathematics
18.093	Tutoring in Mathematics
18.094	Seminar in Mathematical Education
18.099	Independent Activities

*Full descriptions of all subjects are given in the catalogue entitled **Courses and Degree Programs, 1974–75**, which may be obtained by writing to the Institute Information Services, Room 7-111, M.I.T.

	Analysis
18.100	Analysis I (A)
18.101	Analysis II (A)
18.104	Seminar in Analysis
18.109	The Architecture of Modern Analysis (A)
18.115	Functions of a Complex Variable (A)
18.116	Functions of a Complex Variable (A)
18.117	Topics in Complex Variables (A)
18.118	Topics in Complex Variables (A)
18.125	Lebesgue Integration (A)
18.126	Functional Analysis (A)
18.127	Differential Equations and Generalized Functions (A)
18.128	Complex Functional Analysis (A)
18.135	Fourier Analysis (A)
18.155	Introduction to Partial Differential Equations (A)
18.157	Partial Differential Equations I (A)
18.158	Partial Differential Equations II (A)
18.165	Pseudodifferential Operators (A)
18.166	Pseudodifferential Operators (A)
18.175	Theory of Probability (A)
18.176	Topics in Probability (A)
18.177	Introduction to Stochastic Processes (A)
18.185	Mathematical Statistics (A)
18.194	Seminar in Analysis
18.199	Topics in Analysis (A)
18.235J	The Mathematics of Quantum Mechanics (A)
18.238J	Modern Statistical Mechanics (A)
18.247	Topics in Operator Theory (A)
18.255	Mathematical Methods of Advanced Physical Theory (A)
18.257	Mathematical Theory of Quantum Fields (A)
18.259	Theoretical and Observational Cosmology (A)
18.270	Integral Equations (A)
18.275	Numerical Analysis (A)
18.276	Numerical Analysis (A)
18.277	Approximations and Numerical Anlaysis (A)
18.279	Analysis of the Finite Element Method (A)
18.284	Introduction to Functions of a Complex Variable (A)
18.285	Introduction to Functions of a Complex Variable (A)
18.295	Tensor Calculus (A)

	Applied Mathematics
18.301	Introduction to Physical Mathematics I
18.302	Introduction to Physical Mathematics II
18.303	Probability and Random Variables
18.304	Statistical Inference
18.305	Methods of Applied Mathematics I (A)
18.306	Methods of Applied Mathematics II (A)
18.307	Methods of Applied Mathematics III (A)
18.308	Wave Motion (A)
18.312	Statistics for Applications
18.313	Probability
18.314	Applied Combinatorial Analysis
18.315	Combinatorial Theory (A)
18.318	Theory and Application of Finite Fields
18.325	Topics in Applied Mathematics (A)
18.326	Numerical Methods of Applied Mathematics (A)
18.330	Introduction to Elasticity
18.335	Theoretical and Applied Elasticity (A)
18.336	Theoretical and Applied Elasticity (A)
18.337	Topics in Solid Mechanics (A)
18.350	Introduction to Fluid Mechanics
18.356	Rotating Fluids (A)
18.357	Seminar in Fluid Dynamics (A)
18.358	Hydrodynamic Stability and Turbulence (A)
18.370	Introduction to Dynamics in Astronomy
18.375	Stellar Dynamics and Galactic Structure (A)
18.376	Galaxies, and Their Dynamics (A)
18.387	Statistical Mechanics (A)

Continued on next page

18.395	Mathematical Theory of Modern Physics (A)
18.397	General Relativity (A)
18.401	Control Theory
18.404	Seminar in Computer Calculus
18.405	Mathematical Learning Theory (A)
18.411	Applied Algebra
18.420	Introduction to the Mathematical Theory of Computation
18.424	Seminar in Computation
18.425	Theory of Computers (A)
18.427	Formal Language Theory (A)
18.428	Advanced Topics in Computation (A)
18.429	Algorithms Seminar (A)
18.435	Mathematical Topics in Artificial Intelligence (A)
18.436J	Artificial Intelligence and Heuristic Programming (A)

Logic

18.511	Introduction to Mathematical Logic
18.515	Mathematical Logic (A)
18.525	Seminar in Logic (A)
18.565	Recursion Theory (A)
18.566	Higher Recursion Theory (A)
18.575	Theory of Models (A)
18.576	Theory of Models (A)
18.585	Set Theory (A)
18.586	Set Theory (A)
18.587	Infinitary Combinatorics (A)
18.595	Seminar on Current Topics in Logic (A)

Algebra and Number Theory

18.700	Linear Algebra
18.701	Algebra I
18.702	Algebra II
18.703	Modern Algebra
18.704	Seminar in Algebra and Number Theory
18.705	Algebra III (A)
18.710	Abstract Linear Algebra
18.715	Homological Algebra (A)
18.716	Homological Algebra (A)
18.725	Algebraic Geometry (A)
18.727	Topics in Algebraic Geometry (A)
18.735	Topics in Algebra (A)
18.737	Linear Algebraic Groups (A)
18.755	Lie Groups and Lie Algebras (A)
18.756	Analysis of Lie Groups (A)
18.757	Representations of Lie Groups (A)
18.775	Algebraic Number Theory (A)
18.776	Algebraic Number Theory (A)
18.781	Theory of Numbers
18.785	Analytic Number Theory
18.786	Topics in Number Theory
18.794	Seminar in Algebra and Number Theory

Topology and Geometry

18.901	Introduction to Topology (A)
18.903	Introduction to Algebraic Topology
18.904	Seminar in Topology
18.905	Algebraic Topology (A)
18.906	Algebraic Topology (A)
18.915	Graduate Topology Seminar (A)
18.917	Advanced Topology (A)
18.925	Differential Topology (A)
18.950	Elementary Differential Geometry
18.961	Elementary Differential Topology
18.965	Geometry of Manifolds (A)
18.966	Geometry of Manifolds (A)
18.969	Topics in Geometry (A)
18.975	Elliptic Operators (A)
18.976	Elliptic Operators (A)
18.994	Seminar in Geometry
18.999	Mathematical Reading

Department of Meteorology

Jule Gregory Charney, Ph.D., Sc.D.
Alfred P. Sloan Professor of Meteorology
Head of the Department

Professors

James Murdoch Austin, Sc.D.
Professor of Meteorology
Director of Summer Session

Henry Garrett Houghton, Sc.D.
Professor of Meteorology, Emeritus
Senior Lecturer

Richard Siegmund Lindzen, Ph.D.
Visiting Professor

Edward Norton Lorenz, Sc.D.
Professor of Meteorology

Erik Leonard Mollö-Christensen, Sc.D.
Professor of Oceanography

Reginald Edward Newell, Sc.D.
Professor of Meteorology

Frederick Sanders, Sc.D.
Professor of Meteorology

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John Ellsworth Hart, Ph.D.
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Professor of Meteorology, Emeritus

Meteorology is the science of the atmosphere, primarily that of the earth but also of other planets. It is one of the sciences which deal with the physical properties of the earth. Many of man's unsolved problems depend for their solution on increased knowledge of our physical environment. The Department's educational aim is to provide its students with a broad background in meteorology and related sciences, one which will prepare them to cope with these challenging problems of the atmosphere and the physical environment.

The Department also does teaching and research in physical oceanography, the study of how oceanic waves, currents, and density fields are created and how they interact with the atmosphere.

Undergraduate Study

Modern professional practice in both fields, at all educational levels from baccalaureate to doctoral, emphasizes the quantitative aspect of the subject. This requires a considerable background in the more basic sciences or engineering 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 careful selection of undergraduate electives is offered instead:

	Fall Term
19.03	Meteorological Aspects of Air Pollution
19.05J	Environmental Chemistry of the Ocean Atmosphere System
19.43*	Synoptic Meteorology I
19.83*	Physical Oceanography

	Spring Term
19.02*	Descriptive Meteorology
19.70	Elementary Physics of the Atmosphere

*Science Distribution Requirement

Certain introductory graduate level subjects, such as 19.61 Introduction to Dynamical Meteorology and 19.84 Dynamic Oceanography, are also available to undergraduates who can satisfy the prerequisites. The above subjects are suitable for students who plan to stop at the bacca- students who plan to stop at the baccalaureate level with a "minor" in meteorology, for students who plan to continue with graduate studies in meteorology / oceanography, and for students who wish to supplement their basic undergraduate program with an exposure to interesting environmental problems. Department offerings in the Undergraduate Seminar Program and the Undergraduate Research Opportunities Program are listed in advance of each term in the appropriate announcement booklet.

Undergraduate students at 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 Physics and Mathematics, and in the Environmental Science program of Course XII.

Advice on registration for this purpose and selection of the above subjects as electives is available from Professor J. Austin, Room 54-1610, from the faculty member in charge of each subject, or from Departmental Headquarters, Room 54-1712.

Graduate Study

Emphasis in graduate training is placed on the theoretical and quantitative approach, supplemented by empirical and experimental methods. This approach is based on the conviction that the progress of meteorology and oceanography depends on the quantitative application of the laws of physics. However, the Department recognizes that there is equal demand for individuals who are more concerned with applications and experimental studies. Such students need to understand the implications of the theoretical developments, while the theory oriented students need an appreciation of the observational material.

Undergraduate Preparation

The most essential element is a sound preparation in physics and mathematics, 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 above. Students with baccalaureate degrees in meteorology or oceanography may be required to supplement their physics and mathematics during the first year of graduate residence, in lieu of some of the introductory meteorology subjects given by the Department.

Meteorology

Formal subjects of instruction are offered in all of the principal areas of meteorology. Subjects commonly taken by graduate students include:

19.35	Statistical Problems in Meteorology
19.45	Synoptic Meteorology II
19.46	Numerical Weather Prediction
19.61	Introduction to Dynamical Meteorology
19.62	Dynamic Meteorology
19.64	Dynamic Meteorology II
19.65	Turbulence and Random Phenomena in Fluid Mechanics

19.67	Planetary Fluid Dynamics
19.71	Atmospheric Precipitation Processes
19.72	Physical Meteorology
19.73	Atmospheric Chemistry and Radiation
19.74	Physics of the Upper Atmosphere

As this list suggests, facilities for instruction and research are available in all of the principal areas of meteorology. There are several radar systems and associated equipment together with a large and comprehensive file of radar data. Current weather data covering North America, Western Europe, and the adjacent oceans are available on teletypewriter circuits and by facsimile. Extensive files of weather data are available for most areas of the world; much of this is already in form for use on modern computing machines, and students have access to desk computers, IBM card equipment, and the high-speed computing facilities of the Information Processing Center.

The Meteorological Instrumentation Laboratory contains standard and specialized instrumentation and special test equipment. Laboratory facilities are available for research in physical meteorology, especially in the fields of cloud and precipitation physics. The Fluid Dynamics Laboratory contains apparatus for modeling atmospheric and oceanic circulations.

The Department conducts an extensive program of sponsored research. Graduate students are often able to participate in this program as research assistants. Such active participation is considered a valuable supplement to the formal academic program and also provides some financial assistance.

Cambridge and its surroundings contain a number of institutions engaged in meteorological research, such as Harvard University, the Woods Hole Oceanographic Institution, the Air Force Cambridge Research Laboratories, and the Boston office of the National Weather Service. Close contact with the scientific personnel of these institutions is maintained through joint seminars and symposia as well as by more informal means.

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 this section of the 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 III. The Department does not require candidates for the doctorate to present evidence of competence in a foreign language or languages. 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. It is preferable that this competence in foreign languages be acquired prior to enrollment as a graduate student, but the study of language may be undertaken while in residence at M.I.T. Russian and German are recommended but French and Spanish are also appropriate.

Teaching and Research Assistantships

The Department offers a limited number of research and teaching assistantships each year. Research assistants are assigned to work on one of the many research projects in the Department.

Teaching assistants may be assigned to assist in laboratory instruction or in the preparation of teaching materials and the grading of papers. Information concerning these appointments may be obtained from the Head of the Department.

The Department offers a few predoctoral fellowships in the atmospheric sciences and oceanography. Announcements and application forms are available in early October and 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 Jule G. Charney, Department of Meteorology, Room 54-1712, M.I.T., Cambridge, Massachusetts 02139, (617) 253-2281.

Subjects in Meteorology*

(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
19.24	Fluid Dynamics Laboratory (A)
19.34	Statistical Methods in Meteorology
19.35	Statistical Problems in Meteorology (A)
19.43	Synoptic Meteorology I
19.44	Tropical Meteorology (A)
19.45	Synoptic Meteorology II (A)
19.46	Numerical Weather Prediction (A)
19.61	Introduction to Dynamical Meteorology (A)
19.62	Dynamic Meteorology I (A)
19.63	Atmospheric Models (A)
19.64	Dynamic Meteorology II (A)
19.65	Turbulence and Random Phenomena in Fluid Mechanics (A)
19.66	Small-Scale Turbulence in the Atmosphere and Oceans (A)
19.67	Planetary Fluid Dynamics (A)
19.69	Large-Scale Statistical Hydrodynamics in the Atmosphere (A)
19.70	Elementary Physics of the Atmosphere
19.71	Atmospheric Precipitation Processes (A)
19.72	Physical Meteorology (A)
19.73	Atmospheric Chemistry and Radiation (A)
19.74	Physics of the Upper Atmosphere (A)
19.80	Surface and Internal Waves (A)
19.81	Introduction to Oceanic Models (A)
19.82	Introduction to Oceanic Models (A)
19.83	Physical Oceanography
19.84	Dynamic Oceanography (A)
19.851	Undergraduate Research Program
19.852	Undergraduate Research Program
19.86	Oceanic Circulations (A)
19.87	Seminar in Physical Oceanography (A)
19.88	Readings in Oceanography (A)
19.89	Special Problems in Oceanography (A)
19.891–19.899	Special Problems in Oceanography (A)
19.93	Special Problems in Oceanography
19.94	Special Problems in Meteorology
19.95	Special Problems in Meteorology (A)
19.961–19.969	Special Subject in Meteorology (A)
19.97	Special Subject in Oceanography

*Full descriptions of all subjects are given in the catalogue entitled **Courses and Degree Programs, 1974–75**, which may be obtained by writing to the Institute Information Services, Room 7-111, M.I.T.

Department of Nutrition and Food Science

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Head of the Department

Marcus Karel, Ph.D.
Professor of Food Engineering
Deputy Department Head

Professors

Alan D. Berg
Professor of Nutrition (Visiting)

Arnold Lester Demain, Ph.D.
Professor of Industrial Microbiology

Charles S. Davidson, M.D.
Professor of Medicine (Visiting)
Director of the Clinical Research Center

Mac V. Edds, Jr., Ph.D.
Professor of Neuro-biology

Samuel Abraham Goldblith, Ph.D.
Underwood-Prescott Professor of Food Science

Charles J. Kensler, Ph.D.
Professor of Pharmacology (Visiting)

Robert Spencer Lees, M.D.
Professor of Cardiovascular Disease
Director of the Arteriosclerosis Center

Padmakar Pratep Lele, Ph.D., M.D.
Professor of Experimental Medicine

Sanford Arthur Miller, Ph.D.
Professor of Nutritional Biochemistry

Hamish Nisbet Munro, M.D., D.Sc.
General Foods Professor of Physiological Chemistry

Paul Medford Newberne, D.V.M., Ph.D.
Professor of Nutritional Pathology

John Burton Stanbury, M.D.
Professor of Experimental Medicine

Steven Robert Tannenbaum, Ph.D.
Professor of Food Science

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

Gerald Norman Wogan, Ph.D.
Professor of Toxicology

George Wolf, D.Phil.
Professor of Physiological Chemistry

Richard Jay Wurtman, M.D.
Professor of Endocrinology and Metabolism

Associate Professors

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Ronald Carlyle Shank, Ph.D.
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Robert Suskind, M.D.
Associate Professor of Medicine and Associate Director of the Clinical Research Center

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Associate Professor of Nutritional Biochemistry

Assistant Professors

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Charles Leland Cooney, Ph.D.
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Charles Edward Kimble, Ph.D.
Assistant Professor of Food Microbiology

F. James Levinson, Ph.D.
Assistant Professor of International Nutrition

Maria Christine Linder, Ph.D.
Assistant Professor of Physiological Chemistry

Loy Denham Lytle, Ph.D.
Assistant Professor of Psychopharmacology

William G. Thilly, Sc.D.
Assistant Professor of Toxicology

Senior Lecturers

John Everett Gordon, Ph.D., M.D.
Gordon Steinbach Myers, M.D.

Lecturers

M. Elliott Alpert, M.D.
Ricardo Bressani, Ph.D. (Visiting)
James L. Carpenter (Visiting)
Luigi Deluca, Ph.D. (Visiting)
Ann Forbes, M.D.
Ronald Duncan Hunt, D.V.M.
Charles A. Sanders, M.D.
David Yesair, Ph.D.

Administrative Officer

Thomas Bernard Duff, B.S.

Administrative Assistant

James William McGurl, B.S.

Senior Research Scientists

Ernst Reinhard Pariser, S.M.
Adrianne Ellefson Rogers, M.D.

Research Associates

Celestina Jesus Alvarez, D.D.S.
Bantval Surendra Baliga, Ph.D.
George L. Blackburn, M.D., Ph.D.
William Busby, Ph.D.
Peter Francis Daniel, Ph.D.
John Field, Ph.D.
Janina Galler, M.D.
Reinaldo F. Gomez, Ph.D.
Ann L. Griffith, Ph.D.
Tadayuki Imanaka, Ph.D.
Wayne Iwaoka, Ph.D.
Conrad C. Jaffe, M.D.
Joseph Kanner, Ph.D.
Michael Lavyne, M.D.
Ann Lees, M.D.
Harry Lynch, Ph.D.
Bernard Maire, M.S.
Rita Messing, Ph.D.
William Nelson, Ph.D.
William Nixon, Ph.D.
David Ozonoff, M.D.
Enrique Perez-Cuvit, M.D.
Deanna Talley, Ph.D.
Harold Torsvik, M.D.
Chu Tzeng, Sc.D.
Bette Weiss, Ph.D.
Patricia White, Ph.D.
Judith Wurtman, Ph.D.

Professors Emeriti

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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; the regulation of metabolic processes in experimental animals and man; 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
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.

Bachelor of Science in Life Sciences
Course VII
Program 2. Applied Biology Curriculum

	General Institute Requirements	Total units
	Specific science and humanities and social science subjects	132
	The subjects 5.41, 5.60, and 20.30, which are required in the Departmental Program, appear on the list of Science Distribution Subjects and can be used to satisfy the Science Distribution Requirement.	12
	The subject 20.02, which is required in the Departmental Program appears on the list of Laboratory Subjects and can be used to satisfy the Laboratory Requirement.	

	Departmental Program				
	Required subjects				115–118
5.41	Introduction to Structure, Bonding and Mechanism[1]	5	0	7	
5.60	Chemical Equilibrium[1]	4	0	8	
7.05	General Biochemistry	5	0	7	
20.02	Laboratory in Applied Biology[2]	2	8	4	
20.30	Physiological and Nutritional Biochemistry	4	0	8	
	Any *two* of the following subjects:				
7.03	Genetics	3	0	9	
7.04	Developmental Biology	3	0	6	
7.06	General and Cell Physiology	3	0	9	
7.21	General Microbiology	3	0	9	

1
Students who take 5.41 or 5.60 to fulfill the General Institute Requirement in Chemistry/Biology must take 12 additional units of unrestricted elective.

2
7.011 Introduction to Experimental Biology may be substituted for 20.02.

	Departmental Program continued				
	Restricted Electives				72
	One of the following subjects:				
1.00	Information Systems	3	3	6	
5.42	Organic Chemistry	3	0	6	
5.61	Physical Chemistry	4	0	8	
5.62	Physical Chemistry	4	0	8	
6.030	Introduction to Computation	4	3	5	
6.071	Introduction to Electronics	4	2	6	
7.07J	Biophysical Chemistry	3	0	9	
18.03	Differential Equations	4	0	8	
20.48J	Mathematical Ecology	3	3	6	
20.91	Biostatistics I	2	2	4	
	Either of the following:				
5.31	Introduction to Chemical Experimentation	2	8	2	
20.41	Microbiology Laboratory	2	6	4	
	In addition, 24 units as thesis or 20.06, 20.07 (Special Projects in Undergraduate Research.)				
	A coordinated set of subjects of at least 24 units approved in advance by the Department, such a set is to be selected from fields including applied microbiology, biochemical engineering, endocrinology, food chemistry, engineering and marketing, growth and development, human and international nutrition, neuroendocrine regulation, nutritional animal pathology, physiological chemistry, psychopharmacology, systems ecology and toxicology.				
	Unrestricted Electives[2]				73–70
	Total Units Required for S.B. Degree				360

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 four areas — Nutritional Biochemistry and Metabolism, Food Science and Technology, Biochemical Engineering, and Toxicology.

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 A program of training is offered in the fields of food chemistry, food engineering, and food microbiology. Research in food chemistry is concerned with the formation, occurrence, and analysis of trace substances in foods including those with physiological significance, changes in food composition and loss of nutrient value due to chemical reactions in processing and storage. Research in food microbiology deals with the establishment of fundamentals of behavior of microorganisms and applications of these fundamentals to the processing, storage, and use of foods. Research in food processing and engineering deals with scientific principles and engineering practices required for production distribution, and utilization of foods with superior nutritional and organoleptic quality.

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 in mammalian biochemistry is offered to graduate students who wish to acquire knowledge and research experience in physiological chemistry and biochemistry as it applies to nutritional problems. Current research projects include: biochemical, morphological, and physiological effects of malnutrition; biochemical defects underlying inherited disorders of the endocrine system; endocrine control mechanisms; effects of infection and stress on nutrient requirements and nutritional status; dietary and hormonal factors influencing protein synthesis; environmental factors influencing endocrine rhythms; enzyme synthesis and turnover in tissues; synthetic compounds as energy sources; functions of vitamin A in the metabolism of amino acids and related compounds; protein and nucleic acid synthesis and turnover; biological activities of fatty acids; effects of nutritional and endocrine variations on the activities of tissue enzymes; congenital defects due to vitamin deficiencies; effects of protein malnutrition on brain chemistry; effects of drugs and amino acids on neurotransmitters; and effects of environmental lighting on neuroendocrine functions.

Toxicology A program is offered leading to the Master of Science and Doctoral degrees in the field of toxicology. The training program consists of a series of specialized subjects dealing with cellular responses to various chemical and physical agents of toxicological interest. Typical research projects in toxicology include: chemical carcinogenesis; metabolism of carcinogens, toxic compounds, and drugs; isolation and identification of toxic compounds produced by fungi; carcinogenesis and mutagenesis in mammalian and human cells in culture; studies on the mode of action of toxic agents; structure-activity relationships of carcinogens and toxins; and biochemical lesions induced by carcinogens and mutagens.

Biochemical Engineering A program in biochemical engineering is offered leading to the Master of Science and Doctoral degrees. Integration of studies in biological sciences with engineering is emphasized with particular attention to industrial microbiology and fermentation processes. Research projects in biochemical engineering include: continuous culture of microorganisms; dynamics of microbial growth; microbiology of mixed cultures and multiple substrate utilization; recovery of metabolites from fermentation broths; ultrafiltration and reverse osmosis for recovery of biological substances; mass transfer in fermentation vessels; microbiology and fermentation technology in single-cell protein production; biosynthesis of secondary metabolites; and enzyme technology and engineering.

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 III. 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. degree 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 four curricula, Nutritional Biochemistry and Metabolism, Food Science and Technology, Biochemical Engineering, and Toxicology, consists of a limited number of recommended graduate subjects supplemented by sufficient elective units selected by the student in consultation with his 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. Programs of study in biochemical engineering must be approved by an interdepartmental committee consisting of faculty members in the Departments of Nutrition and Food Science, Biology, and Chemical Engineering.

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 upon which the thesis research will be based.

Thesis research is done under the supervision of faculty members in the various areas of specialization described above. Research progress is evaluated periodically by the thesis advisory committee, which also conducts an oral defense of the completed thesis.

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 Undergraduate Student Office, Department of Nutrition and Food Science, Room 56-125, M.I.T., Cambridge, Massachusetts 02139, (617) 253-1712, or the Graduate Student Office, Department of Nutrition and Food Science, Room 16-337, (617) 253-5804.

Subjects in Nutrition and Food Science*

(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.U.R.	Undergraduate Research Opportunities
20.02	Laboratory in Applied Biology
20.05J	Modelling and Analysis of Systems Pertaining to National Development (A)
20.06	Special Projects in Undergraduate Research
20.07	Special Projects in Undergraduate Research
20.08	Human Fertility and the Population Problem
20.09	Mammalian Physiology
20.11	Food Science and Technology
20.12	Food Technology Laboratory (A)
20.13	Food Engineering
20.15	Advanced Food Engineering (A)
20.16	Food Plant Visits (A)
20.17	Physical and Engineering Properties of Food Materials (A)
20.171	Physical and Engineering Properties of Food Materials Laboratory (A)
20.18	Food Fabrication and Structure Synthesis (A)
20.20	Sensory Qualities of Foods (A)
20.30	Physiological and Nutritional Biochemistry
20.32	Biochemical Research Methods (A)
20.321	Laboratory in Biochemical Research Methods (A)
20.35	Nutrition, Growth and Development (A)
20.36	Human Nutrition
20.361	Field Studies of Human Nutrition
20.362	Ecology of Malnutrition
20.37J	Endocrinology (A)
20.39	The Vitamins (A)
20.40	Selected Topics in Nutrition and Food Science (A)
20.41	Microbiology Laboratory
20.43	Industrial Microbiology (A)
20.46	Food Microbiology (A)
20.47	Biochemical Engineering (A)
20.48J	Ecology
20.50	Food Biochemistry (A)
20.51	Food Chemistry (A)
20.52	Advanced Food Technology (A)
20.59	Experimental Toxicology and Pharmacology (A)
20.591	Laboratory in Experimental Toxicology (A)
20.592	Toxicology of Food-Borne Substances (A)
20.593	Chemical Carcinogenesis, Mutagenesis, and Teratogenesis (A)
20.594	Environmental Toxicology (A)
20.595	Pharmocokinetics (A)
20.596	Topics in Environmental Chemistry and Toxicology (A)
20.60	Research Programs in Nutrition and Food Science (A)
20.61	Seminar in Nutrition and Food Science (A)
20.62	Seminar in Nutrition and Food Science (A)
20.65	Pathobiology (A)
20.651	Seminar in Nutritional Pathology (A)
20.652	Seminar in Nutritional Pathology (A)
20.68	Food Marketing (A)
20.71	Research Problems (A)
20.72	Research Problems (A)
20.75J	Nutrition, National Development, and Planning
20.76	Nutrition Policy and Planning in Selected Countries
20.78	Biochemistry of the Neuron and the Synapse
20.79J	Pharmacology of Behavior (A)
20.80J	Neurendocrine Regulation (A)
20.81	Clinical and Public Health Nutrition (A)
20.83	Topics in Engineering in Medicine (A)
20.84	Human Genetics (A)
20.88	Special Topics in Oral Science (A)
20.89	Special Topics in Oral Science (A)
20.91	Biostatistics I (A)
20.92	Biostatistics II (A)
20.95	Mammalian Biochemistry and Metabolism I (A)
20.96	Mammalian Biochemistry and Metabolism II (A)
20.97	Mammalian Nutrition (A)
20.98	Advanced Human Nutrition (A)
20.99	The Human Nervous System (A)

*Full descriptions of all subjects are given in the catalogue entitled **Courses and Degree Programs, 1974–75**, which may be obtained by writing to the Institute Information Services, Room 7-111, M.I.T.

Department of Physics

Herman Feshbach, Ph.D.
Professor of Physics
Head of the Department

Professors

Michel Baranger, Ph.D.
Professor of Physics

Walter Carlisle Barber, Ph.D.
Professor of Physics (Absent)

Alan Hildreth Barrett, Ph.D.
Professor of Physics

George Bekefi, Ph.D.
Professor of Physics

George Bernard Benedek, Ph.D.
Professor of Physics

William Bertozzi, Ph.D.
Professor of Physics

Hale Van Dorn Bradt, Ph.D.
Professor of Physics

Herbert Sage Bridge, Ph.D.
Professor of Physics
Associate Director, Center for Space Research

Sanborn Conner Brown, Ph.D.
Professor of Physics
Associate Dean of the Graduate School

William Weber Buechner, Ph.D., Sc.D.
Professor of Physics

Bernard Flood Burke, Ph.D.
Professor of Physics

George Whipple Clark, Ph.D.
Professor of Physics

Bruno Coppi, Ph.D.
Professor of Physics

Peter Theodore Demos, Ph.D.
Professor of Physics
Director, Bates Linear Accelerator

Martin Deutsch, Ph.D., Sc.D.
Professor of Physics
Director, Laboratory for Nuclear Science

Thomas Henderson Dupree, Ph.D.
Professor of Physics
Professor of Nuclear Engineering

Harald Anton Enge, Dr. Phil.
Professor of Physics

Bernard Taub Feld, Ph.D.
Professor of Physics (Absent)

Anthony Philip French, Ph.D.
Professor of Physics

Jerome Isaac Friedman, Ph.D.
Professor of Physics

David Henry Frisch, Ph.D.
Professor of Physics

Lee Grodzins, Ph.D.
Professor of Physics

Albert Gordon Hill, Ph.D.
Professor of Physics
Vice President, Research

Kerson Huang, Ph.D.
Professor of Physics

Robert Inslee Hulsizer, Jr., Ph.D.
Professor of Physics

Karl Uno Ingard, Ph.D.
Professor of Physics
Professor of Aeronautics and Astronautics

Ali Javan, Ph.D.
Professor of Physics

Kenneth Alan Johnson, Ph.D.
Professor of Physics

Henry Way Kendall, Ph.D.
Professor of Physics (Absent)

Arthur Kent Kerman, Ph.D.
Professor of Physics

John Gordon King, Ph.D.
Francis Friedman
Professor of Physics (Absent)

Vera Kistiakowsky, Ph.D.
Professor of Physics

Daniel Kleppner, Ph.D.
Professor of Physics (Absent)

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 (Absent)

Elliot Hershel Lieb, Ph.D.
Professor of Mathematics and Physics (Absent)

Earle Leonard Lomon, Ph.D.
Professor of Physics (Absent)

Francis Eugene Low, Ph.D.
Karl Taylor Compton Professor of Physics
Director, Center for Theoretical Physics

Philip Morrison, Ph.D.
Institute Professor
Professor of Physics

Stanislaw Olbert, Ph.D.
Professor of Physics

Louis Shreve Osborne, Ph.D.
Professor of Physics

Irwin Abraham Pless, Ph.D.
Professor of Physics

Lawrence Rosenson, Ph.D.
Professor of Physics

Irwin Ira Shapiro, Ph.D.
Professor of Physics
Professor of Geophysics

Clifford Glenwood Shull, Ph.D.
Professor of Physics

Malcolm Woodrow Pershing Strandberg, Ph.D.
Professor of Physics

Samuel C. C. Ting, Ph.D.
Professor of Physics

Laszlo Tisza, Ph.D.
Professor of Physics, Emeritus
Senior Lecturer

Felix Marc Hermann Villars, D.Sc.
Professor of Physics

Steven Weinberg, Ph.D.
Professor of Physics (Absent)

Rainer Weiss, Ph.D.
Professor of Physics

Victor Frederick Weisskopf, Ph.D., Sc.D.
Institute Professor
Senior Lecturer

Peter Adalbert Wolff, Ph.D.
Professor of Physics

James Edward Young, Ph.D.
Professor of Physics

Associate Professors

Ulrich Justus Becker, Ph.D.
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Aron Myron Bernstein, Ph.D.
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Wit Busza, Ph.D.
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Eric Richard Cosman, Ph.D.
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Michael Stephen Feld, Ph.D.
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Edward Victor George, Ph.D.
Associate Professor of Physics

Thomas John Greytak, Ph.D.
Associate Professor of Physics

Jochen Heisenberg, Ph.D.
Associate Professor of Physics

Roman Wladimir Jackiw, Ph.D.
Associate Professor of Physics

James David Litster, Ph.D.
Associate Professor of Physics

Margaret Love Agnes MacVicar, Sc.D.
Class of 1922 Associate Professor
Associate Professor of Physics

John William Negele, Ph.D.
Associate Professor of Physics

Richard Marcus Price, Ph.D.
Associate Professor of Physics (Absent)

Saul Alan Rappaport, Ph.D.
Associate Professor of Physics

Claudio Rebbi
Diploma, University of Turin
Associate Professor of Physics (Visiting)

Harry Eugene Stanley, Ph.D.
Associate Professor of Physics
Hermann von Helmholtz Associate Professor of Health Sciences and Technology

Robert John Taylor, Ph.D.
Associate Professor of Physics

Vytenis Marija Vasyliunas, Ph.D.
Associate Professor of Physics

Richard Kumeo Yamamoto, Ph.D.
Associate Professor of Physics

Koichi Yazaki, Ph.D.
Associate Professor of Physics (Visiting)

Assistant Professors

Donald Shailer Barton, Ph.D.
Assistant Professor of Physics

John Winston Belcher, Ph.D.
Assistant Professor of Physics

George W. Brandenburg, Ph.D.
Assistant Professor of Physics

Kenneth Brecher, Ph.D.
Assistant Professor of Physics

Claude Roger Canizares, Ph.D.
Assistant Professor of Physics

Min Chen, Ph.D.
Assistant Professor of Physics

Carleton Edward DeTar, Ph.D.
Assistant Professor of Physics (Absent)

Robert Loren Jaffe, Ph.D.
Assistant Professor of Physics

John D. Joannopoulos, Ph.D.
Assistant Professor of Physics

Paul Christopher Joss, Ph.D.
Assistant Professor of Physics

Marc Aaron Kastner, Ph.D.
Assistant Professor of Physics

Susan Geisel Kleinmann, Ph.D.
Assistant Professor of Physics

June Lorraine Matthews, Ph.D.
Assistant Professor of Physics

Ernest Moniz, Ph.D.
Assistant Professor of Physics

Dirk Joachim Muehlner, Ph.D.
Assistant Professor of Physics

Bruce R. Patton, Ph.D.
Assistant Professor of Physics

David Edward Pritchard, Ph.D.
Assistant Professor of Physics

Charles Thorn, Ph.D.
Assistant Professor of Physics

James Wolfson, Ph.D.
Assistant Professor of Physics

Executive Officer

Daniel Henry Gould

Lecturers

Frederic John Eppling, Ph.D.
Associate Director, Laboratory for Nuclear Science

Harry Moritz Schey, Ph.D.

Instructors

Elie Br·idy, Ph.D.
Judith Bostock, Ph.D.
Richard Freeman, Ph.D.
Seppo Sari, Ph.D.
Alan Solinger, Ph.D.
Sunny Yuen, Ph.D.

Technical Instructors

William Douglas Allen
Angelo DeLara Larraga, B.S.E.E., J.D.
Harold Adolph Lundquist
Jan Orsula
Thomas Joseph White, Jr.

Senior Research Scientists

Stanley Benedict Kowalski, Ph.D.
Alan Jay Lazarus, Ph.D. (Absent)
Paul David Luckey, Jr., Ph.D.
Charles Philip Sargent, Ph.D.
Edwin Floriman Taylor, Ph.D.
William Ernest Turchinetz, Ph.D.
William Upton Walton, M.S.

Professors Emeriti

William Phelps Allis, Sc.D.
Professor of Physics, Emeritus

Robley Dunglison Evans, Ph.D.
Professor of Physics, Emeritus

Nathaniel Herman Frank, Sc.D.
Professor of Physics, Emeritus

Arthur Cobb Hardy, Sc.D.
Professor of Optics and Photography, Emeritus

George Russell Harrison, Ph.D., D.Sc., LL.D., D.Eng.
Professor of Physics, Emeritus
Dean of the School of Science, Emeritus

George Graham Harvey, Ph.D.
Professor of Physics, Emeritus

Milton Stanley Livingston, Ph.D., Sc.D.
Professor of Physics, Emeritus

Philip McCord Morse, Ph.D., Sc.D.
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Bruno Benedetto Rossi, Ph.D.
Institute Professor, Emeritus
Professor of Physics, Emeritus

John Clarke Slater, Ph.D., Sc.D.
Institute Professor, Emeritus
Harry B. Higgins Professor of the Solid State, Emeritus

Laszlo Tisza, Ph.D.
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Senior Lecturer

Bertram Eugene Warren, Sc.D.
Professor of Physics, Emeritus

Victor Frederick Weisskopf, Ph.D., Sc.D.
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Professor of Physics, Emeritus
Senior Lecturer

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

The programs of study and research in the Department of Physics emphasize the 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 are also an important area of study, both through the use of space probes and by complementary theoretical study. Research in astrophysics is a rapidly growing field at 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 in the School of Science section of this Catalogue.

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 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

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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. Reactor is used for neutron diffraction studies, and the extensive facilities of the Information Processing Center and Project MAC are available for research involving high-speed computation.

Nuclear and Particle Theory The emphasis of the research at the Center for Theoretical Physics is on the understanding of the fundamental particles of nature, as revealed by their interactions and by their decay and on the characteristic quantum modes of motion of systems composed of strongly interacting particles such as atomic nuclei. Work is conducted in the intermediate energy region in collaboration with experimentalists at the M.I.T. Bates Linear Accelerator and at the Los Alamos Meson Physics Facility, as well as at CERN and Saclay. Studies of low-energy nuclear reaction processes are carried out at the Center for Theoretical Physics, in addition to work on the question of high-energy hadronic interactions.

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, and the Center for Space Research. 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.

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, geophysics, etc. Many students have also found it to be an excellent preparation for subsequent graduate work in professional schools of medicine, law, management, etc. The undergraduate curriculum in physics offers students the opportunity to acquire basic competence in the fundamentals of both experimental and theoretical physics. The central core of requirements for the Bachelor of Science is designed not only to accomplish this objective but also to allow plenty of scope for students to select from a considerable variety of subjects and to proceed at the pace and degree of specialization best suited to their individual capabilities.

It is suggested that students in the second year take 6.011 Introductory Network Theory or 6.071 Introduction to Electronics in the second term in order to acquire a familiarity with and a knowledge of some topics in electrical engineering. Adequate elective time is made available in the second year, and students may wish to take a mathematics subject beyond 18.03 Differential Equations at this time. During the second year, the prospective physics major should also take a project laboratory (preferably, but not necessarily, the project laboratory administered by the Department) or some departmentally approved substitute.

The departmentally prescribed subjects 8.05 Principles of Quantum Physics II, 8.13 Experimental Atomic Physics I, and 8.14 Experimental Atomic Physics II are normally taken in the third year. This is also an appropriate time for students to take some of the restricted elective subjects. It is usual to begin the theoretical physics sequence with 8.06 Theoretical Physics I in the second term of the third year. Students are urged to explore with faculty counselors possibilities of electing those subjects which are best suited to individual needs at this stage of study.

Bachelor of Science in Physics Course VIII

	General Institute Requirements				Total units
	Specific science and humanities and social science subjects.				132
	The Science Distribution Requirement will be satisfied by 8.03 and 18.03, which are required in the Departmental Program, plus appropriate subjects[1] totaling				12
	The Institute laboratory requirement may be satisfied through the Department's project laboratory (8.11 or 8.12)[2]				12
	Departmental Program				
	Required Subjects				94
8.03	Physics III	5	0	7	
8.04	Principles of Quantum Physics I[3]	5	0	7	
8.05	Principles of Quantum Physics II	5	0	7	
8.13	Experimental Atomic Physics I	1	6	8	
8.14	Experimental Atomic Physics II	1	6	8	
18.03	Differential Equations	4	0	8	
	Thesis[4]		12		
	Restricted Electives				48
	Two subjects given by the Department of Mathematics beyond 18.03		24		
	Two subjects given by the Department of Physics in addition to those listed above[5]		24		
	Unrestricted Electives[6]				62
	Total Units Required for the S.B. Degree				360

1
Students may find it advantageous to elect 6.011 Introductory Network Theory (4-0-8) or 6.071 Introduction to Electronics (4-2-6) in the second term of the second year. This would complete the Science Distribution Requirement.

2
The Institute Laboratory Requirement may not be satisfied by 8.13 or 8.14.

3
8.211 Introduction to Quantum Physics may be substituted for 8.04.

4
A thesis of 12 units is required. Not more than 30 units of thesis credit may be included in the minimum of 360 units required for the S.B. degree.

5
Students planning to do graduate work in physics would normally take the theoretical sequence 8.06, 8.07 and 8.08.

6
Schedules of students in Course VIII may always be arranged to leave available 12 units of unrestricted elective in the second year.

Graduate Study

In the fourth year, the theoretical sequence can be continued with 8.07 Theoretical Physics II and completed with 8.08 Theoretical Physics III. Students intending to continue with graduate studies in Physics are encouraged to take all three parts of this theoretical physics sequence.

An important component of the physics program is the undergraduate thesis which is a project carried out under the guidance of a faculty member. Many thesis projects in the recent past have grown out of the undergraduate research opportunities program. It is advisabie that students have some idea of a thesis topic by the middle of their junior year; they are required to submit a thesis proposal at the end of the junior year. In order to introduce students to the research activities in the department, undergraduate physics colloquia are held weekly at a time so that all physics majors can attend.

A relatively large amount of elective time usually becomes available during the fourth year and can be used effectively in a variety of ways, in physics or on other subjects.

Inquiries

Additional information concerning degree programs, admissions, 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.

The Department of Physics offers graduate work leading to the Master of Science in Physics, the Doctor of Philosophy, and the Doctor of Science. No stated curriculum of subjects is required for any of these degrees; rather, individual curricula are chosen in consultation with the Registration Officer in accordance with certain broad principles. Subjects of study include work in almost all of the experimental fields described in the Department's introduction, as well as in the various branches of theoretical physics. Graduate students are expected to gain familiarity with several of the branches of physics, not merely with one specialty. Students will be well prepared for either academic work or industrial research, since the training includes a broad and thorough understanding both of the fundamentals of physics and of some advanced applications.

Students should also note the possibilities of interdisciplinary research, particularly in Astronomy and Astrophysics and in biophysical or biomedical areas (see Chapter III 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 III. 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.

	General Undergraduate Subjects
8.U.R.	Undergraduate Research
8.01	Physics I (Standard version)
8.011	Physics I (Non-specialist version)
8.012	Physics I (Mathematically advanced version)
8.013	Physics I (Biomedical option)
8.014	Physics I (Seminar-tutorial)
8.02	Physics II (Standard version)
8.021	Physics II (Non-specialist version)
8.022	Physics II (Mathematically advanced version)
8.023	Physics II (Biomedical option)
8.024	Physics II (Seminar-tutorial)
8.03	Physics III (Standard version)
8.033	Physics III (Biomedical option)
8.04	Principles of Quantum Physics I
8.043	Physics IV (Biomedical option)
8.05	Principles of Quantum Physics II
8.06	Theoretical Physics I
8.07	Theoretical Physics II
8.08	Theoretical Physics III

	Undergraduate Laboratory and Special Project Subjects
8.11	Physics Project Laboratory I
8.12	Physics Project Laboratory II
8.13	Experimental Atomic Physics I
8.14	Experimental Atomic Physics II
8.16	Environmental Measurements Project Laboratory
8.17	Environmental Measurements Project Laboratory
8.18	Special Problems in Undergraduate Physics
8.19	Readings in Physics

	Undergraduate Elective Subjects
8.20	Introduction to Special Relativity
8.202J	Science, Technology and Ritual
8.211	Introduction to Quantum Physics
8.231J	Physics of Solids I
8.232J	Physics of Solids II
8.236	Topics in Quantum Theory of Matter
8.242	Quantum Electronics
8.244	Modern Optics
8.251	Physics of Noise and Fluctuations
8.262	Plasma Physics of Gas Lasers
8.263J	Physics of Fluids
8.272	Introduction to Nuclear Physics
8.274	Introduction to Particle Physics
8.281	Introduction to Astrophysics
8.285	Topics in Astrophysics
8.291J	Planetary Physics and Chemistry I
8.292J	Planetary Physics and Chemistry II
8.293J	Dynamical Astronomy
8.299	Physics Teaching

Graduate Subjects

	General and Mathematical Physics
8.311	Electromagnetic Theory I (A)
8.312	Electromagnetic Theory II (A)
8.321	Quantum Theory I (A)
8.322	Quantum Theory II (A)
8.323	Quantum Theory III (A)
8.333	Statistical Mechanics I (A)
8.334	Statistical Mechanics II (A)
8.336J	Modern Statistical Mechanics (A)
8.341	Methods of Theoretical Physics I (A)
8.342	Methods of Theoretical Physics II (A)
8.352	Applied Geometric Algebra (A)
8.361	Quantum Theory of Many-Particle Systems I
8.362	Quantum Theory of Many-Particle Systems II
8.732J	The Mathematics of Quantum Mechanics (A)
8.381	Selected Topics in Theoretical Physics (A)
8.382	Selected Topics in Theoretical Physics (A)
8.391	Special Problems in Theoretical Physics (A)
8.392	Special Problems in Theoretical Physics (A)
8.399	Physics Teaching (A)

*Full descriptions of all subjects are given in the catalogue entitled **Courses and Degree Programs, 1974–75**, which may be obtained by writing to the Institute Information Services, Room 7-111, M.I.T.

	Physics of Atoms, Radiation, Solids, Fluids, and Plasmas
8.411	Advanced Atomic Physics (A)
8.421	Introduction to Optical, Microwave, and Radiofrequency Physics (A)
8.432	Interaction of Radiation with Solids and Plasmas (A)
8.442	Statistical Optics and Spectroscopy (A)
8.451	Physics of Optical and Infrared Lasers (A)
8.452	Seminar in Optical and Infrared Lasers (A)
8.481	Selected Topics in Physics of Atoms and Radiation (A)
8.482	Selected Topics in Physics of Atoms and Radiation (A)
8.491	Special Problems in Physics of Atoms and Radiation (A)
8.492	Special Problems in Physics of Atoms and Radiation (A)
8.511J	Theory of Solids I (A)
8.512J	Theory of Solids II (A)
8.513J	Application of Group Theory to the Physics of Solids (A)
8.531J	Science and Engineering of Biological Membranes and Structural Tissue (A)
8.541	Neutron Diffraction (A)
8.581	Selected Topics in the Theory of Solids (A)
8.582	Selected Topics in the Theory of Solids (A)
8.591	Special Problems in Solid-State Physics (A)
8.592	Special Problems in Solid-State Physics (A)
8.611	Introduction to Physics of Fluids and Plasmas (A)
8.613J	Introduction to Plasma Physics (A)
8.621J	Plasma Kinetic Theory (A)
8.622J	Advanced Topics in Plasma Kinetic Theory (A)
8.641	Physics of High Temperature Plasmas I (A)
8.642	Physics of High Temperature Plasmas II (A)
8.681	Selected Topics in Fluid and Plasma Physics (A)
8.682	Selected Topics in Fluid and Plasma Physics (A)
8.691	Special Problems in Fluid and Plasma Physics (A)
8.692	Special Problems in Fluid and Plasma Physics (A)

	Nuclear and Particle Physics
8.711	Nuclear Physics I (A)
8.712	Nuclear Physics II (A)
8.721	High Energy Nuclear Physics (A)
8.751	Theory of Nuclear Structure I (A)
8.752	Theory of Nuclear Structure II (A)
8.781	Selected Topics in Nuclear Theory (A)
8.782	Selected Topics in Nuclear Theory (A)
8.791	Special Problems in Nuclear Physics (A)
8.792	Special Problems in Nuclear Physics (A)
8.811	Particle Physics I (A)
8.812	Particle Physics II (A)
8.822	Theoretical Particle Physics (A)
8.871	Topics in Relativistic Quantum Theory (A)
8.872	Topics in Relativistic Quantum Theory (A)
8.881	Selected Topics in Particle Physics (A)
8.882	Selected Topics in Particle Physics (A)
8.891	Special Problems in Particle Physics (A)
8.892	Special Problems in Particle Physics (A)

	Space- and Astro-physics
8.912	Cosmic Electrodynamics I (A)
8.913	Cosmic Electrodynamics II (A)
8.921	Stellar Structure and Evolution I (A)
8.922	Stellar Structure and Evolution II (A)
8.932	Physics of the Galaxy (A)
8.942	Cosmology (A)
8.951J	Fundamentals of Radio Astronomy (A)
8.952J	Radio Interferometry (A)
8.954	Dynamical Problems of the Solar System (A)
8.962	General Relativity (A)
8.971	High-Energy Astrophysics (A)
8.981	Selected Topics in Astrophysics (A)
8.982	Selected Topics in Astrophysics (A)
8.991	Special Problems in Astrophysics (A)
8.992	Special Problems in Astrophysics (A)

Joint Programs in Oceanography with the Woods Hole Oceanographic Institution

M.I.T. and the Woods Hole Oceanographic Institution 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 and ocean 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.

Subjects, seminars, and opportunities for research participation are offered at both institutions. Transportation is provided to make it possible for students to live in either Cambridge or Woods Hole (80 miles apart), however, depending upon individual study and research programs, students are encouraged to reside for at least one year at each place. Upon admission students are assigned academic advisors at each institution.

The Woods Hole Oceanographic Institution operates four oceangoing research ships, a deep-submergence research vehicle, and several inshore boats. A resident staff of more than 650 scientists, engineers, and support personnel conduct a wide range of ocean related studies in biology, chemistry, physical oceanography, geology, and geophysics from extensive laboratory facilities in Woods Hole. A modest marine facility is maintained by M.I.T. in the Boston Harbor consisting of dock space and a small research vessel.

The joint program involves several departments at M.I.T. — Earth and Planetary Sciences, Biology, Ocean Engineering, and Meteorology. 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 Meterorology offer programs with the Woods Hole Oceanographic Institution in chemical oceanography, marine geology, marine geophysics, and physical oceanography. The programs all lead to the Doctor of Philosophy or the Doctor of Science.

Biological Oceanography

The Departments of Biology and Nutrition and Food Science and the Woods Hole Oceanographic Institution offer programs in biological oceanography leading to the Doctor of Philosophy. Students in this program will be expected to acquire a background in modern concepts of molecular biology or applied biology and ecology.

Ocean Engineering and Oceanographic Engineering

The Department of Ocean Engineering offers a joint program in ocean engineering with the Woods Hole Oceanographic Institution leading to the Ocean Engineer, the Doctor of Philosophy, or the Doctor of Science. Students interested in oceanographic or oceanography related engineering problems and those concerned with engineering in the ocean and control of the ocean and ocean resources can be served by this program. (See also the corresponding description following the School of Engineering.)

Inquiries

Application for admission to the joint programs 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 the Woods Hole Oceanographic Institution. Requests for further information may be addressed to the Dean of Graduate Studies, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts, 02543; or, at M.I.T., to Room 54-912 for chemical, geological and physical oceanography; to Room 56-509 for biological oceanography; or to Room 5-221 for ocean engineering. Inquiries may also be addressed to the appropriate Department Heads, the Joint Program in Oceanography, M.I.T., Cambridge, Massachusetts, 02139.

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 in fields such as astronomy, meteorology, oceanography, environmental sciences, 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 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.

Registration procedures for the Interdisciplinary Science Program are like those of regular departmental programs. However, before registering in the program, students should prepare a written plan for satisfying the Restricted Elective requirement, 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. General advice on possible curricula, help in preparing a detailed plan, and names of interested faculty members are available from Professor Louis N. Howard, faculty member in charge of the program, Room 6-219, (617) 253-5723. Professor Howard 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.

Bachelor of Science
Interdisciplinary Science Program
Course XXV

General Institute Requirements	Total units
Specific science and humanities and social science subjects	132
Science Distribution Requirement	36
Laboratory Requirement	12
Restricted Electives A coherent set of science subjects beyond the introductory level which, together with the remaining portions of the student's program, is aimed at a well-defined educational goal. The Restricted Electives are to be planned by the student with his Faculty Counselor and must be approved by the Interdisciplinary Science Faculty Committee.	84
Unrestricted Electives	96
Total Units Required for the S.B. Degree	360

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 Science, Mathematics, Electrical Engineering, and Chemistry. 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 pulsars, supernova ejecta, and the planets are being investigated with X-ray, optical and radio telescopes. Quasars, 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 and by optical telescopes in both the visible and the infrared. The moon is being examined not only from afar but also on site with seismographs, and lunar material is being analyzed in several of our laboratories.

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. However, the bulk of our theoretical effort lies in intensive studies of the structure and evolution of stars, the dynamics of spiral galaxies and the solar system, 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 new Wallace Observatory. Active experimental programs with student participation also involve instruments launched in balloons, rockets, satellites, and interplanetary spacecraft. In addition, M.I.T. students and staff observe at other installations such as the National Radio Astronomy Observatory in West Virginia and 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 1974–75.

Undergraduate Study

8.281*	Introduction to Astrophysics
8.285*	Topics in Astrophysics
12.002*	The Earth and the Planets
12.111*	Astronomy I
12.112*	Astronomy III
12.114*	Workshop in Astronomy
12.115J* 8.293J 16.441J	Dynamical Astronomy
12.121*	Exploration of the Solar System
12.131J* 5.121J 8.291J	Planetary Physics and Chemistry I
12.132J* 5.122J 8.292J	Planetary Physics and Chemistry II
12.141*	Remote Sensing of the Earth
12.143*	Experimental Optical Astronomy
18.370*	Introduction to Dynamical Astronomy

Graduate Study

5.125J* 12.631J	Planetary Atmospheres
5.129J 12.636J	Meteoritics
6.231	Detection and Measurement of Radio Astronomical Signals
8.912*	Cosmic Electrodynamics I
8.913	Cosmic Electrodynamics II
8.921	Physics of the Stars
8.922*	Stellar Evolution
8.932*	Physics of the Galaxy
8.942*	Cosmology
8.951J 6.625J	Fundamentals of Radio Astronomy
8.962*	General Relativity
8.971	High-Energy Astrophysics
8.981	Selected Topics in Astrophysics
8.982	Selected Topics in Astrophysics
12.614J 8.954J 16.442J	Dynamical Problems of the Solar System
12.623*	Planetary Surfaces
12.626J 6.664J	Radio Interferometry
12.627J* 6.663J	Techniques of Radar Astronomy
18.325	Topics in Applied Mathematics — Asymptotic Problems in Plasma and Stellar Dynamics
18.375	Stellar Dynamics and Galactic Structure
18.376*	Galaxies and Their Dynamics
18.397	General Relativity

R.O.T.C. Programs

Army R.O.T.C. Program

John Sobchuk Kark, M.A.
Colonel, Infantry
Visiting Professor of Military Science
Director of the Office of Military Science

Francis William Creighton, M.A.
Lieutenant Colonel, Military Intelligence
Technical Instructor

Edward H. Leekley, A.B.
Captain, Armor
Technical Instructor

Jack Harold Nunn, M.A.
Major, Artillery
Technical Instructor

Kevin Michael Upton, S.M.
Captain, Signal Corps
Technical Instructor

Rushen L. Baker, Jr.
Master Sergeant, U.S. Army
Technical Instructor

Peter Paul Desimone
Staff Sergeant, U.S. Army
Technical Instructor

James Francis Loan
Staff Sergeant, U.S. Army
Technical Instructor

All full-time male and female 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. 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 interrelationship 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 listed below is by no means rigid, and other relevant subjects may be substituted on the student's initiative with the approval of his or her R.O.T.C. faculty advisor. R.O.T.C. elective subjects may also be used to satisfy the Institute humanities requirement.

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. 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, 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. In addition to the Advanced Camp, applicants for the two-year program are required to complete the R.O.T.C. Basic Camp, also of six weeks duration. The purpose of this camp is to make up the material that would normally be completed in the first two years of the four-year program. The camp is scheduled during the summer immediately prior to the student's first academic year as an R.O.T.C. cadet. Students at the Advanced Camp are paid at the rate of half the pay of a Second Lieutenant, plus mileage to and from the camp location. Students at the Basic Camp receive Private's pay plus the mileage allowance. In addition, 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 writing to the Director of Military Science.

In addition to the requirements outlined above, Army airborne, ranger, and flight 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.

Applicants for the two-year program must successfully pass an aptitude test and an Army physical examination. Two-year applicants must also be able to qualify for commission before reaching their 28th birthday.

Application Procedures

Application for the four-year program is effected by enrollment in MS-11 and MS-111. This is accomplished in the same manner as in other Institute subjects. The student should contact the Office of Military Science if additional information is desired.

Students interested in the two-year program should apply through the Military Science Office 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.

Program of Instruction

One Institute subject listed for each year and all Military Science subjects are required.

	First Year
14.53	Comparative Economic Systems (3–0–6)
17.21	Introduction to the American Political Process (3–0–6)
17.41	Science, Technology, and Politics (3–0–6)
17.56	International Relations: War and Peace (3–0–6)
17.57	American Foreign Policy in a Changing World (3–0–6)
MS11	Military Organization, Tactics, and Communication (2–0–1) (no M.I.T. credit)
MS111	Leadership Development (0–1–0) (no M.I.T. credit)
MS121	United States Military History (0–1–0) (no M.I.T. credit)

	Second Year
17.43	Determinants of Strategic Nuclear Forces (3–0–6)
17.44	Determinants of General Purpose Forces (3–0–6)
17.58	Seminar in International Politics (3–0–6)
21.541	The American Revolution (3–0–6)
MS21	Principles of Leadership (2–0–1) (no M.I.T. credit)
MS211	Leadership Development (0–1–0) (no M.I.T. credit)
MS221	Leadership Development (0–1–0) (no M.I.T. credit)

	Third Year
15.515	Information and Decision Systems I (3–0–6)
MS31	Principles of Military Management, Operations, and Logistics (2–0–1) (no M.I.T. credit)
MS311	Leadership Development (0–1–0) (no M.I.T. credit)
MS321	Leadership Development (0–1–0) (no M.I.T. credit)

	Fourth Year
9.70	Social Psychology (3–0–6)
9.80	Behavior in Groups (3–0–6)
15.301	Managerial Psychology Laboratory (2–6–4)
15.304	Complex Organizations (3–0–6)
17.46	Political Psychology (2–1–6)
MS41	Principles and Applications of Military Law and Administration (2–0–1) (no M.I.T. credit)
MS411	Leadership Development (0–1–0) (no M.I.T. credit)
MS421	Leadership Development (0–1–0) (no M.I.T. credit)

Air Force R.O.T.C. Program

Larry Schwartzman, M.S.
Lieutenant Colonel, U.S. Air Force
Visiting Professor of Aerospace Studies
Director of the Office of Aerospace Studies

Donald Theodore Carlson, M.A.
Major, U.S. Air Force
Technical Instructor

Donna Mae Kuha, M.Ed.
Captain, U.S. Air Force
Technical Instructor

George Joseph Vrtiak, M.A.
Captain, U.S. Air Force
Technical Instructor

Elmer F. Sterling
Staff Sergeant, U.S. Air Force
Technical Instructor

William Maciura, Jr.
Staff Sergeant, U.S. 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 corps training 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.

During the first two years, the program acquaints students with organization, mission, and history of the United States Air Force. The course deals with the Air Force in the contemporary world through a study of the total force structure, strategic offensive and defensive forces, general purpose forces, and aerospace support forces. The development of air power from the days of ballooning to the present is also examined. During the last two years, the course concentrates on three main themes: national security forces in contemporary American society, the concepts and practices of leadership, and the theory and techniques of management, especially as related to the United States Air Force. Students are given practical leadership training through assumption of positions of responsibility in the Cadet Corps and in the required summer training.

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 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.

At the beginning of the junior year each student who has not already done so is required to sign a formal agreement that he 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 he has been granted his 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, engineering, or any other non-flying field, the term of service is four years. If the student is physically qualified and desires to become a pilot or navigator, the required term of service is five years after completion of flight training.

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 $100 a month in subsistence allowance and complete the same academic program required of the upperclass four-year students. Undergraduate students in the two-year program may also compete for scholarships.

Eligibility Requirements

To be eligible for the Air Force R.O.T.C. program a student must be: 1) a citizen of the United States; 2) physically qualified for commission in the United States Air Force in accordance with existing Air Force regulations; 3) enrolled at M.I.T. as a full-time student; and 4) willing to sign a formal agreement and enlist in the Air Force Reserve at the beginning of the junior year, which obligates him to remain in the R.O.T.C. program for the

two final years, to accept a commission, and to serve the required period in the Air Force upon graduation.

Application Procedure

Eligible students should apply for admission to the Air Force R.O.T.C. after they have been notified of admission to the Institute. Application should be made directly to the Professor of Aerospace Studies, either by mail or by personal visit as soon as possible. Further information, including physical standards, will be furnished upon receipt of the initial inquiry.

Program of Instruction

The program of instruction is as follows:

	First Year
21.10	Scientific and Engineering Writing (2–0–7)
AS11	U.S. Military Forces (1–0–1) (no M.I.T. credit)
AS111	Corps Training (0–1–0) (no M.I.T. credit)
AS121	Corps Training (0–1–0) (no M.I.T. credit
	Second Year
	An M.I.T. subject in American History, Military History, or Political Science from an approved list. (See the Professor of Aerospace Studies for details.)
AS21	The Development and Growth of Aerospace Power (1–0–1) (no M.I.T. credit)
AS211	Corps Training (0–1–0) (no M.I.T. credit)
AS221	Corps Training (0–1–0) (no M.I.T. credit)
	Third Year
	An M.I.T. subject in American Defense Policy from an approved list. (See the Professor of Aerospace Studies for details)
AS31	National Security Forces in Contemporary American Society (3–0–3) (no M.I.T. credit)
AS311	Corps Training (0–1–0) (no M.I.T. credit)
AS321	Corps Training (0–1–0) (no M.I.T. credit)
	Fourth Year
AS41	Seminar in Air Force Leadership (3–0–3) (no M.I.T. credit)
AS42	Seminar in Management Principles (3–0–3) (no M.I.T. credit)
AS411	Corps Training (0–1–0) (no M.I.T. credit)
AS421	Corps Training (0–1–0) (no M.I.T. credit)

Adjustments in the curriculum to accommodate students enrolling in an honors or cooperative course are possible. Students who are eligible for graduate training or who desire to continue their graduate work may request a delay in reporting for active duty until completing graduate training.

Naval R.O.T.C. Program

Kevin J. O'Toole, Nav.E.
Captain, U.S. Navy
Visiting Professor of Naval Science
Director of the Office of Naval Science
Professor of Naval Architecture

Kenneth I. Bergstrom, M.S.
Commander, U.S. Navy
Technical Instructor

Robert Leonard, B.S., M.B.A.
Lieutenant, U.S. Navy
Technical Instructor

Mark J. Ryan, B.A.
Lieutenant, U.S. Navy
Technical Instructor

Leon J. Martin
Chief Storekeeper, U.S. Navy
Technical Instructor

William F. Welch
Chief Yeoman, U.S. 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 the Restricted Line category (Engineering Duty) or other specialties in the Navy.

The M.I.T. Navy unit is the only one of the nationwide Naval R.O.T.C. programs designed primarily to produce "engineering duty" officers who may serve their active duty aboard ship, in naval shipyards, or in other technical assignments. However, students may apply for other officer programs, such as Navy Nuclear Propulsion training, submarine or flight training, or for the Civil Engineers Corps of the Navy.

The Naval R.O.T.C. unit at M.I.T. offers two officer development programs. The Bureau of Naval Personnel has authorized the *Scholarship Program* which provides full tuition, certain fees, all books and uniforms, and $100 per month for four or two years. A four year scholarship student must complete three summer cruises and incurs a four-year active duty obligation. 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.

The *College Program* 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.

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, U.S. Navy, in the case of Scholarship Program students, and Ensign, U.S. Naval Reserve in the case of College Program students. All newly commissioned officers report directly to active duty unless plans are approved to attend graduate school. Upon completion of the active duty period, the officer may be released to inactive duty, but must retain his 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 (18 for women) and not more than 21 years of age by June 30 of the year in which enrolled in the program. 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. 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

Eligible students should apply for admission to the Naval R.O.T.C. program as soon as they have been notified of their admission to the Institute. Applications should be made directly to the Commanding Officer of the Naval R.O.T.C. Unit, either by mail or by personal visit by Registration Day or as soon as possible thereafter.

The Naval R.O.T.C. program at M.I.T. is now open to students selected under the nationwide Navy scholarship program known as the Regular N.R.O.T.C. or Hol-

loway Plan. Further inquiries regarding the M.I.T. program should be addressed to the Commanding Officer, N.R.O.T.C. and Naval Administrative Unit, M.I.T., or any local U.S. 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, and one term of computer science. 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 Navigation Training Craft at Newport, Rhode Island.

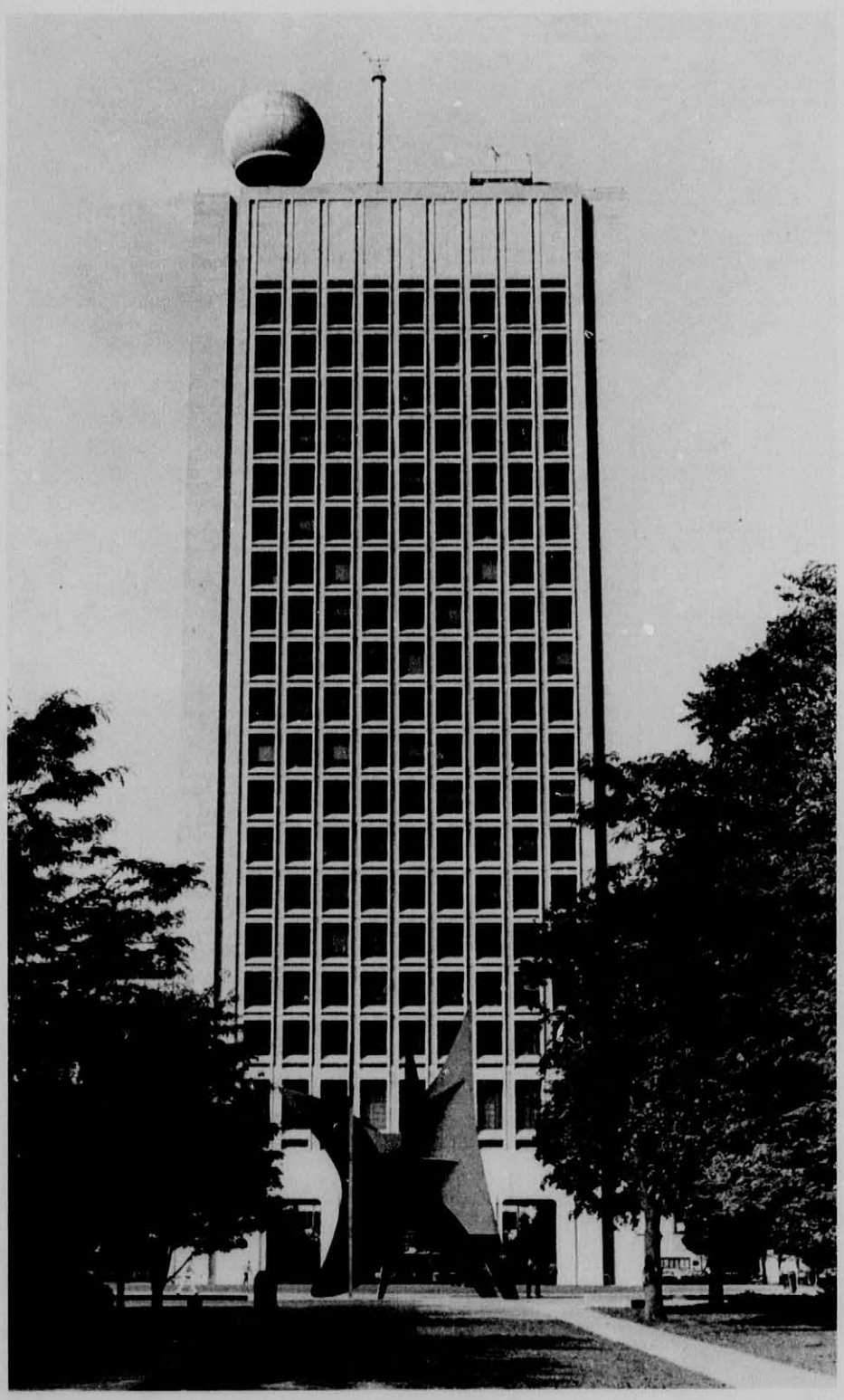
Students entering their sophomore year, who are eligible for the four-year College Program, can complete the requirements for commissioning in three years. This is accomplished by beginning with the second year Naval Science curriculum and making up the two missed Naval Science courses. The sophomore student must take three Institute subjects prior to graduation.

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	Seapower and Maritime Affairs (2–0–1) (no M.I.T. credit)
13.64J NS51J	Water, Air and Interface Vehicles (2–0–7)
	Second Year
NS21*	Naval Engineering Systems I (3–0–3) (no M.I.T. credit)
NS22*	Naval Engineering Systems II (3–0–3)* (no M.I.T. credit)
17.43 or 17.56	A staff specified M.I.T. subject on Military History/International Relations (3–0–6)
	Third Year
NS31	Navigation and Naval Operations I (2–0–2) (no M.I.T. credit)
NS32*	Navigation and Naval Operations II (2–2–2)* (no M.I.T. credit)
17.44 or 17.57 17.58 17.59 17.60	An appropriate M.I.T. subject on Defense Policy Formulation
	Fourth Year
NS41	Principles of Naval Organization and Management (2–0–2) (no M.I.T. credit)
NS42	The Junior Naval Officer (2–0–2) (no M.I.T. credit)
17.43 or 17.56	A staff specified M.I.T. subject on Military History/International Relations (3–0–6)

*These are normally given in conjunction with M.I.T. accredited seminars.

Massachusetts Institute of Technology



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Headmistress
St. Paul's School for Girls
Brooklandville, Maryland

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Senior Vice President
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President
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Financial Vice President
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Director and President
Digital Equipment Corporation

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Physician-in-Chief, Emeritus
Peter Bent Brigham Hospital

William Gerald Austen (1977)
Chief of Surgery
Massachusetts General Hospital

1
Address correspondence to the Massachusetts Institute of Technology, Cambridge, Massachusetts 02139.

2
Terms expire on June 30 of the year indicated.

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Sippican Corporation

William Henry Krome George (1977)
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Paul Victor Keyser (1977)
Former Executive Vice President and Director
Mobil Oil Corporation

Ralph Landau (1977)
President
Halcon International, Inc.

Clint Williams Murchison, Jr. (1977)
Partner
Murchison Brothers

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I. M. Pei & Partners

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Managing Partner
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Girl Scouts of the United States of America

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Arica Institute

Rebecca Anne Donnellan (1977)
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Harvard Law School

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Walter Ling Milne, A.M.
Assistant to the Chairman of the Corporation

Elizabeth Jane Whittaker, A.B.
Administrative Assistant

Joseph Stanislaus Collins, B.S.
Special Assistant

3
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Edwin Herbert Land, LL.D., Sc.D. (Visiting)

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*See page viii

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Administrative Assistant

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Administrative Assistant

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Associate

Peggy Joyce Murrell, B.A.
Associate

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Associate Dean for Student Affairs

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Visiting Associate Dean for Student Affairs
Foreign Study Advisor

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Associate Dean for Student Affairs

William Speer, A.B.
Associate Dean for Student Affairs

Kenneth Craig Browning, S.M.
Assistant Dean for Student Affairs

Anne Elizabeth Ellison, M.S.
Assistant Dean for Student Affairs

Jonathan Edward Hartshorne, B.A., B.D.
Assistant Dean for Student Affairs

Mary Olivia Hope, M.A.
Assistant Dean for Student Affairs

Nancy Wheatley, S.B.
Assistant to the Dean for Student Affairs

Alice Marie Seelinger, S.B.
Administrative Officer

Margaret Ann Gibson
Staff Accountant
Undergraduate Finance Board

Susan Haigh Houpt, B.A.
Advisor on Preprofessional Education

Faculty Families in Residence

Baker House
Mehmet Nafi Toksöz, Ph.D.
Helena Toksöz, B.S.

Bexley Hall
Jerome Y. Lettvin, M.D.
Margaret B. Lettvin

Burton House
James D. Bruce, Sc.D.
Eleanor M. Bruce, R.N.

East Campus
Adrianus, J. M. Houtsma, Ph.D.
Evelyn M. Houtsma

McCormick Hall
Stephen D. Senturia, Ph.D.
Alice M. Senturia, M.A.

MacGregor House
Nathan Henry Cook, Sc.D.
Alice C. Cook, B.A.

Senior House
Murray Eden, Ph.D.
Pat Warnock Eden, A.B.

Athletic Department

Ross Harold Smith, B.S., M.Ed.
Professor of Physical Education
Director of Athletics
Head of the Department

John Gale Barry, M.S.
Associate Professor of Physical Education
Varsity Golf Coach
Assistant Director of Athletics

Charles Batterman, B.S., M.A.
Associate Professor of Physical Education
Varsity Swimming Coach

Wilfred Raymond Chassey, M.S.
Associate Professor of Physical Education
Varsity Wrestling Coach
Freshman Lacrosse Coach

Edward Arthur Crocker, B.S.
Associate Professor of Physical Education
Director of Physical Education
Varsity Squash Coach
Varsity Tennis 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

Francis Charles O'Brien, Jr., M.Ed.
Associate Professor of Physical Education
Varsity Basketball Coach
Varsity Baseball Coach

Peter Anderson Holland, M.A.
Assistant Professor of Physical Education
Head Rowing Coach

William Stanley Morrison, B.S., M.Ed.
Assistant Professor of Physical Education
Varsity Ski Coach
Varsity Soccer Coach

Mary-Lou Sayles, M.S.
Assistant Professor of Athletics
Director of Women's Athletics

Silvio Napoleon Vitale, M.F.A.
Assistant Professor of Physical Education
Fencing Master

Instructors

Harold Brown, Jr., B.S.
Associate Director of Sailing Program
Varsity Sailing Coach

Peter Michael Close, B.A.
Sports Information Director
Cross Country Coach
Assistant Track Coach

James Ernest Lester, B.S.
Physiotherapist and Trainer

Frederick Victor Lett, M.A.
Assistant Wrestling Coach
Assistant Baseball Coach

Robert F. Lilly, B.S.
Varsity Gymnastics Coach

Thomas Patrick McLennan
Pistol-Rifle Range Officer

Gerald Melville Reed, Jr.
Sailing Master

Other Staff

Roderick R. Arthur
Business Manager
Assistant to the Director of Athletics

Maggie B. Lettvin
Lecturer in Charge of the Program in Self-Designed Fitness

Robert G. McQuaid
Assistant Trainer

Research

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Vice President for Research

Joseph Francis O'Connor, A.B.
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(On Leave)

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Administrative Assistant

Interdepartmental Laboratories and Centers*

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Nicholas John Grant, Sc.D.
Director

Merton Corson Flemings, Sc.D.
Assistant Director

Peter Adalbert Wolff, Ph.D.
Assistant Director

Center for Space Research

John Francis McCarthy, Jr., Ph.D.
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Benjamin Lax, Ph.D.
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Assistant Director

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Assistant Director for Administration

Laboratory for Nuclear Science

Martin Deutsch, Ph.D.
Director

Frederic John Eppling, Ph.D.
Associate Director

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Research Laboratory of Electronics

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Assistant Director

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Equal Employment Opportunity Officer

James Joseph Culliton, S.B., S.M.
Assistant to the Vice President, Administration and Personnel
Director, Personnel Services

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Adviser to Foreign Students

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Robert A. Schuiteman, Ph.D.
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Charles J. Gisondi, B.S.A.
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Marilyn Lynch, A.B., M.A.
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Assistant Comptroller

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Staff Accountant

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Staff Accountant

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Guy Louis Spina, B.S.
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Operations

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Cashier

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Assistant Director

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Assistant Director

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Program Officer

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Michael Thomas Leonard, B.S., M.B.A.
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Thomas Edward Lightburn, B.S.
Assistant Director

Paul Chester Powell, B.S.B.A.
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Patent Attorney

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Patent Attorney

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General Counsel

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Research Coordinator

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Assistant Director

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Director

Fiscal Planning

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Assistant Director

John Francis O'Brien, Jr., B.S.
Assistant to the Director

Budget

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James Lewis Maclary
Accounting Officer for Budgets

Richard Vincent McDevitt, B.S.
Assistant to the Director

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Manager

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Assistant Supervisor, Computer Operations

Mitchell Anthony Kloza, B.S.A.
Accounting Supervisor

Philip A. McMahon, B.S.A.
Supervisor, Computer Operations

Thomas Saxon, Jr.
Disbursing Supervisor

Bruce Kenyon Willard, B.S., M.B.A.
Assistant Manager

Philip Arnold Stoddard, S.B.
Vice President, Operations

Richard Arthur Sorenson, B.S.
Executive Assistant to the Vice President, Operations
(On Leave)

Physical Plant

William Robert Dickson, S.B.
Director of the Physical Plant

Miles Payne Cowen
Assistant Director of the Physical Plant

Paul Frank Barrett, B.S.
Superintendent for Engineering and Construction

Morton Berlan, B.A., M.B.A.
Superintendent of Telecommunications

Paul Murray Blanchard
Manager of Electrical Systems

William Hobart Combs, S.B.
Superintendent of Buildings

Theodore Mulford Doan, Jr.
Manager of Building Services

Alfred Edward Ennis
Administrative Assistant

Haig Garo Gechijian, S.B.
Manager of Engineering Services

Carl William Hagge, II, S.B.
Environmental Engineer

Earl Miners Harvey, M.Arch.
Staff Architect

Charles Ross Johnson, B.S.
Project Manager

Michael John Karaffa, B.Arch.
Project Manager

Henry Joseph Leonard
Superintendent for Support Services

Richard Freeman McKay, S.B.
Manager of the Central Utilities Plant

Howard Francis Miller, A.B., M.S.
Assistant to the Director of Physical Plant

Agnes Niven Morrice
Administrative Assistant

George Nikola Petievich, B.S., M.B.A.
Administrative Officer

Laurence William Pickard
Manager of Grounds Services

Joseph Mario Salvatore
Project Manager

Robert Fay Scofield
Construction Coordinator

Garret Leroy Sheldon, S.B.
Systems Analyst/Designer

Thomas Elwell Shepherd, Jr., S.B.
Superintendent of Utilities

George Edward West, Jr., B.S.
Manager of Mechanical Services

Safety Office

John Michael Fresina, B.S.
Director

Raymond Michael Diffley, B.S.
Associate Director

Joseph Francis Kuchta, B.S.
Safety Engineer

Mark John Dondero, B.S.
Consultant

Campus Patrol

James Olivieri, B.S.
Chief

Richard Gordon Driscoll
Captain

Graphic Arts and Audio-Visual Services

James William Coleman
Director of the Graphic Arts and Audio-Visual Services

Vernon Albert Raine
Assistant Director

Albert Kenneth Paone
Production Manager

Housing and Food Services

Harmon Eugene Brammer, B.B.A.
Director of Housing and Food Services

Arthur Leroy Beals, S.M.
Associate Director of Housing and Food Services

Vice President

James Edward Gross
Manager, Campus Housing Maintenance Services

Dexter John Kamilewicz, B.A.
Assistant Director, Housing

Salvatore Lauricella
Assistant Director, Food Services

Samuel Edward Leonard, Jr., B.S., B.A.
General Manager, Food Services

Joseph Fitzgerald Lynch, A.A.
Assistant Director, Housing

John Thornton McNeill
Manager, Student Center Food Services

Robert James Radocchia
Manager, Walker Memorial Food Service

Robert Edgar Shaw
Manager, Campus Housing Administrative Services

Mary Chute Smith, B.A.
Manager, Community Housing Services

Endicott House

Aimee Pierson, B.A.
Manager

Kenneth Robert Wadleigh, Sc.D.
Vice President

James H. Eacker
Assistant to the Vice President

Office of the Registrar

Warren Davis Wells, S.B.
Registrar

Ronald Paul Smith
Associate Registrar

Winston E. Flynn, B.A.
Assistant Registrar

Johanna Barbara Bond
Assistant to the Registrar

Ruth Selma Goodwin, A.B.
Assistant to the Registrar

Medical Department

Albert Otto Seeler, M.D.
Professor of Medicine
Medical Director
Head of Department

Melvin Herbert Rodman, M.D.
Associate Medical Director
Physician

Franklin Dalton Aldrich, M.D.
Assistant Medical Director
Physician in Charge of Environmental Medical Service

Warren Point, M.D.
Assistant Medical Director
Physician

Edward Strong Rendall, M.D.
Assistant Medical Director
Physician

Samuel Wolf Stein, M.D.
Assistant Medical Director
Physician

John Vernon Pikula, M.D.
Surgeon-in-Chief

Julius Eli Goldblatt, M.D.
Associate Surgeon-in-Chief

Merton Jerome Kahne, M.D.
Professor of Social Psychiatry
Psychiatrist-in-Chief

Joseph Hyman Brenner, M.D.
Associate Psychiatrist-in-Chief

Peter Borie Jenney, M.D.
Associate Psychiatrist-in-Chief

Benson Rowell Snyder, M.D.
Professor of Psychiatry

Frederic Garfield Worden, M.D.
Professor of Psychiatry

Jacqueline Alice Buck, M.S.S.
Chief Social Worker

Myra Aileen Rodrigues, M.S.S.
Social Worker

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Director of Nurses

Janice Marie McDonough, R.N.
Supervisor of Nurses — Clinics

Elinor Josephine Spita, R.N.
Supervisor of Nurses, M.I.T. Infirmary

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Leo David Caplice, A.B.
Administrative Officer

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Manager, Insurance and Billing

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Systems Analyst

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Personnel Officer

Physicians

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Melvin Howard Chalfen, M.D.
Samuel Drury Clark, M.D.
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George Goldman, M.D.
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H. Walter Jones, M.D.
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Charles Samuel Keevil, Jr., M.D.
Melvin Joel Krant, M.D.
Barbara Lynne O'Pray, M.D.
Noemi Martha Pedraza, M.D.
June Wise Pryor, M.D.
Willard Samuel Putnam, M.D.
Sanford Martin Reder, M.D.
Robert Carlyle Stewart, M.D.
Gordon Dufour Winchell, M.D.

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Harry Yegishe Azadian, M.D.
George Blackburn, M.D.
George Taylor Bottomley, M.D.
Henry Brown, M.D.
Donald Englund Butterfield, M.D.
Carl Joseph Canzanelli, M.D.
Reneé Bennett O'Sullivan, M.D.
John Loring Rowbotham, M.D.

Orthopedic Surgeons

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James Gavin Manson, M.D.
Robert Chase Runyon, M.D.

Psychiatrists

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Louise A. Dierker, M.D.
Rochelle Rame Friedman, M.D.
Alfred Jan Koumans, M.D.
Chester Middlebrook Pierce, M.D.
Wade Rockwood, M.D.
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Charlotte Green Schwartz, M.A.

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Joseph Perkell, D.M.D.
Lloyd V. Sutfin, D.M.D.

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Milton Elliot Helman, M.D.
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Paul Ira Winig, M.D.

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Karl Harvey Sorger, M.D.
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Charles Spencer Langston, M.D.
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Richard Schatzki, M.D.
Stefan Conrad Schatzki, M.D.

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Gail Anne Magenis, M.S.

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Associate Industrial Hygiene Officer

George William Boylen, Jr., B.S.

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Stephen Kenneth Piccolo, B.B.A.

Veterinarian

James Gahan Fox, F.V.M.

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Stephen Louis Nigro, B.S.

Consultant in Industrial Hygiene

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Underwood-Prescott Professor of Food Science
Director of Industrial Liaison Office

Nelson Cooper Lees, S.B., M.A.
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Institute Secretary

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Institute Estate Secretary

Charles Warren Smalzel, S.M.
Institute Secretary for Foundations

Arnold Herbert Singal, A.B., S.M., J.D.
Institute Secretary for Charitable Trusts

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Institute Secretary

Robert Hagopian, S.B.
Institute Secretary

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Project Officer

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Advisor to Foreign Students

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Director of the Educational Council

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Mary O. Hope
Assistant Dean for Student Affairs

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Assistant Dean of the Graduate School

Ronald S. Stone
Assistant Dean of the Graduate School

Louis Menand III
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Joel Orlen
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(Chairman)
Dean for Student Affairs*
Registrar*
Medical Director*
Director of Student Financial Aid*
Chairman of the Freshman Advisory Council*

Thomas M. Hill (1976)
Robert I. Rotberg (1976)
Robert S. Kennedy (1977)
August F. Witt (1977)
Bernhardt J. Wuensch**

Curricula

Leonard A. Gould (1975)
(Chairman)
Registrar*
Chairman of the Freshman Advisory Council*
Associate Provost*

John W. Cahn (1975)
Arthur Steinberg (1976)
Charles E. Holt III (1977)
Christopher T. Walsh (1977)
Arthur P. Mattuck**

Discipline

Adel F. Sarofim (1975)
(Chairman, fall 1974 term)
Judith J. Thomson (1976)
(Chairwoman, spring 1975 term)
Dean for Student Affairs*

Michael J. Piore (1975)
Earle L. Lomon (1976)
Edgar H. Schein (1977)
Ian T. Young (1977)
Ernest G. Cravalho**

Educational Policy

Elias P. Gyftopoulos (1975)
(Chairman)*

Robert G. Gallager (1975)
(Deputy Chairman)
Provost*
Vice President*
Associate Provost*

Ernest G. Cravalho (1975)
Richard S. Eckaus (1975)
Allan F. Henry (1975)
Frank S. Jones (1975)
Margaret L. A. MacVicar (1975)
Frank E. Perkins (1975)
Arthur P. Mattuck (1976)
Lisa A. Steiner (1976)
David G. Wilson (1976)
Bernhardt J. Wuensch (1976)

Graduate School Policy

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(Chairman)*
Associate Dean of the Graduate School (Secretary)*
Assistant Deans of the Graduate School*
Executive Officer of the Graduate School*
Director of Admissions*
Associate Chairman of the Faculty*

Stanford Anderson (1975)
James M. Austin (1975)
Sylvain Bromberger (1975)
Robert L. Coble (1975)
Peter A. Diamond (1975)
David J. Epstein (1975)
J. Harvey Evans (1975)
Maurice S. Fox (1975)
Allan F. Henry (1975)
Thomas M. Hill (1975)
George F. Koster (1975)
Robert D. Logcher (1975)
Thomas Nutt (1975)
Gordon H. Pettengill (1975)
Lucian W. Pye (1975)
Whitman A. Richards (1975)
Warren M. Rohsenow (1975)
John R. Ross (1975)
Richard D. Schafer (1975)
Dietmar Seyferth (1975)
Wallace E. Vander Velde (1975)
Glenn C. Williams (1975)
Gerald N. Wogan (1975)

1
The dates to the right indicate the years in which the terms of appointment expire
*Ex officio.
**Appointed from the Committee on Educational Policy.
†Presidential appointment.

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Industrial Liaison

Richard H. Lyon (1975)
(Chairman)

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Ernst G. Frankel (1976)
Daniel I. C. Wang (1976)
Thomas J. Allen (1977)
Clifford G. Shull (1977)

Library System

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(Chairman)
Provost*
Director of Information Processing Services*
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Keith H. Johnson (1975)
Krystyna Pomorska (1976)
Evsey D. Domar (1977)
Dietmar Seyferth (1977)

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(Chairman)

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Kenneth A. Johnson (1977)
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(Chairman)

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Robert M. Fogelson (1976)
Travis R. Merritt (1976)
Paul L. Joskow (1977)
George W. Pratt, Jr. (1977)

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Vice President, Administration and Personnel
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Secretary of the Institute
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Doctor of Philosophy, Earth and Planetary Sciences 313
Doctor of Philosophy, Economics 264
Doctor of Philosophy, Electrical Engineering 215
Doctor of Philosophy, Foreign Literatures and Linguistics 267
Doctor of Philosophy, Management 296
Doctor of Philosophy, Mathematics 318
Doctor of Philosophy, Mechanical Engineering 229
Doctor of Philosophy, Metallurgy and Materials Science 236
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